Draft Screening Assessment

Gas Oils and Kerosenes

Environment and Climate Change Canada
Health Canada

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Synopsis

Pursuant to section 68 or 74 of the *Canadian Environmental Protection Act, 1999* (CEPA), the Minister of the Environment and the Minister of Health have conducted a screening assessment of substances referred to collectively under the Chemicals Management Plan as the Gas Oils and Kerosenes Group. Forty two of the substances in this group were identified as priorities for assessment as they met categorization criteria under subsection 73(1) of CEPA or were considered a priority on the basis of other human health concerns. The Chemical Abstracts Service Registry Numbers (CAS RN[1]) and their *Domestic Substances List* (DSL) names are listed in Appendix A.

Gas oils and kerosenes are complex and highly variable combinations of hydrocarbons produced either directly through atmospheric distillation of crude oil or by the cracking of heavier vacuum distillation streams into lighter fractions. Gas oils contain straight and branched chain alkanes (i.e., paraffins and cycloparaffins), cycloalkanes, aromatic hydrocarbons, and mixed aromatic cycloalkanes, predominantly in the carbon range of C_9 to C_{30}. Kerosenes consist of hydrocarbons in the range of C_9 to C_{16}. The major components of kerosenes are branched and straight chain alkanes and cycloalkanes. The aromatic hydrocarbon content of gas oils and kerosenes can be variable, especially for the gas oils, ranging from less than 1 % by weight (wt%) to approximately 98 wt%, however, more typically the range of aromatic content of gas oils is from 20 to 80%. For kerosenes, aromatic hydrocarbons do not normally exceed 25% by volume, though one kerosene CAS RN is defined as consisting predominantly of aromatic hydrocarbons. Gas oils and kerosenes are considered to be of Unknown or Variable composition, Complex reaction products or Biological materials (UVCBs).

In site restricted and industry restricted uses, gas oils and kerosenes may be consumed at the refinery where they are produced, blended into substances leaving the refinery under different CAS RNs, or transported by truck or train to other petroleum or non-petroleum sector facilities for use as feedstocks or to be blended with other feedstocks, resulting in a new CAS RN. Twenty-seven of the gas oils and kerosenes in this assessment were identified (via their identification through the corresponding CAS RNs) as being used industrially, as petroleum diluents, or in lubricants, petroleum production aids, printing inks, adhesives and sealants, paints and coatings, or as industrial processing aids (e.g., cleaners, degreasers). The aromatic contents of the gas oils and kerosenes used in these industries are unknown; therefore, aromatic contents ranging from 20 to 80 % by weight were considered in the ecological assessment. Empirical and modelled aquatic toxicity data for gas oils and kerosenes indicate moderate to high hazard. The gas oils and kerosenes are also present in products available to consumers

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including in automotive and furniture polishes, and household cleaning products. These products have been determined via analytical testing to have low benzene, toluene, and xylenes content as well as and very low polycyclic aromatic hydrocarbon content. Due to their similarity of sources, production, properties and hazard, gas oils and kerosenes have been assessed together in this report.

The ecological screening assessment uses a group-based approach that focuses on gas oils and kerosenes with an aromatic content ranging from 20 to 80% by weight, which includes the 42 substances listed in Appendix A that were identified as priorities for assessment. Given that the compositional variability that exists within and between gas oils and kerosenes having different CAS RNs can lead to their interchangeable use (provided they meet property specifications), the ecological portion of the assessment focuses on the broader class of gas oils and kerosenes.

The uses of gas oils and kerosenes identified as having the highest potential for release to the environment and considered in this assessment are: formulation of lubricants or lubricant additives; formulation of various products including oil-water separation aids, printing inks, adhesives and sealants, processing aids, and paints and coatings; the industrial application of certain formulated products including printing inks, and adhesives and sealants; the use of processing aids by paper mills; the use of processing aids by facilities in other sectors including plastics and rubber, fabricated metal, machinery, and transportation equipment; and the application of biosolids containing gas oils and kerosenes to agricultural land. Environmental concentrations and compositions of gas oils and kerosenes following wastewater treatment were estimated and compared to modelled predicted no-effect concentrations based on the predicted composition of gas oils and kerosenes in the effluent.

There is a risk of harm predicted to the environment for both low- and high-aromatic content gas oils and kerosenes when used by paper mills as processing aids. For the use of processing aids in other industrial sectors, the level of risk to the environment was estimated to be low. A low risk of harm to the environment was also found for the other exposure scenarios considered. Components of gas oils and kerosenes might accumulate in sediment near points of discharge; however, there is no information on their environmental concentration or impact of these substances to sediment organisms.

Considering all available lines of evidence presented in this draft screening assessment, there is risk of harm to the environment from gas oils and kerosenes with aromatic contents of 20 % by weight or greater. It is proposed to conclude that the gas oils and kerosenes with aromatic contents of 20 % by weight or greater meet the criteria under paragraph 64(*a*) of CEPA as they are entering or may enter the environment in a quantity or concentration or under conditions that have or may have an immediate or long-term harmful effect on the environment or its biological diversity. However, it is proposed to conclude that gas oils and kerosenes with aromatic contents of 20 % by weight or greater do not meet the criteria under paragraph 64(*b*) of CEPA as they are not entering the environment in a quantity or concentration or under conditions that constitute or may constitute a danger to the environment on which life depends.

A critical health effect for the initial categorization of gas oils and kerosenes was carcinogenicity, based primarily on classifications by international agencies. Based on the likelihood of gas oils and kerosenes to contain polycyclic aromatic hydrocarbons (PAHs), the European Commission classifies a number of the gas oils and kerosenes CAS RNs as Category 1B (10 substances) carcinogens ("*may cause cancer*"), but considers these substances not carcinogenic if they are refined to contain less than 3% w/w PAHs as extracted by dimethyl sulfoxide (DMSO). Adverse reproductive and developmental effects were also considered in the risk characterization of gas oils and kerosenes.

Gas oils and kerosenes used as ingredients in products available to consumers are refined to contain a low level of PAHs. To confirm that Canadian gas oil and kerosene products available to consumers have low levels of PAHs, 28 readily available products were tested for PAHs. Only residual to low levels (low parts per billion to low parts per million) of PAHs were found. According to the European Commission classification, these gas oils and kerosenes are therefore not considered to be carcinogenic.

Based on the carbon range of the gas oils and kerosenes, other potential components which may lead to health effects are benzene, toluene, ethylbenzene, and xylenes (BTEX). To determine the level of these substances in Canadian gas oil and kerosene products available to consumers, 24 readily available products were tested for BTEX. Benzene was not detected in any household cleaning product and was present in only very low levels in one engine cleaning product; one anti-rust product; and a firearm powder, lead, and rust removing solvent containing gas oils and kerosenes.

After consideration of the types of products available to consumers and their use patterns, long-term dermal exposure of the general population to gas oil and kerosenes is not expected. However, dermal and inhalation exposure may occur to the gas oil and kerosene from the intermittent use of such products. The levels of PAH in these products result in a maximum benzo[a]pyrene equivalent exposure of 0.1 µg/kg-bw per event. A comparison of levels of refined gas oils and kerosenes Canadians can be exposed to from products available to consumers and levels associated with effects following intermittent acute dermal and oral exposures in laboratory studies were considered adequate to address uncertainties in the health effects and exposure datasets.

After consideration of the types of products available to the general population in Canada and their use patterns, estimates of exposure from inhalation of benzene and other monocyclic aromatic hydrocarbons from the use of paste varnish and engine cleaners were calculated. A comparison of levels of BTEX components Canadians can be exposed to from these products and levels associated with effects following intermittent acute inhalation exposure in laboratory studies were considered adequate to address uncertainties in the health effects and exposure datasets.

On the basis of the information presented in this draft screening assessment, it is proposed to conclude that the 42 gas oils and kerosenes listed in Appendix A do not meet the criteria under paragraph 64(*c*) of CEPA as they are not entering the environment in a quantity or concentration or under conditions that constitute or may constitute a danger in Canada to human life or health.

Therefore, it is proposed to conclude that gas oils and kerosenes with aromatic contents of 20 % by weight or greater meet one or more of the criteria set out in section 64 of CEPA.

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1. Introduction

Pursuant to section 68 or 74 of the *Canadian Environmental Protection Act, 1999* (CEPA) (Canada 1999), the Minister of the Environment and the Minister of Health have conducted a draft screening assessment on a group of gas oils and kerosenes to determine whether these substances present or may present a risk to the environment or to human health. During the categorization exercise, 42 gas oils and kerosenes were identified as priorities for assessment as they met categorization criteria under subsection 73(1) of CEPA or were considered a priority on the basis of other human health concerns (ECCC, HC [modified 2017]). The Chemical Abstracts Service Registry Numbers (CAS RN[2]), and *Domestic Substances List* (DSL) names of these 42 substances are listed in Table A.1 in Appendix A; descriptions of each CAS RN as reported on the DSL are provided in ECCC (2018a). Due to their similarity of sources, production, properties, and hazard, gas oils and kerosenes have been assessed together in this report.

The focus of the ecological assessment is on gas oils and kerosenes with aromatic contents of 20 to 80 % by weight. This includes, but is not limited to, the 42 individual gas oil and kerosene substances identified in Appendix A. This range is representative of most gas oils, with the upper end of the range, 80%, considered to be a reasonable worst-case for the aromatics content of gas oils and kerosenes. Compositional variability exists within and between gas oils and kerosenes that can lead to their interchangeable use in products provided they meet product use specifications.

This assessment does not consider the use of kerosenes in aviation fuels or gas oils in fuels (e.g., Fuel Oil No. 2) as these have been assessed previously (Environment Canada, Health Canada 2014, 2015). In addition, some gas oil CAS RNs were addressed previously for site- (1 CAS RN) or industry- (2 CAS RN) restricted uses (Environment Canada, Health Canada 2011, 2013). The use of gas oils as diesel fuels is being assessed separately. This assessment also did not consider the use of gas oils and kerosenes as petroleum diluent, as this is more suitably considered in the context of the petroleum substance(s) that has been diluted.

This draft screening assessment includes consideration of information on chemical properties, environmental fate, hazards, uses and exposures, including additional information submitted by stakeholders. Relevant data were identified up to March 2018. Empirical data from key studies as well as some results from models were used to

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reach proposed conclusions. When available and relevant, information presented in assessments from other jurisdictions was considered.

This draft screening assessment was prepared by staff in the CEPA Risk Assessment Program at Health Canada and Environment and Climate Change Canada and incorporates input from other programs within these departments. The ecological and human health portions of this assessment have undergone external written peer review and/or consultation. Comments on the technical portions relevant to the environment were received from Geoff Granville (GCGranville Consulting Corp) and Dr. Connie Gaudet. Comments on the technical portions relevant to human health were received from Dr. Glenn Talaska (University of Cincinnati, USA) and Dr. Susan Griffin (US EPA). While external comments were taken into consideration, the final content and outcome of the screening assessment remain the responsibility of Health Canada and Environment and Climate Change Canada.

This draft screening assessment focuses on information critical to determining whether substances meet the criteria as set out in section 64 of CEPA by examining scientific information and incorporating a weight of evidence approach and precaution[3]. This draft screening assessment presents the critical information and considerations on which the proposed conclusion is based.

2. Identity of substances

Gas oils and kerosenes are Unknown or Variable composition, Complex reaction products or Biological materials (UVCB) substances that are complex combinations of hydrocarbon molecules that originate in nature or are the result of chemical reactions and processes that take place during processing and blending of petroleum. Given their complex and variable compositions, gas oils and kerosenes cannot practicably be synthesized by simply combining individual constituents.

Gas oils consist predominantly of molecules in the carbon number range of C_9 to C_{30} and boiling over the interval of approximately 150 to 471 °C by the American Petroleum Institute which is a United States trade association representing different facets of the oil and natural gas industries (API 2012a). The European petroleum industry organization Conservation of Clean Air and Water in Europe (CONCAWE) defines gas oils slightly differently than API, giving a predominant carbon range of C_{11} to C_{25}, and a boiling range of 150 to 450 °C (CONCAWE 1996). Gas oils contain straight and

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[3] A determination of whether one or more of the criteria of section 64 of CEPA are met is based upon an assessment of potential risks to the environment and/or to human health associated with exposures in the general environment. For humans, this includes, but is not limited to, exposures from ambient and indoor air, drinking water, foodstuffs, and products available to consumers. A conclusion under CEPA is not relevant to, nor does it preclude, an assessment against the hazard criteria specified in the *Hazardous Products Regulations*, which are part of the regulatory framework for the Workplace Hazardous Materials Information System for products intended for workplace use. Similarly, a conclusion based on the criteria contained in section 64 of CEPA does not preclude actions being taken under other sections of CEPA or other Acts.

branched chain alkanes, cycloalkanes, aromatic hydrocarbons, and mixed aromatic cycloalkanes (API 2012a). Gas oils can be produced directly through atmospheric distillation of crude oil, or they can be obtained from the cracking of heavier vacuum distillation streams into a lighter gas oil fraction. Cracking results in gas oils with higher amounts of aromatics and alkenes. Gas oils that are obtained through distillation with no or minimal additional processing are called straight run gas oils. Gas oils can be straight run or a blend of straight run and/or cracked gas oil streams (API 2012a).

Kerosenes[4], the fraction of crude oil that boils approximately in the range of 150 to 290°C and consists of hydrocarbons approximately in the range of C_9-C_{16} (API 2010a) are considered together with the gas oils group as they are produced in a similar manner as gas oils (atmospheric distillation and/or cracking) (API 2010a) and represent the lighter end of the gas oil carbon range. Additional processing of the kerosenes might be undertaken to remove or reduce the levels of undesirable components, such as sulfur, nitrogen or alkenes, and increase the levels of cycloalkanes and isoalkanes. This also reduces their compositional variation (API 2010a).

Alkanes (normal, branched and cyclic) generally constitute at least 70% by volume of kerosenes, while aromatic hydrocarbons (mainly alkylbenzenes and alkylnaphthalenes) and alkenes are generally less than 25 vol% and 5 vol%, respectively (API 2010a, CONCAWE 1995). Eight CAS RNs in this report are kerosenes: 8008-20-6, 64742-14-9, 64742-47-8, 64742-81-0, 64742-88-7, 64742-91-2, 64742-94-5 and 64742-96-7 (API 2010a), with the rest being gas oils (Appendix A). Operational definitions for the forty-two gas oils and kerosenes in this report are included in ECCC (2018a).

One of the substances regarded as a kerosene (CAS RN 64742-91-2; C_7-C_{16}) falls partly outside the carbon and boiling point ranges for kerosene, although it is included in the CONCAWE kerosenes category (CONCAWE 1995). Six other substances (i.e., CAS RNs 64741-85-1, 128683-26-1, 128683-28-3, 128683-29-4, 128683-30-7, and 129893-10-3) also fall partly outside of the carbon and boiling point ranges included in the above definition of gas oils (i.e., collectively, the carbon ranges of these substances span C2 to C40, and the boiling ranges span -38 to 550 °C). However, they are considered to be sufficiently similar to the other gas oils and kerosenes to include them in this assessment.

Compositional information on 86 gas oil samples (representing 15 CAS RNs) was generated by the American Petroleum Institute. Percentage compositions for aromatic content ranged from less than 1 % by weight (wt%) to approximately 98 wt% (API 2014a). However, the <1% and 98 wt% values were only found for single samples; most gas oil samples had aromatic contents in the 20 wt% to 80 wt% range. Compositional data was found for one sample of kerosene (CAS RN 8008-20-6) and for four samples of hydrodesulfurized kerosene (CAS RN 64742-81-0). These substances had aromatic

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[4] Kerosenes are synonymous with kerosines and the terms appear interchangeably in the scientific literature.

contents ranging from 18.8 to 27 wt%, of which mono-aromatics made up the majority (17.8-24.7 wt%) (API 2014b). CAS RN 64742-94-5, a kerosene, is defined as consisting of primarily aromatic hydrocarbons (ECCC 2018a, Table 1.1). Based on the range of aromatics found in the gas oils and kerosenes as described above, a range of 20 to 80 wt% aromatics was used in the ecological assessment, with the upper end of the range, 80%, considered as a worst-case scenario for the aromatics content of kerosenes.

An important characteristic of gas oils is the presence of polycyclic aromatic compounds (PACs). PACs are a broader group of compounds than polycyclic aromatic hydrocarbons (PAHs) that also includes heterocyclic compounds in which one or more of the carbon atoms in the PAH ring system are replaced by nitrogen, oxygen, or sulfur atoms. The alkyl substitutions are usually one to four carbons long and can include non-carbon compounds such as sulfur (API 2012a). The relative abundance of the C_1-C_4 alkylated polycyclic aromatics in petroleum far exceeds the abundance of the parent compound (C_0) (Speight 2007, Altgelt 1994). Most commercial gas oils contain PACs. The levels of PACs, including heterocyclics, as well as polycycloalkanes increase with increasing boiling point ranges of the fractions, while the levels of normal and branched alkanes and monocycloalkanes decrease (API 2012a). In light straight-run gas oils the PACs are mainly 2 and 3-ringed compounds. The heavier atmospheric, vacuum or cracked gas oil components may contain increased levels of PACs with 4 or more rings (API 2012a). Petroleum streams from thermal or catalytic cracking processes generally have higher PAC contents than straight-run distillation fractions or streams derived from other non-cracking processes (e.g., hydrotreating). Straight run gas oil streams that have undergone a limited amount of additional processing are composed predominantly of saturated hydrocarbons (API 2012a).

Compositional information available for the kerosenes (specifically, CAS RNs 8008-20-6 and 64742-81-0) indicates that these substances contain approximately 15 - 31 % aromatics, 65 - 83% saturates and 1.4 - 3.5% alkenes (API 2010a, API 2014b). An analysis of a series of kerosenes found that virtually all of the aromatics had either one or two rings (API 2010a).

Generally, kerosenes contain <0.01% by mass of benzene (API 2010a, CONCAWE 1995). However, based on their carbon and boiling point range and depending on the degree of purification, gas oil and kerosene substances may have residual levels of benzene, plus low levels of toluene, ethylbenzene, and xylene components. The results of the testing of Canadian products available to consumers containing gas oils and kerosenes for benzene, toluene, ethylbenzene and xylene (BTEX) are described in Section 8.1.4.

The aromatic fraction includes all components that contain an aromatic (i.e., benzene) ring within the structure, and includes parent monoaromatic hydrocarbons (MAHs) and polycyclic aromatic hydrocarbons (PAHs) as well as their alkylated derivatives (i.e., MAHs and PAHs containing normal, branched or cyclic alkyl groups) and aromatics containing heteroatoms. The PAHs and aromatics containing heteroatoms are collectively referred to as polycyclic aromatic compounds (PACs). In terms of volatile aromatics with carbon numbers less than C10, the human health components of main concern are the BTEX content. In terms of C10 or larger aromatics, the human health component of this assessment is mainly concerned with parent PAH content and thus considers the PAH concentration as determined by methods equivalent to the IP 346 (Institute of Petroleum 1992). Hazard information on the whole gas oil and kerosene substances are considered when available. However, the total aromatic content (wt%) of petroleum substances is of more importance to the ecological assessment than PAH concentration, as aromatics in general are the main contributors to the ecotoxicity (Verbruggen 2008, Cermak 2013), and thus the total aromatic content is considered in the ecological assessment.

3. Physical and chemical properties

The composition and physical-chemical properties of gas oils and kerosenes vary with the source of crude oil or bitumen and the refining steps involved. General physical-chemical properties of gas oils and kerosenes are presented in **Error! Reference source not found.** and Table 3-2, respectively.

Table 3-1. General physical and chemical property of gas oils

Property	**Type**	**Value**	**Temperature (°C)**	**Reference**
Pour point (°C)	experimental	-30 to 0	-	API 2012b
Boiling point (°C)	-	150 to 450	-	API 2012a
Density (g/cm^3)	experimental	0.8 - 0.99	15	ECB 2000a,b,c,d,e
Density (g/cm^3)	experimental[a]	0.81- 0.90	15	CONCAWE 1996
Vapour pressure (Pa)	modelled[a]	0.01 – 23	20	ECB 2000a,b,c
Vapour pressure (Pa)	-	≤ 133	20	MSDS 2013, 2014
Vapour pressure (Pa)[b]	-	280 -3520	21	Air Force 1989
Vapour pressure (Pa)	Modelled and experimental, for representative structures	3.6×10^{-9} - 384	20	ECCC 2018b
Water solubility (mg/L)	-	< 10	20	ECB 2000b,c
Water solubility (mg/L)	Modelled, for representative structures	<0.001-52[d]	25	API 2012b
Water solubility (mg/L)	Measured[c]	2.0-8.7	5-20	API 2012b
Water solubility (mg/L)	-	negligible	-	MSDS 2013, 2014, 2016

Property	Type	Value	Temperature (°C)	Reference
Water solubility (mg/L)	Modelled and experimental, for representative structures	8.6×10^{-11} – 95	20	ECCC 2018b
Log K_{ow} (dimensionless)	Calculated	3.4 to 9.2	-	ECB 2000a,b,d,e
Log K_{ow} (dimensionless)	Modelled and experimental, for representative structures	3.3 - 15	20	ECCC 2018b

Abbreviations: K_{ow}, octanol–water partition coefficient; K_{oc}, organic carbon–water partition coefficient
- no data provided
[a] densities of automotive gas oil, and heating oil
[b] Based on water solubility of representative structures of for typical gas oils with carbon length C_9 to C_{30}
[c] For Fuel Oil No. 2, (a gas oil)

Table 3-2. Physical and chemical properties of kerosenes

Property	Type	Value	Temperature (°C)	Reference
Boiling range (°C)	Measured	150 - 290	-	API 2010a
Vapour pressure (Pa)	Measured[a]	300 - 3500	21	API 2010a
Vapour pressure (Pa)[b]	Measured	1000	20	MSDS 2017
Water solubility (mg/L)	Measured[b]	2.8 - 39	20-22	Murray 1984, Maclean and Doe 1989, Sunito 1986
Log K_{ow} range (dimensionless)	Modelled	3.3 to > 6	20	API 2010a

[a] For kerosene jet fuels
[b] For diesel fuel

To predict the physical/chemical properties and ecological fate of complex petroleum substances such as gas oils and kerosenes, representative structures were chosen from each chemical class found in these substances. As the compositions of the gas oils and kerosenes are variable, representative structures could not be chosen based on their proportion in the mixture. This lack of general compositional data resulted in the selection of representative structures for alkanes, isoalkanes, alkenes, cycloalkanes, one-ring to six-ring aromatics, and alkyl-aromatics ranging from C_9 to C_{30}, based solely on carbon numbers for each hydrocarbon class. Physical–chemical data were assembled from scientific literature and from the EPI Suite (2008) group of environmental models. A summary of empirical and modelled physical and chemical property data for the representative hydrocarbon structures of gas oils and kerosenes is provided in ECCC (2018a).

It should be noted that the physical and chemical behaviour of the representative structures, when present as a component in a UVCB substance, can differ from that of the pure form. The vapour pressures of components of a mixture are lower than their individual vapour pressures due in accordance with Raoult's Law, which states that the total vapour pressure of an ideal mixture is proportional to the sum of the vapour pressures of the mole fractions of each individual component. Similar to Raoult's Law, the water solubilities of components in a mixture are lower than when they occur individually (Banerjee 1984; Di Toro et al. 2007). Concurrently, however, when an individual petroleum hydrocarbon chemical that is normally solid under environmental conditions is part of a petroleum mixture (or UVCB), it will, in reality, be found in a liquid state due to the lowering of its melting point when in a mixture (Di Toro et al. 2007). This results in an increase in the vapour pressure and water solubility of the hydrocarbon that is normally solid as determined by the subcooled vapour pressure (Staikova et al. 2005) and subcooled solubility (Di Toro et al. 2007). The physical and chemical properties of the individual representative structures (Table 2.1, ECCC 2018a) give an indication of how these individual components of the petroleum mixture behave in the environment. This is discussed in Section 6.1.

4. Sources and uses

Information on a number of gas oils and kerosenes was gathered through several surveys conducted under section 71 of CEPA, as well as one voluntary data gathering initiative, as listed in Table 4.1. The 2008 and 2009 Notices applied only to petroleum refining and/or upgrading facilities. The 2008 survey collected information on the quantity of substances used and their industrial fate, while the 2009 survey collected information on the transportation of the substances. Seven gas oils (CAS RNs 64741-77-1, 64741-91-9, 64742-13-8, 64742-30-9, 64742-46-7, 64742-79-6, 68477-31-6) were included in the 2008 survey and four of the same ones (64741-77-1, 64742-30-9, 64742-46-7, 64742-79-6) were included in the 2009 survey. The 2011 survey applied to all sectors and collected information on the manufacture, import and use of the gas oils included in the 2008 and/or 2009 surveys, which were thought to be used in products available to consumers. The 2015 survey collected information on industrial and commercial usage patterns, but not quantities, and included 19 of the gas oils and kerosenes (Appendix A) that were not included in the previous surveys. Information on the usage patterns of 12 gas oils and kerosenes were also reported to the 2015 voluntary data gathering initiative.

Table 4-1 Information submitted pursuant to section 71 surveys of CEPA and a voluntary survey

Title of survey	Data reporting year / No. of GOs and Ks surveyed[a]	Survey reference	Data report reference
Notice with respect to certain high priority petroleum substances.	2006 / 7 gas oils	Environment Canada 2008	Environment Canada 2011b

Notice with respect to potentially industry-limited high priority petroleum substances.	2006 / 4 gas oils	Environment Canada 2009	Environment Canada 2011c
Notice with respect to certain high priority petroleum substances on the Domestic Substances List	2010 / 7 gas oils	Environment Canada 2011a	Environment Canada 2012
Notice with respect to certain priority petroleum substances on the Domestic Substances List	2014 / 19 gas oils not included in previous surveys	Environment Canada 2015b	ECCC 2016a
Voluntary data gathering initiative, 2015	2014 / 10 gas oils	NA	ECCC 2016b

[a] The number of gas oils and kerosenes CAS RNs (as listed in ECCC(2018a)) included in the survey

The seven gas oils surveyed in 2008/2009 and 2011 have been identified as blending stocks for other products, and/or products available to the consumer (Environment Canada 2011b,c). Of these seven gas oils, five were consumed at the facilities and three of the seven are transported mainly by pipeline to other Canadian petroleum refinery facilities. These seven gas oils may also enter commerce directly without further blending.

The predominant use of gas oils is as intermediate blending components in the production of fuels that are used in diesel engines (i.e., diesel fuel) and for heating (i.e., fuel oil) (API 2012a). They may also serve as blending components for other fuels such as kerosene, gasoline, and aviation fuel, which leave the facility under different CAS RNs. Some gas oils are used in the production of products available to consumers.

The predominant use of kerosene in the United States is as aviation turbine fuel for civilian (using Jet A or Jet A-1) and military (using JP-8 or JP-5) aircraft (API 2010a), and a similar usage profile is expected in Canada. Kerosenes are also used as diesel fuel (No. 1), domestic heating fuel (Fuel oil No. 1), and illuminating kerosene (No.1-K), as well as being used as solvents in the formulation of a range of products including cleaning products, insecticides, antifoaming agents and mold release agents (CONCAWE 1995). The kerosenes used in these products are often of a narrower distillation range than those used in fuels and are often further treated to reduce odour and aromatics content (CONCAWE 1995).

The seven gas oil substances surveyed in 2011 have been identified as being used in eight different use categories, as detailed in Table 4.2. (Environment Canada 2012).Later surveys showed that the uses of the other gas oil and kerosene substances also fall into these use categories. The highest usage quantity of these seven gas oils was as petroleum diluents (Table 4.2). In 2015, several kerosenes were also identified as being used in manufacturing in several sectors, including automotive manufacturing, fibres and filament manufacturing and the pulp and paper sector (Table 4.3).

Table 4-2. Uses and usage quantities of seven gas oils[a] - 2010 data (Canada 2012)

Use Category	Quantity (millions of kg)[b]	Activities	Usage info
Petroleum diluent, viscosity adjustor	1000 -10 000	Pipeline transport	Blended with bitumen or crude oil
Lubricants & lubricant additives	10 – 100	Import, formulation, incorporation into equipment[c]	Viscosity adjustors, corrosion inhibitors, anti-scaling agents
Oil production aids[d]	1 – 10	Formulation, use in oil recovery	Surfactants, demulsifiers, defoamers, corrosion inhibitors, anti-scaling agents
Printing inks and printing ink additives	1 – 10	Import, formulation, commercial printing	Solvents, viscosity adjustors
Adhesives/sealants & their additives	0.1 – 1	Import, formulation, industrial use[e]	solvents
Processing aids	0.1 – 1	Import, formulation, repackaging, industrial use[f]	Solvents (ingredient carriers, penetrating agents), surfactants
Products available to consumers	0.1 – 1	Import, formulation, distribution	Polishing agents, solvents
Paints and coatings, additives for them[g]	0.01 – 0.1	Import, formulation, repackaging, industrial metal coating	Defoaming agents, solvents, surfactants

[a] CAS RNs of the seven gas oils are listed in the first paragraph of this section

[b] Values reflect quantities reported in response to the survey conducted under section 71 of CEPA (Environment Canada 2012). See survey for specific inclusions and exclusions (schedules 2 and 3).

[c] Equipment includes automobiles, engines, transformers, rock-drilling equipment. In 2015, two other gas oils and 6 kerosenes were also identified as being used in lubricants and oils (Table 4.3).

[d] In 2015, five additional gas oils and two kerosenes were also identified as being used in the oil and gas industry as production or processing aids (Table 4.3).

[e] Uses include the production of flooring and glass.

[f] Industrial uses include pulp and paper production, equipment cleaning, water treatment, plastic or metal molding and gypsum board manufacture, detection of defects in aerospace metal components.

[g] Five kerosene substances are also used in paint and coating manufacturing (Table 4.3).

The gas oils and kerosenes CAS RNs surveyed (Canada 2011, 2015a,b) were identified in or as having the potential to be ingredients in products available to the Canadian consumer. A more detailed search indicated that the products include lubricants, automotive care products, fuels and solvents, paints and coatings, adhesives and sealants, household cleaning products, lawn and garden care products, building products, and other miscellaneous products (Table 4.3, Meridian 2009, Household Product Database 2016). Product categories (Table B-1) and detailed uses by CAS RN are given in Appendix B.

The gas oils and kerosenes CAS RNs 64741-44-2, 64741-77-1, 64742-46-7, 64742-47-8, 64742-88-7, 64742-94-5, 64742-96-7, 68477-31-6, and 8008-20-6 are considered as formulants by Health Canada's Pest Management Regulatory Agency (PMRA) (PMRA 2010). (Personal communication, from Health Canada PMRA to Health Canada Risk Management Bureau, dated September 2017; unreferenced).

Table 4-3. Usage Information on gas oils and kerosenes (Environment Canada 2012, ECCC 2016a,b)

Use Category	**CAS RNs**
Automobile and light-duty motor vehicle manufacturing	64742-46-7, 64742-79-6, 64742-81-0, 92704-36-4 (power steering fluid)
Additive in rubber and plastic parts (e.g., for automotive parts)	64741-44-2, 64742-47-8, 64742-81-0
Adhesives and sealants	64742-46-7, 64742-81-0, other (CBI)
Asphalt paving, roofing and saturated materials manufacturing	64742-47-8, 64742-81-0
Automotive maintenance products and waxes[a]	8008-20-6, 64741-44-2, 64742-47-8, 64742-88-7
Automotive products (unspecified) for consumer retail	64742-96-7, other (CBI)
Confidential usage[b]	68333-88-0
Cosmetics and lotions[a]	64741-44-2, 64742-47-8, 64742-94-5
Fibres and filaments, artificial and synthetic, manufacturing	64742-81-0
Food packaging[a]	64741-43-1
Fuels (e.g., gasoline, diesel, heating oil) and related products (e.g., fuel additives)	64741-77-1, 64742-46-7, 64742-79-6, 64742-81-0, 68333-81-3, 64742-47-8, 64742-31-0, 64742-94-5, 8008-20-6
Ink, toner and colourants[a]	64741-91-9, 64742-13-8, 64742-46-7, 64742-81-0
Laboratory substances	64741-43-1
Laundry detergent, stain remover[a]	64742-47-8, 64742-94-5
Lighting fixture manufacturing	64742-81-0
Lubricants & oils	8008-20-6, 64741-44-2, 64742-14-9, 64742-38-7, 64742-46-7, 64742-47-8, 64742-79-6, 64742-88-7, 64742-81-0, 64742-94-5, other (CBI)

Use Category	**CAS RNs**
Organic chemical manufacturing (other basic), other misc. chemical product manufacturing	64742-46-7, 64742-96-7
Other misc. products available to consumers (e.g., candles, polish, floor care product, air freshener, insect repellant, plant fertilizer	64742-46-7, 64742-47-8, 8008-20-6
Paints & coatings[a]	8008-20-6, other (CBI), 64742-47-8, 64742-46-7, 64742-81-0, 64742-88-7, 64742-94-5
Paper manufacturing (paper process additive, processing aid, solids conditioning agent, carrier in defoaming formulations, flocculant, coagulant aid/sludge conditioning agent, viscosity adjustor	64742-47-8, 64742-13-8, 64742-46-7, other (CBI)
Pesticide products[a]	64742-47-8
Products used in oil & gas industry (eg., used in oil and gas extraction, cleaning product, processing aids)	64742-47-8, 68915-97-9, 68477-30-5, 64742-81-0, 68814-87-9, 68915-96-8, 2 others (CAS RNs CBI)
Pipeline transportation of crude oil	64742-81-0
Roofing applications	64742-81-0
Solvents (as part of a formulation)	8008-20-6, 64741-44-2, 64742-47-8, 64742-88-7, 64742-46-7
Surfactant/drying agent, emulsion breaker	64742-94-5, 2 others CBI
Mining sector, chemical reagent [c]	64741-85-1
Water treatment	64742-46-7, 64742-47-8

Abbreviations: CBI - Confidential Business Information

[a] Use Category includes products with consumer uses.

[b] This use was declared as confidential business information. However, it was considered in the context of this risk assessment, and is not expected to have significant potential for releases.

[c] Usage not commercialized as of March 2016.

Eleven of the 42 gas oils and kerosenes, CAS RNs 8008-20-6, 64741-44-2, 64742-06-9, 64742-14-9, 64742-46-7, 64742-47-8, 64742-81-0, 64742-88-7, 64742-94-5, 64742-96-7, and 68477-31-6 are identified as potentially being used in the manufacture of food packaging materials and/or as components of incidental food additives, including lubricants in machinery, components in defoamers for materials for food pads, components of cleaners (which are afterwards rinsed with potable water), components of coating for paper, paper board, and inks, components of interior lacquer of cans, and components of paper making systems used for processing food. Certain substances, that is, CAS RNs a 64741-44-2, 64742-06-9, 64742-47-8, 64742-88-7, 64742-94-5, 64742-96-7 have potential for direct food contact therefore potential exposure is possible from contact with food packaging. Of the substances identified as components in incidental additives, only CAS RN 64742-14-9, 64742-46-7, 64742-88-7, and 64742-

94-5 were identified as having potential incidental contact with food. (Personal communication, from Health Canada Food Directorate to Health Canada Risk Management Bureau, dated August 2017; unreferenced).

Three gas oil and kerosene substances (CAS RNs 64742-46-7 and 64742-47-8, 8008-20-6) were initially identified as being used in cosmetic products (Personal communication, email from the Consumer Product Safety Directorate, Health Canada (HC) to the Existing Substances Risk Assessment Bureau (HC), dated August 3, 2017, personal communication, email from the NNHPD, Health Canada (HC) to the Existing Substances Risk Assessment Bureau (HC), dated August 3, 2017). However, the International Nomenclature of Cosmetic Ingredients (INCI) provides multiple ingredient names under the heading of each of these CAS. For example under CAS RN 64742-46-7, the following ingredient names are listed: C13-14 Alkane, C13-15 Alkane, C15-19 Alkane, and C12-20 Isoparaffin. Follow-up with the Consumer Product Safety Directorate (personal communication, email from the Consumer Product Safety Directorate, Health Canada (HC) to the Existing Substances Risk Assessment Bureau (HC), dated Dec. 1, 2017) indicated that in these circumstances the suppliers are producing materials with more specific composition ranges and greater refinement, and that a generic CAS has been assigned to them. It is expected that the same substances (e.g., 64742-46-7) with specific composition ranges are used in the Licensed Natural Health Products as they are also labelled as C13-14 Alkane. As these substances, as described under their ingredient names, are considered to be different in composition and much more refined than as defined by the standard CAS RN descriptions of gas oils and kerosenes, this assessment does not further consider their exposures to the general population.

Distillates (petroleum), hydrotreated middle (CAS RN 64742-46-7) is listed in the Natural Health Products Ingredients Database (NHPID) as “C13-15 Alkane” with a non-medicinal role for topical use only as solvent in natural health products. It is also listed in the Licensed Natural Health Products Database (LNHPD) as being present as such, a non-medicinal ingredient, in licensed topical natural health products (NHPID [modified 2017]; LNHPD [modified 2016].

Distillates (petroleum), hydrotreated light (CAS RN 64742-47-8) is listed in the Natural Health Products Ingredients Database (NHPID) as “C13-14 alkane” with a non-medicinal role for topical use only as solvent in natural health products; however, it is not listed in the Licensed Natural Health Products Database (LNHPD) as being present in currently licensed natural health products in Canada (NHPID [modified 2017]; LNHPD [modified 2016].

Kerosene (petroleum) (CAS RN 8008-20-6) is listed in the Natural Health Products Ingredients Database (NHPID) under the ingredient name “HPUS_Petroleum” as a homeopathic substance only. It is also listed in the Licensed Natural Health Products Database (LNHPD) as being present in homeopathic medicines licensed as natural health products. The minimum homeopathic potency currently allowed in homeopathic medicines licensed as natural health products, based on the Homeopathic

Pharmacopoeia of United States as outlined in the NHPID, is 1X. [modified 2017]; LNHPD [modified 2016].

A number of the substances included in this report were not found to have uses in commercial/industrial or products available to consumers in Canada or the US. This was determined through web, literature, MSDS, and database searches, as well as information obtained through S71 surveys and a voluntary data gathering initiative (Canada 2015a, ECCC2016b). These substances include the following CAS RNs: 64741-60-2, 64742-91-2, 64742-31-0, 68921-07-3, and 128683-26-1.

The following CAS RNs were also found not to have product uses in Canada or the U.S. through web and database searches: 64741-90-8, 64742-13-8, 64742-77-4, 64742-87-6, 128683-27-2, 128683-28-3, 128683-29-4, 128683-30-7, and 129893-10-3. These substances would be restricted to uses within the petroleum industry.

5. Releases to the environment

Gas oils and kerosenes may be released to the environment from activities associated with production, transportation, and storage, as well as a result of commercial, industrial or consumer uses. Fugitive releases of these gas oils from production, transportation and storage were assumed to follow the same pattern as found for industry-restricted gas oils assessed previously (Environment Canada, Health Canada 2013). Details on potential releases of gas oils within petroleum facilities from activities associated with processing these substances can be found in this previous assessment (Environment Canada, Health Canada 2011), and this information is also considered to apply to the processing of gas oils and kerosenes.

5.1 Releases from petroleum refineries

Gas oils and kerosenes originate from distillation columns as a distillate in a refinery or upgrader and may be refined by other processes following distillation. Thus, the potential locations for controlled releases of gas oils and kerosenes include relief, venting, or drain valves on the piping or equipment (e.g., vessels). Under typical operating conditions, releases would be captured in a closed system, according to defined procedures, and returned to the processing facility or to the wastewater treatment system. In both cases, exposure of the general population is not expected.

Unintentional releases of gas oils and kerosenes may occur at production facilities. Existing legislation covers releases of gas oils and kerosenes and includes requirements at the federal, provincial, and territorial levels to prevent or manage the unintentional releases of petroleum substances and streams from facilities (SENES 2009). Non-regulatory measures (e.g., guidelines, best practices) are also in place at petroleum sector facilities to reduce unintentional releases.

5.2 Releases from transportation

In general, three operating procedures are involved in the process of transportation: loading, transit and unloading. Loading and unloading of gas oils and kerosenes is normally conducted at sites with limited access to the general public.

The handling of gas oils and kerosenes at petroleum facilities for the purpose of transportation is regulated at both the federal and provincial levels, with legislation covering loading and unloading. Collectively, this legislation establishes requirements for the safe handling of petroleum substances and is intended to minimize or prevent potential releases during loading, transportation and unloading operations (SENES 2009).

Releases from washing or cleaning transportation vessels are not considered in this screening assessment, as tanks or containers for transferring petroleum substances are typically dedicated vessels and, therefore, washing or cleaning is not required on a routine basis (US EPA 2008).

Spills of gas oils and kerosenes during transportation and storage are considered in section **Error! Reference source not found.**.

5.3 Releases from products available to consumers

Gas oils and kerosenes can be found in many products available to consumers, as noted in Section 4. Generally, the volume of gas oil or kerosene released from products available to consumers is small for each consumer application, and the releases from these uses are expected to be dispersed across Canada. Thus, releases from consumer applications are not considered to be a significant point source of gas oils and kerosenes to the environment.

5.4 Releases from other industrial facilities

Based on the reported use patterns of these gas oils and kerosenes as discussed in Section 4, there is potential for releases to the aquatic environment through wastewater effluents from industrial sources other than petroleum refineries. Releases to the environment from industrial facilities are further discussed in Section 7.2.

5.5 Releases from spills

Gas oils and kerosenes may be spilled to the environment during storage, transport or use. For those gas oils and kerosenes which do not have any identified product use, spills are the only significant potential route for release to the environment.

Spill data for the five-year period 2012 to 2016 from Ontario, Alberta, Saskatchewan (the top five population centres only), and Nunavut, the Yukon and the Northwest Territories, and from British Columbia for the one year period of March 2016 to March

2017, as well as the selected older spills data available on their website (British Columbia 2017), was compiled. Releases of aviation fuels and motor vehicle fuels were excluded. During this period, there were a total of 9 spills of gas oils and kerosenes with a total reported volume of 2956 L. Most of this volume (2600 L) was from one spill at a pulp and paper facility, and it was reported that this spill was contained and was not expected to impact the environment. Given the small number and volume of spills reported from these provinces and territories, spills are not further considered in the context of this assessment.

6. Environmental fate and behaviour

6.1 Environmental distribution

When petroleum substances are released into the environment, the major fate processes include dissolution in water, volatilization, adsorption, biodegradation and photodegradation. These processes will cause changes in the composition of these substances.

As noted previously (Section 3), the solubility and vapour pressure of components within a mixture will be proportional to their concentrations in the mixture and thus lower than their individual water solubilities and vapour pressures.

Biodegradation almost always occurs when petroleum mixtures are released in the environment. Studies have found populations of bacteria and other organisms (e.g., fungi and yeasts) that are capable of degrading petroleum hydrocarbons in both fresh and marine waters and sediments, as well as soils (Atlas 1981). Degradation occurs both in the presence and absence of oxygen. In general, aromatic components tend to be degraded more slowly than aliphatic components, though the degradation of some higher molecular weight cycloalkanes may be very slow (Atlas 1981; Potter and Simmons 1998).

Three weathering processes—dissolution in water, volatilization, and biodegradation—typically result in the depletion of the more readily soluble, volatile, and degradable compounds and the accumulation of those most resistant to these processes in residues.

Gas oils and kerosenes are expected to be liquids at ambient temperatures. They are less dense than water, so if they are released to water, they will float on the water’s surface while dissolution of the more soluble components is on-going.

Due to the complex interaction of components within a mixture that impacts their physical-chemical properties and behaviour, it is difficult to predict the fate of a complex mixture. Therefore, as a general indication of the fate of gas oils and kerosenes, the physical-chemical properties of representative structures of gas oils and kerosenes were examined (Table 2.1, ECCC 2018a).

Components in the carbon range C_9–C_{30} are characterized by low to high water solubilities (8.6×10^{-11} to 95 mg/L), very low to high vapour pressures (3.6×10^{-9} to 339 Pa), low to very high Henry's Law constants (0.03 to 2.1×10^{9} $Pa\cdot m^3/mol$), moderate to very high log K_{ow} values (3.3 to 15), and moderate to very high log K_{oc} values (3.0 to 13) (Table 2.1, ECCC 2018a).

Based on their very low to moderate vapour pressures (1.6×10^{-9} – 13.1 Pa), the majority of aromatic and polycycloalkane components of gas oils and kerosenes are not expected to partition significantly to air, while the majority of alkane and cycloalkane components, as well as C_9 monoaromatics, are likely to partition to air based on their moderate to high vapour pressures (Table 2.1, ECCC 2018a). Only about 30% of diesel fuel (a gas oil with a vapour pressure of 1000 Pa at 20 °C) (MSDS 2017) evaporated after a 2 day period at 15°-20° C with no wind (Fingas 2001, Fingas 1997).

Gas oils and kerosenes are less dense than water (0.80–0.99 g/mL) (Table 3.1), thus upon entering water, the majority of components are expected to rise to the surface and spread out while only those components with higher water solubilities will enter the water column. Based on water solubility, the components less than C_{15} are expected to be the dominant components dissolved in the water column. Based on the moderate to very high log K_{oc} values (3.0 to 13), components of gas oils and kerosenes are expected to sorb to suspended solids and sediments (Table 2.1, ECCC 2018a).

If released to soil, all components of gas oils and kerosenes are expected to have high adsorptivity to soil particles, to the point of being relatively immobile for the largest structures, based on their estimated range of log K_{oc} values (3.0–13; Table 2.1 in ECCC 2018a). However, from studies at contaminated sites, diesel fuel was found to be moderately mobile in soil, being able to move down through soil and along gradients. The speed of the movement is related to the volume of fuel, the type of soil and the gradient. Although no direct releases to soil are anticipated, indirect releases of the components of gas oils and kerosenes may result from the application of biosolids to land from wastewater treatment systems[5].

Gas oils and kerosenes are expected to form light non-aqueous-phase liquids (LNAPLs) in groundwater. Based on an overall low to high solubility in water (8.6×10^{-11} to 95 mg/L), certain components will partition from the LNAPL into the groundwater. Lighter hydrocarbons are mobile and can be a problem at considerable distances from their point of release, due to transport in groundwater (CCME 2008). When large quantities of a hydrocarbon mixture enter the soil compartment, soil organic matter and other sorption sites in soil become fully saturated and the hydrocarbons will begin to form a

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[5] In this assessment, the term "wastewater treatment system" refers to a system that collects domestic, commercial and/or institutional household sewage and possibly industrial wastewater (following discharge to the sewer), typically for treatment and eventual discharge to the environment. Unless otherwise stated, the term wastewater treatment system makes no distinction of ownership or operator type (municipal, provincial, federal, indigenous, private, partnerships). Systems located at industrial operations and specifically designed to treat industrial effluents will be identified by the terms "on-site wastewater treatment systems" and/or "industrial wastewater treatment systems".

separate phase (a non-aqueous phase liquid, or NAPL) in the soil. At concentrations below the retention capacity for the hydrocarbon in the soil, the NAPL will not move as a bulk phase (Arthurs 1995); this is referred to as residual NAPL (Brost 2000). Above the retention capacity, the NAPL becomes mobile and will move as a bulk phase within the soil (Arthurs 1995; Brost 2000).

6.2 Environmental persistence and bioaccumulation

Due to the complex nature of gas oils and kerosenes, their persistence and bioaccumulation potential were assessed based on empirical and/or modelled data for representative petroleum hydrocarbons expected to be similar to those that may be released into the environment. These representative structures do not include all possible components present within gas oils or kerosenes, nor do they necessarily provide a complete picture of the full range of the persistence potential for any given chemical class (e.g., alkanes, one-ring aromatics) or carbon number (e.g., C_{15}). Thus, the modelling results do not indicate the persistence and bioaccumulation potential of all components in a specific class and carbon range but instead give a more general indication of these properties.

In addition, when available, empirical data on the persistence of the whole substance was considered.

6.2.1 Environmental persistence

Ultimate (ready) biodegradation tests were available for four gas oil samples and one straight-run kerosene, as described in API (2012a,b) and API (2010a,b). The ready biodegradation test results ranged from 56 to 64% mineralization within 28 days (the pass criterion is greater than 60% mineralization), which included a high aromatic and a lower aromatic content gas oil (75 wt% and 17 wt% aromatics, respectively), and commercial diesel fuel. However, as gas oils and kerosenes consist of hundreds of individual components, each with different susceptibilities to biodegradation, the results of such degradation studies can only indicate that some components are susceptible to biodegradation, and cannot determine the biodegradation potential of all components.

Under anoxic conditions (e.g., in sediments), rates of biodegradation for gas oils are negligible (API 2012a).

Persistence of a suite of representative petroleum hydrocarbons for gas oils and kerosenes was characterized based on empirical and/or modelled data. Model results and the weighing of information are reported in the technical document on petroleum substance persistence and bioaccumulation (Environment Canada 2014a) and results are summarized in ECCC (2018a).

Empirical and modelled atmospheric half-lives for most representative structures of gas oils and kerosenes are less than 2 days, indicating that most gas oil and kerosene components are unlikely to persist in air (Environment Canada 2014a). However, some three- to six-ring aromatic components, as well as cycloalkane diaromatic components have the potential to remain in the atmosphere for longer periods, allowing for their possible long distance transport to remote regions as a result of sorption to particulate matter in the atmosphere (Environment Canada 2014a).

Based on their chemical structure, components of gas oils and kerosenes are not expected to hydrolyze under environmental conditions (Lyman et al. 1990; Environment Canada 2014a).

On the basis of modelled biodegradation results for representative structures in water, soil, and sediment, the following components of gas oils and kerosenes are expected to have half-lives greater than 6 months in water and soils and greater than 1 year in sediments: C_{15}–C_{30} two-ring cycloalkanes, C_{18} and C_{22} polycycloalkanes, C_9-C_{15} one-ring aromatics, C_9–C_{20} cycloalkane monoaromatics, C_{10}–C_{30} two-ring aromatics, C_{12} cycloalkane diaromatics, C_{14}-C_{30} three-ring aromatics, C_{16} –C_{20} four-ring aromatics, C_{20}–C_{30} five-ring aromatics and C_{22} six-ring aromatics (Environment Canada 2014a). The C_9–C_{12} dicycloalkanes, C_{14}-C_{22} polycycloalkanes, and C_9, C_{11}, and C_{15} one-ring aromatics have half-lives greater than 1 year in sediments, and therefore have high potential to persist in sediment.

6.2.2 Potential for bioaccumulation

Bioaccumulation potential for a suite of representative petroleum hydrocarbons expected to occur in gas oils and kerosenes was characterized based on empirical and/or modelled data. Bioaccumulation factors (BAFs) are the preferred metric for assessing the bioaccumulation potential of substances, as the bioconcentration factor (BCF) may not adequately account for the bioaccumulation potential of substances via the diet, which predominates for substances with log K_{ow} greater than approximately 4.5 (Arnot 2003).

In addition to fish BCF and BAF data, bioaccumulation data for aquatic invertebrate species were also considered. Biota-sediment/soil accumulation factors (BSAFs), trophic magnification factors, and biomagnification factors were also considered in characterizing bioaccumulation potential.

Empirical and modelled bioaccumulation data for petroleum hydrocarbons can be found in Environment Canada (2014a) and are summarized in Table 3.2 of ECCC (2017a).

There is consistent empirical and predicted evidence to suggest that the following components of gas oils and kerosenes have the potential for high bioaccumulation with BAF/BCF values greater than 5000: C_{13}–C_{15} isoalkanes, C_{12} alkenes, C_{12}–C_{15} one-ring cycloalkanes, C_{12} and C_{15} two-ring cycloalkanes, C_{14} and C_{22} polycycloalkanes, C_{15} one-ring aromatics, C_{15}–C_{20} cycloalkane monoaromatics, C_{12}–C_{13} diaromatics, C_{20} cycloalkane diaromatics, C_{14} and C_{20} three-ring aromatics, C_{16}–C_{20} four-ring aromatics, C_{20} five-ring aromatics, and C_{22} six-ring aromatics. These components are highly lipophilic and are associated with a slow rate of metabolism in certain organisms such that the rate of uptake greatly exceeds the total elimination rate. However, most of these components are not expected to biomagnify (relative to their concentration in the diet) in aquatic or terrestrial food webs, largely because the combination of metabolism (albeit slow), growth dilution, and low dietary assimilation efficiency of these components allows the elimination rate to exceed the uptake rate when exposure occurs from the diet only (Environment Canada 2014a). In addition, fish and other vertebrates have a higher capacity to metabolize aromatic components than do invertebrates, which decreases the potential for trophic transfer of these components. However, a study measuring PAHs and alkyl-PAHs in sea otters (Harris et al. 2011) suggests that some higher alkylated- three- and four-ring PAHs may biomagnify. While BSAFs were only found for some PAHs (Environment Canada 2014), it is possible that BSAFs will be greater than one for invertebrates, given that they do not have the same metabolic competency as fish. BSAFs will likely decrease beyond C_{22} due to reduced bioavailability of the higher boiling point fractions (Muijs and Jonker 2010). However, for a given PAH, slight increases in BSAFs for invertebrates were noted with increasing alkylation of the parent PAH, suggesting some degree of bioaccumulation in invertebrates (Harris et al. 2011).

7. Potential to cause ecological harm

7.1 Ecological effects assessment

7.1.1 Aquatic compartment

Due to the low water solubility of gas oils and kerosenes, most of the available toxicity tests were conducted using water accommodated fractions (WAFs). This approach is common in testing with poorly water soluble UVCBs such as petroleum products. WAFs are laboratory-prepared aqueous media derived from low-energy mixing of a poorly soluble test material such as a petroleum product. WAFs are essentially free of particles of bulk material, containing only the fraction that is dissolved or present as a stable dispersion or emulsion (Singer et al. 2001).

Exposure concentrations were not measured in the test solutions and results are reported in terms of the petroleum product loading rate[6] rather than concentrations (e.g., a median lethal loading (LL_{50}) rather than a median lethal concentration (LC_{50})). This approach is common in testing with poorly water soluble UVCBs such as petroleum products.

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[6] A loading rate is the amount of petroleum substance added to the exposure solution to generate a WAF or oil in water dispersion (OWD) and is reported in mg/L. When used to describe an effect endpoint, the loading rate is the amount of petroleum substance added to generate a WAF/OWD that results in the effect reported; e.g., the lethal loading rate 50 (LL_{50}) is the amount of petroleum substance needed to generate a WAF/OWD that is lethal to 50% of the test organisms. A loading rate is not a direct measure of the concentration of the petroleum components dissolved in the exposure solution.

Toxicity tests may also be conducted as water-soluble fractions (WSFs). In WSF studies, the test solutions are expressed in terms of the percent dilution of a WSF. Use of WSFs is not broadly supported because this method does not allow the ecotoxicity of the test substance to be expressed in terms of the amount of that test substance required to produce a particular effect (OECD 2000). Such results are not comparable to results obtained under WAF preparation methods (API 2012).

Acute aquatic toxicity data (expressed as lethal loading/effective loading rates, LL/EL50 values) for gas oils and kerosenes is reviewed in API (2012a,b, 2010a,b) and are summarized in Table 7-1. The evaluation of the acute toxicity of the kerosenes category by API (2010a,b) included data on kerosene, sweetened (CAS RN 91770-15-9), solvent naphtha, hydrocracked heavy aromatic (CAS RN 101316-80-7), and hydrodesulfurized kerosene (CAS RN 64742-81-0). Because of the large variability in the toxicity data for each species with gas oils, it is difficult to compare their toxicity to that of kerosenes.

Table 7-1. Summary of acute toxicity of gas oils and kerosenes (API 2012a, 2010a,b)

Species	Gas oils LL50/EL50 (mg/L)	Gas oils: No. of CAS RNs, species[a]	Kerosenes LL50/EL50 (mg/L)	Kerosenes: No. of CAS RNs, species[a]
Fish	3.2 - 65	4, 6	18 - 25	3, 1
Aquatic invertebrates	0.51 - 210	5, 3	1.4 - 21	3, 1
Aquatic plants	0.28 - 25	4, 2	5.0 - 11	2, 1

[a] No. of CAS RNs for either gas oils or kerosenes that were tested. Species refers to species of fish, aquatic invertebrates or aquatic plants that were tested.

Abbreviations: EL_{50}, loading rate of test substance resulting in a specified effect (e.g. immobilization, growth) in 50% of the test species exposed to the WAF; LL_{50}, median lethal loading rate, loading rate of the test substance that results in 50% mortality in a population of test organisms exposed to the WAF; WAF, water-accommodated fraction, aqueous medium containing only the fraction of the petroleum substance that is dissolved or present as a stable dispersion or emulsion.

The available chronic toxicity data for gas oils and kerosenes includes two fish studies, one with a gas oil and one with a kerosene, and three daphnia studies with two gas oils and a kerosene. In the chronic gas oil study of Fuel Oil No. 2 with rainbow trout (*Oncorhynchus mykiss*) (API 2012a), reduced survival and growth rate were seen at the highest loading rate WAF used in the test (3.0 mg/L), and the 28-day LL50 for survival was 2.7 mg/L. *O. mykiss*) and flagfish (*Jordanella floridae*) were exposed to WSFs of JP-8 jet fuel (kerosene); the 128 day no observed effect concentrations (NOECs) were greater than 1.4-1.5 mg/L (Klein and Jenkins 1983). Chronic toxicity data were available for *Daphnia magna* exposed to a light hydro-cracked gas oil (HCGO) (CAS RN 64741-77-1) and a light catalytic-cracked gas oil (CCGO) (64741-59-9) with aromatic contents of 17 and 75%, respectively, and a hydro-desulfurized kerosene (HDK) (CAS RN 64742-81-0) with aromatic content of 17% (Swigert et al. 2014, Table 7.2). SwigertWater-accommodated fractions (WAFs) were used as exposure solutions and results reported as both loading rates and measured concentrations of total dissolved hydrocarbons. Acute toxicity tests with were also conducted with these two gas oils with green algae (*Pseudokirchnerella subcapitata*), daphnia (*Daphnia magna*), and rainbow trout (*O. mykiss*). These studies are summarized in Table 7.2. The 21 day daphnia EL20 values with hydrodesulfurized kerosene and with catalytic cracked gas oil were 0.41 mg/L and 0.12 mg/L, respectively. The no-observable-effect loading rate (NOELR) with hydrocracked gas oil was 0.64 mg/L, which was the highest loading rate tested.

Table 7-2 Acute and chronic aquatic toxicity of two gas oils and a kerosene (Swigert et al. 2014)

Test Organism	**CAS RN**	**Duration**	**Endpoint**	**Value (mg/L)[a]**
Oncorhynchus mykiss (rainbow trout)	64741-77-1 (HCGO)	96 h	LL_{50} LC_{50}	>2.6 >0.54
Oncorhynchus mykiss (rainbow trout)	64741-59-9 (CCGO)	96 h	LL_{50} LC_{50}	>0.30 >0.21
Daphnia magna (water flea)	64741-77-1 (HCGO)	48-hr	EL_{50} EC_{50} (immobilization)	5.5 1.0
Daphnia magna (water flea)	64741-59-9 (CCGO)	48-hr	EL_{50} EC_{50} (immobilization)	0.51 0.45
P. subcapitata (algae)	64741-77-1 (HCGO)	96-h	EL_{50} (cell density/growth rate) EC_{50} (cell density, growth rate)	3.0, 5.3 0.51, 0.85
P. subcapitata (algae)	64741-59-9 (CCGO)	96-h	EL_{50} EC_{50}	0.31, 0.80 0.25, 0.70
Daphnia magna (water flea)	64741-77-1 (HCGO)	21-day	EL_{20}, EL_{50} EC20, EC_{50} NOELR LOELR NOEC LOEC	Not calculable Not calculable 0.64 >0.64 0.13 >0.13
Daphnia magna (water flea)	64742-81-0 (HDK)	21 d	$EL_{20(survival)}$ EC_{20} (survival)	0.41 (not calc.) 0.08 (not calc.)
Daphnia magna (water flea)	64741-59-9 (CCGO)	21 d	EL_{20} (reprod.) LC_{20} (reprod.)	0.12 (0.08-0.16) 0.09 (0.06-0.12)

[a] Bracketed values refer to the 95% confidence interval.

Abbreviations: HCGO – hydrocracked gas oil; CCGO – catalytic cracked gas oil; HDK – hydrodesulfurized kerosene; EL_X, median effect loading rate, loading rate of the test substance that results in a specified effect in x% of the test organisms exposed to the water accommodated fraction (WAF); LL_{50}, median lethal loading rate, loading rate of the test substance that results in 50% mortality in a population of test organisms exposed to the WAF; NOELR, no observed effect loading rate; LOELR, lowest observed effect loading rate; LOEC, lowest observed effect concentration.

Some chronic mesocosm tests with Fuel Oil No. 2 (a gas oil) were conducted that showed significant effects on the community structure and density of the benthic, meiobenthic and inbenthic invertebrate organisms, as well as the phytoplankton community at levels of 61-190 µg/L (Stacey and Marcotte 1987; Grassle et al. 1981; Vargo et al. 1982; Bott and Rogenmuser 1978). These studies are more fully described in Environment Canada and Health Canada (2015a).

CONCAWE has developed an aquatic toxicity model specifically for petroleum hydrocarbon mixtures, called PETROTOX (2012). This model is based on chemical action via non-polar narcosis for acute toxicity, the primary mode of action for all petroleum hydrocarbons (CONCAWE 1996), and accounts for additive effects within the petroleum mixture by using a toxic unit approach. PETROTOX estimates petroleum hydrocarbon toxicity for substances in the C_4–C_{41} range that are dissolved in the water fraction.[7] Substances smaller than C_4 are considered too volatile to impart significant toxicity, while those larger than C_{41} are considered too hydrophobic and immobile to impart significant aquatic toxicity. The model can also estimate a chronic NOELR by utilizing an average acute-to-chronic ratio (ACR). PETROTOX v.3.06 uses an ACR of 3.83; however, more recent analysis has adjusted the average ACR to 5.22 (McGrath et al. 2018). Therefore, the ACR in PETROTOX v.3.06 was manually adjusted to 5.22 when calculating chronic values. The model generates toxicity estimates in terms of loading rates rather than concentrations (e.g., a median lethal loading (LL_{50}) rather than a median lethal concentration (LC_{50}), thereby accounting for the poor solubility of petroleum substances in water.

Redman et al. (2012) reported measured acute LL_{50}s or EC_{50}s of petroleum products including gas oils and kerosenes from other studies, for the green algae *P. subcapitata*, *Daphnia magna*, and rainbow trout (*O. mykiss).* Redman et al. (2012) also used the PETROTOX model to generate predicted toxicity values from these empirical studies, where sufficient analytical data were available. The measured and associated predicted values are summarized in Table 4-2 in ECCC (2018b). The PETROTOX predictions based on data from the empirical studies were in general lower than the measured values from the same studies indicating that the PETROTOX estimates are slightly protective.

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[7] PETROTOX uses its own library of petroleum hydrocarbons and their associated physical and chemical properties. These properties may differ from those given for the same representative structures in ECCC (2017a).

PETROTOX was used to compare the acute aquatic toxicities of gas oils and kerosenes with high and low aromatic contents (80% and 20% aromatics respectively) for a variety of species, including fish, invertebrates and algae. For gas oils, a boiling point range of 150-450 °C was used, and for kerosenes, a boiling point range of 150-290 °C was used. The acute toxicities of gas oils with high aromatics content and kerosenes with high aromatics content are similar, and gas oils with low aromatics content and kerosenes with low aromatics content are similar, for most species (Table 4.3 in ECCC2018a).

The acute toxicity values for gas oils and kerosenes generated for *D. magna, P. subcapitata* and *O. mykiss* with PETROTOX (Table 4.4 in ECCC 2018a) are mainly similar to the empirical acute values described by Swigert et al. (2014) (LL50s of 0.31-5.5 mg/L), with the exception of the estimated value of 25 mg/L for daphnia for low aromatic gas oil (Table 4.4 in ECCC 2018a), which is an order of magnitude higher than the empirical value of 5.5 mg/L for a 17% aromatic light hydrocracked gas oil. The chronic EL50 values for daphnia described in Swigert et al. (2014) (0.41 mg/L for a low aromatic kerosene and 0.12 mg/L for high aromatic gas oil; Table 4.1 in ECCC 2018a) are also within one order of magnitude of the PETROTOX modelled chronic values for *D. magna* (0.12 mg/L and 0.018 mg/L for low and high aromatic; Table 4.5 in ECCC 2018a). Therefore, the modelled data from PETROTOX are conservative (protective of the environment), and support the experimental toxicity values.

PETROTOX modelling was also used to estimate the acute and chronic toxicities of the post wastewater treatment compositions of high- and low-aromatic content gas oils and kerosenes (Tables 4.4 and 4.5 in ECCC 2018a). The major sources of release of gas oils and kerosenes to the aquatic environment occur through wastewater treatment plants (Section 7.2). As gas oils and kerosenes consist of hundreds of individual components, each with its own physical and chemical properties that impact its removal during wastewater treatment, such treatment will result in the differential removal of components of gas oils and kerosenes. Thus, the relative proportion of individual components in the gas oil or kerosene released following wastewater treatment is different from that of the gas oil or kerosene that originally entered the treatment system. In order to determine the toxicity of the modified gas oils and kerosenes released in effluent following wastewater treatment, the removal of hydrocarbons during wastewater treatment and thus, the composition of the post-wastewater treatment gas oils and kerosenes were estimated. The estimation of the removal of hydrocarbons uses the library of hydrocarbon representative structures, their physical-chemical properties, and the mapping scheme of hydrocarbons to certain hydrocarbon blocks found in PETROTOX v3.06 (2012). The percent removal of hydrocarbon blocks during wastewater treatment is estimated based on the removal of individual hydrocarbon representative structures using a wastewater treatment model (SimpleTreat version 3.1 (SimpleTreat 2003)). This model estimates removal of substances via sorption, volatilization and degradation but does not provide information on degradation products. From this, the new relative proportion of components in the gas oil or kerosene following wastewater treatment was estimated based on the hydrocarbon blocks, and PETROTOX was used to estimate the acute toxicities and the chronic NOELR for seven aquatic species utilizing the post-wastewater treatment composition of the released gas oil or kerosene. PETROTOX was run using the low-resolution mode and two blocks; one C9 to C19 and one greater than C19 to C30. The lowest chronic no observed effects loading rate (NOELR) for the most sensitive species was used as the critical toxicity value (CTV).

Toxicity increased slightly for most species following wastewater treatment (Table 7-3) as the composition of the first hydrocarbon block (C_9-C_{19}) shifted to a higher proportion of aromatics, though the overall mass of gas oils and kerosenes in the post-treatment effluent decreased by about 88% for the high aromatic scenario and by about 91% for the low aromatic scenario. The aromatic content of the second hydrocarbon block (greater than C_{19}-C_{30}) post-treatment stayed similar to its pre-treatment in the 20% aromatic content scenario, with a small decrease (5%) in the aromatics content in the 80% aromatic content scenario (ECCC 2018b).

Table 7-3 PETROTOX modelled chronic aquatic toxicity (NOELR (mg/L) of high-aromatic and low-aromatic gas oils and kerosenes before and after wastewater treatment

Test organism	Common name	High arom. 80:20 Ar:Al	Post-WWTS High arom.	Low arom. 20:80 Ar:Al	Post-WWTS Low arom
Oncorhynchus mykiss	Rainbow trout	0.0094	0.0092	0.053	0.037
Pimephales promelas	Fathead minnow	0.020	0.019	0.14	0.088
Daphnia magna	Daphnid	0.018	0.018	0.12	0.080
Pseudokirchneriella subcapitata	Green algae	0.026	0.025	0.13	0.090
Palaemonetes pugio	Grass shrimp	0.0080	0.0078	0.043	0.030
Rhepoxynius abronius	Marine amphipod	0.0041	0.0040	0.020	0.014
Menidia beryllina	Inland silverside	0.063	0.060	0.92	0.45

Abbreviations: NOELR - no observed effect loading rate; Ar:Al, aromatic : aliphatic ratio; WWTS – wastewater treatment system

PETROTOX was also used in high-resolution mode with compositional data available for hydrodesulfurized kerosene (HDK) (17-23% aromatics) and light catalytic cracked gas oil (CCGO) (75-84% aromatics) (API 2012c, 2013) to model the chronic toxicities of these substances before and after wastewater treatment. The chronic NOELRs generated for HDK (low aromatic kerosene) in high resolution mode were found to be very similar to those generated in low-resolution mode for a gas oil with 20% aromatics (Table 7-4). The low-resolution chronic NOELRs for a gas oil with 80% aromatics (Table 7-3) were lower, but within an order of magnitude of the NOELRs generated for high aromatic gas oil (CCGO).

Table 7-4 PETROTOX high resolution modelled chronic aquatic toxicity (NOELR in mg/L) of a high aromatic gas oil[a] and a low aromatic kerosene[b] before and after wastewater treatment

Test organism	Common name	High arom. GO	Post-WWTS High arom GO	Low arom. kerosene	Post-WWTS Low arom keros
Oncorhynchus mykiss	Rainbow trout	0.030	0.038	0.056	0.061
Pimephales promelas	Fathead minnow	0.058	0.070	0.11	0.12
Daphnia magna	Daphnid	0.054	0.066	0.11	0.12
Pseudokirchneriella subcapitata	Green algae	0.037	0.038	0.11	0.10
Palaemonetes pugio	Grass shrimp	0.026	0.033	0.048	0.052
Rhepoxynius abronius	Marine amphipod	0.014	0.018	0.025	0.027
Menidia beryllina	Inland silverside	0.15	0.17	0.40	0.43

Abbreviations: GO – gas oil; K – kerosene; [b] NOELR no observed effect loading rate
WWTS – wastewater treatment system

[a] compositional data for light catalytic cracked gas oil, CAS RN 64741-59-9 (API 2012)
[b] compositional data for hydrodesulfurized kerosene, CAS RN 64742-81-0 (API 2013)

As gas oils and kerosenes can have differing aromatic contents, which affect their toxicity, both high and low aromatic content gas oils and kerosenes were considered for the purpose of CTV derivation. A range of 20% to 80% aromatics was chosen to represent the typical range of aromatics found in gas oils and kerosenes (Section 2). As these substances will persist in water long enough to cause chronic toxicity (Section 6), chronic aquatic toxicity values were considered to be most relevant for CTV derivation. Petroleum hydrocarbons, such as gas oils and kerosenes, are expected to have similar toxicities to both freshwater and marine species, as they are non-polar narcotics, and therefore will not be affected by the dissolved salts present in greater quantities in the seawater. Therefore, aquatic toxicity data for both freshwater and marine species were considered for the choice of the aquatic CTV.

The CTVs for modelled chronic toxicity with the most sensitive species (*Rhepoxynius abronius*) with the modelled post-wastewater treatment composition gas oils and kerosenes were 0.004 mg/L *for* gas oils and kerosenes with high (80%) aromatic content, and 0.014 mg/L with low aromatic content (Table 7-3). These values for R. abronius are within one order of magnitude of most of the chronic toxicity values obtained for the six other aquatic species modelled (Table 4.5 in ECCC 2018a). These values were modelled in low-resolution mode, as these low-resolution values were found to be similar or slighter lower than those modelled in high-resolution mode with the compositional data available for one gas oil and one kerosene. As these are chronic NOELRs for the most sensitive species, no assessment factor was added to convert the CTVs to predicted no-effect concentration (PNECs), so the PNECs are the same as the CTVs.

7.1.2 Sediment compartment

Only one sediment toxicity study for gas oils or kerosenes was found: marine sediments contaminated as a result of Jet Fuel JP-5 (a kerosene) spillage were reported to contain residues that were still lethal to juvenile clams for more than 5 years afterwards (Dow 1978).

The toxicity of gas oils and kerosenes to invertebrates, including several species of sediment-dwelling aquatic worms has been reviewed in CONCAWE (1995, 1996) and summarized in Table 4.7 of ECCC (2018a). However, exposure of the worms was through water, and not through sediment. One study that included two species of polychaete worms was available for no. 2 fuel oil (a gas oil). For kerosenes, three studies were available that included four species of aquatic worms. Acute effects of No. 2 fuel oil as well as kerosenes to aquatic worms were mostly in the range of 1 to 3 mg/L, with the exception of one of the kerosene studies with mortality of 1-8% observed at greater than 2000 mg/L. Empirical acute toxicity data for daphnia from Swigert et al. (2014) (Table 4.1, ECCC 2018a) is within the same range or lower than these values for aquatic worms (ECCC 2018a), and PETROTOX modelled low aromatic acute values for daphnia and other aquatic invertebrates are similar (0.23-25 mg/L) (Table 4.4, ECCC 2018a). The PETROTOX modelled acute invertebrate values for high aromatic gas oils and kerosenes are one to two orders of magnitude lower (0.028-0.22 mg/L) (Table 4.4, ECCC 2018a).

Three toxicity studies on synthetic oil-based drilling mud fluids towards various sediment organisms were found, as summarized in ECCC (2018a). The synthetic drilling mud fluids tested contained high concentrations of *n*-alkanes and/or isoalkanes, with carbon numbers in the C_9-C_{32} range. These studies indicate these low aromatic content substances have low toxicity to sediment organisms.

7.1.3 Terrestrial compartment

Diesel fuel (a gas oil) has been found to be toxic to plants and soil invertebrates at levels of 10 000 mg/kg wet wt. (Shin 2005) to 50 000 mg/kg (Adam 1999), though the effects may be species-specific (Adam 1999). Application of 0.74-2.3 L/m^2 of gas oils and kerosenes were found to have effects on grain yield, seed germination and plant growth (Warner et al. 1984, Wang and Bartha 1990). Terrestrial toxicity data is summarized in ECCC (2018a).

The Canada-wide Standards for Petroleum Hydrocarbons (CCME 2008a) provide soil standards for petroleum substances based on toxicity to a variety of terrestrial organisms (invertebrates, plants). These standards are based on four fractions of total petroleum hydrocarbons (TPH): F1 (C_6–C_{10}), F2 (greater than C_{10} to C_{16}), F3 (greater than C_{16} to C_{34}) and F4 (greater than C_{34}) and assume an 80:20 ratio of aliphatics to aromatics. Fractions 2 and 3 encompass the carbon range of gas oils and kerosenes. The standards are also divided into four land-use classes (agricultural, residential, commercial, industrial) and two soil types (coarse grained and fine grained soils) for the determination of remedial standards. The most sensitive land-use and soil type is typically agricultural coarse-grained soils. The standards for F2 and F3 in agricultural coarse-grained soils are 150 and 300 mg/kg dry weight (dry wt.) of soil, respectively (CCME 2008). As gas oils could fall into both of these categories, the lower value, 150 mg/kg dry wt. of soil for F2, is the CTV for terrestrial exposure. This same value is used for kerosenes, as they most resemble F2. As these Canada-Wide Standards were developed to protect key ecological receptors in the soil (CCME 2008), and were chosen for the most protective scenario (i.e., coarse-grained agricultural soils), no assessment factor was applied to convert the CTV to the PNEC.

7.2 Ecological exposure assessment

The sectors with the greatest potential for releases of gas oils and kerosenes to the environment are considered to be (ECCC 2018b):

- formulation of lubricants or lubricant additives;
- formulation of various products including oil-water separation aids, printing inks, adhesives and sealants, processing aids, products available to consumers, and paints and coatings;
- the industrial application of certain formulated products including printing inks, adhesives and sealants, and paints and coatings;
- the use of processing aids by paper mills;
- the use of processing aids by facilities in other sectors, including plastics and rubber, fabricated metal, machinery, and transportation equipment; and
- the application of biosolids to agricultural soils.

These sectors are therefore considered in the exposure scenarios, which are summarized here. A more detailed description of the exposure assessment scenarios for the above industrial sectors, including the assumptions and calculation methods used is available in a supporting document (ECCC 2018b).

7.2.1 Estimation of removal of petroleum components during wastewater treatment

The release of gas oils and kerosenes from industrial facilities generally results in a discharge to systems that treat wastewater prior to release to the aquatic environment. The composition of the gas oils or kerosenes remaining following wastewater treatment will differ from its original composition.

A method, described in section 7.1.1, was developed to estimate the removal of petroleum hydrocarbons during wastewater treatment such that the post-wastewater treatment composition and concentration in effluent could be determined. The estimated concentration in effluent was used to estimate the predicted exposure concentration

(PEC) of gas oils or kerosenes in the receiving water. The estimated wastewater removal rate of 90% for gas oils and kerosenes is supported by measured removal rate data for oil and grease from Canadian wastewater treatment systems (WWTS), as further described in ECCC (2018b).

7.2.2 Formulation of lubricants or lubricant additives

The formulation facilities identified for lubricants or lubricant additives are mainly indirect dischargers (discharging their wastewater to sewers). A conservative PEC was estimated based on the largest facility in Canada, with the highest annual lubricant formulation capacity, which is under 1 000 000 tonne/yr (Environment Canada 2012). The quantity of gas oil and kerosene potentially released from this facility to water was estimated, based on the maximum estimate for wastewater discharge flow, a typical limit for the release of oil and grease to municipal sewers in Ontario (15 mg/L as in the case of Toronto (2014)), which is the primary province involved in lubricant formulation (ECCC 2018b), as well as the estimated average removal rate of 90% of gas oils and kerosenes during wastewater treatment (ECCC 2018b).The maximum aquatic PEC of gas oils and kerosenes for the formulation of lubricants or lubricant additives was thus estimated as 3.3 μg/L.

7.2.3 Generic product formulation and industrial usage scenario

A generic indirect discharge scenario was used to provide an estimate for exposure resulting from two types of activities: (1) the formulation and/or (2) the industrial application of various products including oil-water separation aids, printing inks, adhesives and sealants, processing aids, products available to consumers, and paints and coatings. The facilities involved with these activities are determined to be indirect dischargers who discharge their treated or untreated wastewater to wastewater treatment systems (WWTSs[8]) for final treatment before being released to the aquatic environment. This scenario is based on the facility with the highest use quantity of gas oils and is expected to represent the largest potential release of all the facilities involved. This facility's highest use quantity is in the range of 1 000 000 to 10 000 000 kg/yr (Environment Canada 2012) and the logarithmic average of this range, 3 162 000 kg/yr, is used.

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[8] In this assessment, the term "wastewater treatment system" refers to a system that collects domestic, commercial and/or institutional household sewage and possibly industrial wastewater (following discharge to the sewer), typically for treatment and eventual discharge to the environment. Unless otherwise stated, the term wastewater treatment system makes no distinction of ownership or operator type (municipal, provincial, federal, indigenous, private, partnerships). Systems located at industrial operations and specifically designed to treat industrial effluents will be identified by the terms "on-site wastewater treatment systems" and/or "industrial wastewater treatment systems".

The annual use quantity of gas oils and kerosenes was estimated by prorating for the number (27) of CAS RNs of gas oils and kerosenes reported to be in commerce in Canadian (ECCC 2016a,b) based on use quantity data available for 7 gas oil CAS RNs (EC 2012):

> Annual use quantity of gas oils and kerosenes =
>
> Annual use quantity of 7 gas oils x Number of CAS RNs of gas oils and kerosenes in commerce/Number of gas oil CAS RNs with reported use quantities=
>
> 3 162 000 kg/yr x 27/7 = 12 200 000 kg/yr

The daily quantity of gas oils and kerosenes released to sewer was estimated based on an emission factor of 0.3% (ECB 2003). As a conservative assumption, it was assumed there was no on-site WWTS at these facilities. The wastewater treatment removal rate was estimated as 90%, as previously discussed.

The maximum concentration of gas oils and kerosenes in receiving water was estimated by dividing the daily quantity released to receiving water from the WWTS by the corresponding daily dilution water volume (i.e., daily wastewater flow rate x receiving water dilution near discharge point) (ECCC 2018b). The aquatic PEC for the indirect discharge scenario was thus estimated to be 3.5 µg/L.

7.2.4 Use of processing aids by paper mills

This exposure scenario is based on the release of the processing aids used in papermaking operations and does not account for the contributions from printing inks in case of deinking and other processing aids used in operations other than papermaking. The estimated PECs vary from mill to mill due to large differences in wastewater flow rate and are therefore presented as a distribution, while other parameters were determined to be constant. In particular, the annual quantity of gas oils and kerosenes used in papermaking operations differed between mills according to the survey data (Environment Canada 2012), but no clear relationship could be derived for this quantity with a mill’s production capacity or wastewater flow rate. As a result, an average use quantity of 10 000 kg/yr of gas oils and kerosenes at a paper mill was estimated from the survey data (Environment Canada 2012).

In Canada, there are about 60 paper mills which are involved in the manufacture of newsprint, printing/writing paper, tissue, towel and paperboard (ECCC 2018b). The majority of Canadian paper mills are equipped with on-site, secondary wastewater treatment systems and the treated wastewater is discharged directly to receiving water (Environment Canada 2014b). A few mills discharge to off-site wastewater treatment systems and have limited on-site treatment. An average wastewater treatment removal rate of 90% for gas oils and kerosenes was used for off-site and on-site (if applicable) treatment combined.

A distribution of PECs, reflecting differences in wastewater flow rates, was determined (Table 7-5). Further details on the exposure scenario are available in ECCC (2018b).

Table 7-5. Distribution of estimated PECs for paper mills in Canada

Percent of mills (%)	Wastewater flow (million L/d)	Aquatic PEC (μg/L)
Minimum	2238	0.13
10	199	1.5
20	90.8	3.2
30	65.4	4.4
40	39.9	7.3
50	33.3	8.7
60	22.2	13
70	15.2	19
80	7.4	39
90	4.2	69
100	1.1	264

Incomplete information was available on the aromatic contents of the gas oils and kerosenes used in the paper sector; thus the exposure estimate is based on gas oils and kerosenes with aromatic contents ranging from 20 wt% to 80 wt%.

7.2.5 Use of processing aids by facilities other than paper mills

Gas oils and kerosenes are present in processing aids used by various types of industrial facilities other than paper mills (Environment Canada 2012, ECCC 2016b,c). They can be grouped under the following four sectors: plastics and rubber, fabricated metal, machinery, and transportation equipment. The annual quantity of gas oils estimated to be used is between 100 and 10 000 kg/yr at a facility.

To determine the extent of potential exposure from the use of processing aids by non-paper facilities, the maximum daily quantity of gas oils and kerosenes released from an industrial facility to sewer was estimated. The maximum concentration of gas oils and kerosenes in wastewater discharged to sewer was based on a typical limit for the release of oil and grease to municipal sewers in Ontario (15 mg/L as in the case of Toronto (2014), where 70% of these facilities are located, as well as the daily wastewater volume discharged from a facility (ECCC 2018b). A distribution of PECs, reflecting differences in wastewater flow rate and dilution, was determined (Table 7-6).

Table 7-6. Aquatic PEC Distribution of gas oils and kerosenes for use of processing aids by non-paper facilities

Percent of facilities (%)	Daily dilution water vol. (million L/day)[a]	Aquatic PEC (μg/L)
Minimum	4556	0.007
10	2180	0.01
20	1423	0.02

Percent of facilities (%)	Daily dilution water vol. (million L/day)[a]	Aquatic PEC (μg/L)
30	1095	0.03
40	954	0.03
50	484	0.06
60	239	0.1
70	190	0.2
80	106	0.3
90	13.5	2.2
95	7.8	3.8
100	4.8	6.3

[a] The daily dilution water volume is calculated by multiplying the effluent flow of the wastewater treatment system by the dilution factor of the receiving water near the discharge point.

7.2.6 Agricultural soil exposure from biosolids application

Biosolids produced during wastewater treatment may be applied to agricultural fields as a soil amendment. The amount of gas oils and kerosenes accumulated within the top 20 cm layer of soil over 10 consecutive years of biosolids application was estimated, based on the maximum quantity (12.2 kg/d) released to sewer from the largest product formulator or industrial user, and assuming no losses over time from the biosolids via degradation, volatilization, leaching or run-off (ECCC 2018b). Based on these very conservative assumptions, the soil PEC is estimated to be 103 mg/kg dry wt.

7.3 Characterization of ecological risk

The approach taken in this ecological screening assessment was to examine readily available information and develop proposed conclusions using a weight-of-evidence approach and using precaution. Information was gathered to determine the potential for gas oils and kerosenes to cause harm in the Canadian environment. Lines of evidence considered, including those evaluated in this assessment, support the characterization of ecological risk in the Canadian environment. Secondary or indirect lines of evidence were considered when available, including regulatory decisions and classification of hazard or fate characteristics made by other regulatory agencies.

7.3.1 Risk quotient analysis

Risk quotient analyses were performed by comparing estimates of exposure (PECs; see section 7.2) with ecological toxicity information (PNECs; see section 7.1) to determine whether there is potential for ecological harm in Canada. Risk quotients (RQs) were calculated by dividing the PEC by the PNEC for relevant environmental compartments and associated exposure scenarios (Tables 7-7 and 7-8).

Table 7-7. Summary of risk quotients obtained for exposure scenarios with gas oils and kerosenes with low and high aromatic content

Exposure scenario (compartment)	**PEC or PEC range** (µg/L)	**PNEC (high aromatic content)** (µg/L)	**PNEC (low aromatic content)** (µg/L)	**RQ or RQ range**	**Percentage of locations with RQ greater than 1**
Formulation of lubricants & additives (water)	3.3	4	NA	0.8	0
Generic indirect discharge (water)	3.5	4	NA	0.9	0
Use of processing aids, paper mills (water)	0.13-264	4	14	0.01-66	> 70 (if high aromatic content) > 30 (if low aromatic content)
Use of processing aids, other industrial sectors (water)	0.007-6.3	4	14	0.0005-1.6	<5 (if high aromatic content) 0 (if low aromatic content)
Biosolids application (soil)	103 mg/kg dw	150 mg/kg[a] dw	150 mg/kg[a] dw	0.7	0

Abbreviations: NA—not applicable; the PNEC was not determined for low aromatic gas oils and kerosenes as the RQ was less than one for the high aromatic scenario

[a] Based on Canada-wide Standard for petroleum hydrocarbons greater than C_{10} to C_{16}

Table 7-8. Risk quotient values from use of gas oils and kerosenes as processing aids at paper mills (20% and 80% aromatic scenarios) and other facilities (80% aromatic scenario)[a]

Percent of facilities (%)	**RQ from use of processing aids by paper mills, (20% aromatic)**	**RQ from use of processing aids by paper mills, (80% aromatic)**	**RQ from use of processing aids by facilities other than paper mills (80% aromatic)**
Minimum	0.01	0.03	0.0018
10	0.11	0.38	0.0025
20	0.23	0.80	0.0050

Percent of facilities (%)	**RQ from use of processing aids by paper mills, (20% aromatic)**	**RQ from use of processing aids by paper mills, (80% aromatic)**	**RQ from use of processing aids by facilities other than paper mills (80% aromatic)**
30	0.31	**1.10**	0.0075
40	0.52	**1.83**	0.0075
50	0.62	**2.18**	0.0150
60	0.93	**3.25**	0.0250
70	**1.4**	**4.75**	0.0500
80	**2.8**	**9.75**	0.0750
90	**4.9**	**17.25**	0.5500
95	**-**	**-**	0.9500
100	**18.7**	**66.00**	**1.5750**

[a] RQ values greater than 1 are in bold font

7.3.2 Consideration of the lines of evidence

To characterize the ecological risk of gas oils and kerosenes, technical information for various lines of evidence was considered (as discussed in the relevant sections of this report) and qualitatively weighted. The key lines of evidence supporting the assessment conclusion are presented in Table 7.6, with an overall discussion of the weight of evidence provided below. The level of confidence refers to the combined influence of data quality and variability, data gaps, causality, plausibility and any extrapolation required within the line of evidence. The relevance refers to the impact the line of evidence has when determining the potential to cause harm in the Canadian environment. Qualifiers used in the analysis ranged from low to high, with the assigned weight having five possible outcomes.

Table 7-9. Weighted lines of key evidence considered to determine the potential for gas oils and kerosenes to cause harm in the Canadian environment

Line of evidence	**Level of confidence[a]**	**Relevance in assessment[b]**	**Weight assigned[c]**
Persistence in the environment of components of gas oils and kerosenes in water, soil and sediment	high	moderate	moderate to high
Bioaccumulation of components of gas oils and kerosenes in pelagic and mammalian aquatic organisms	high	moderate	moderate to high
PNEC for pelagic aquatic organisms (high aromatic content scenario)	moderate to high	high	moderate to high

Line of evidence	Level of confidence[a]	Relevance in assessment[b]	Weight assigned[c]
PNEC for pelagic aquatic organisms (low aromatic content scenario)	moderate to high	high	moderate to high
PEC (aquatic) for processing aids used by paper mills	moderate	high	moderate
PEC (aquatic) for processing aids used by other facilities	moderate	high	moderate
RQ(s) (aquatic) for processing aids used by paper mills	moderate	high	moderate
RQ(s) (aquatic) for processing aids used by other facilities	moderate	high	moderate

[a] Level of confidence is determined according to data quality, data variability, data gaps and if the data are fit for purpose.

[b] Relevance refers to the impact of the evidence in the assessment.

[c] Weight is assigned to each line of evidence according to the combined level of confidence and relevance in the assessment.

Weight of evidence for determining potential to cause harm to the Canadian environment

Gas oils and kerosenes contain components (e.g., PAHs), that may persist in air and undergo long-range transport to remote regions. They also contain some components that might persist in soil, water and/or sediment, thus increasing the duration of exposure to organisms. The gas oils assessed in this report are also expected to contain components that are highly bioaccumulative, such as PAHs and alkyl-PAHs. Studies suggest that parent PAHs will not likely biomagnify in food webs; however, there is some evidence that alkylated PAHs might. Also, PAHs and alkyl-PAHs may bioaccumulate in aquatic invertebrates, as they lack the capacity to efficiently metabolize aromatic compounds.

The PNECs for aquatic organisms were modelled with PETROTOX based on the estimated post-wastewater treatment compositions of the gas oils and kerosenes. The PETROTOX chronic modelled data without wastewater treatment are consistent with the limited empirical ecotoxicity data on gas oils and kerosenes, giving confidence in the modelled values. The modelled and empirical chronic NOELRs for low and high aromatic gas oils and kerosenes are mainly less than 0.1 mg/L, indicating that gas oils and kerosenes have high chronic toxicity to aquatic organisms. These substances will persist in water long enough to cause chronic toxicity, and they are released on a continuous basis from industry. The range of wastewater discharge rates and the average wastewater treatment removal rate of 90% for gas oils and kerosenes, are considered to be reliable, as the wastewater discharge rates are consistent measured Canadian averages, and the modeled removal rate is supported by monitoring data and is consistent with the physical-chemical properties of the gas oils and kerosenes (e.g., high log K_{ow} and K_{oc} values of many representative structures). The main unknown for these scenarios is the aromatic contents of the gas oils and kerosenes, and for this reason, both low and high aromatic content scenarios were considered.

The RQs for the use of processing aids by paper mill facilities scenarios indicate that, for both the low and high aromatics content scenarios, 30% and 70% of the facilities, respectively, have RQs >1 (Table 7-8). This indicates there may be a risk of harm to aquatic organisms due to the use of gas oils and kerosenes in this sector. The scenario considering the use of processing aids by other facilities indicates that less than 5% of facilities have RQs slightly >1 for the high aromatic content scenario; however the actual RQs are expected to be lower than 1 considering gas oils and kerosenes make up only a fraction of the oils and greases discharged from these facilities. The RQ scenario was very conservative as it assumed that gas oils and kerosenes would make up all of the oils and greases being discharged (Section 7.2.5). While RQs for this scenario were not estimated for facilities using lower aromatics content gas oils and kerosenes, given the very low percentage of facilities with RQs>1 for the high aromatics content scenario, there is likely to be no concern for facilities using lower aromatics content gas oils and kerosenes.

This information indicates that gas oils and kerosenes with aromatic contents of 20 % by weight or greater have the potential to cause ecological harm in Canada, as a result of their use as processing aids in paper making facilities. Their use as processing aids in other industries, and in other industrial sectors is not likely causing ecological harm in Canada.

Gas oils and kerosenes released to water are expected to partition mainly to sediments and may accumulate over time as some components persist in sediment. The industrial uses of gas oils and kerosenes considered in the exposure scenarios are assumed to result in continuous releases to the environment. Those components of gas oils and kerosenes that are highly persistent may accumulate over time in sediments; many PAHs and other aromatics are considered to be persistent in sediments, and some are also considered to be highly bioaccumulative. The available empirical and modelled toxicity data for sediment organisms with gas oils and kerosenes through water exposure indicate moderate to high toxicity; however information on the toxicity of gas oils and kerosenes through sediment exposure is lacking.

7.3.3 Sensitivity of conclusion to key uncertainties

The exposure scenario for paper mills was based on the quantity of processing aids used at paper mills, which was based on limited data from a supplier pertaining to only a few facilities. More extensive information on the use of processing aids at paper facilities would have allowed for a more accurate exposure scenario, and may have changed the PEC value and subsequent RQ.

The composition of gas oils and kerosenes as defined by the proportions of aliphatic and aromatic chemical classes varies greatly, such that the aromatic content can vary substantially even within one CAS RN. There is uncertainty regarding whether in industrial facilities, normal variation in a single product from a single supplier would cover a broad range of aromaticity. This is important as aromatic content influences the toxicity of gas oils and kerosenes (Section 7.1) To address this uncertainty, the analyses of risk for industrial uses were conducted using both the low- and high-aromatic PNECs. However, the lack of information on aromatics content would not affect the outcomes of most of the scenarios (e.g., scenario for formulation of lubricants and lubricant additives, general indirect discharge scenario), as the level of risk was found to be low in these scenarios even with high aromatics content gas oil and kerosene. For the use of processing aids in the paper industry, a risk was found in 30% of the paper mills using lower aromatic content (20% aromatics) gas oils and kerosenes and in 70% of mills using high aromatic content (80%) gas oils and kerosenes. However, if information is obtained on the aromatic content of the gas oils and kerosenes used in this industry, and the aromatic content is lower than 20% this could affect the proposed conclusion.

The Canada-Wide Standards for Petroleum Hydrocarbons in Soil (CCME 2008) assumes an aromatic to aliphatic ratio of 20:80. As aromatic hydrocarbons have been found to be the primary contributors to toxicity in earthworms (Cermak 2013), the standards are expected to be protective for gas oils and kerosenes with aromatic contents lower than 20%. For gas oils and kerosenes with a higher aromatic content the standards may be less protective. However, given that the soil RQ was less than one (0.7) based on the standard for Fraction 2 (greater than C_{10} to C_{16}) which is conservative for gas oils as it represents only the lower, more toxic portion of the carbon range, this uncertainty is not considered to affect the proposed conclusion.

Gas oils and kerosenes released to water are expected to partition mainly to sediments and may accumulate over time, with some representative structures being persistent in sediment. A determination of risk to sediment organisms could not be made due to the lack of information on environmental concentrations in sediment near points of effluent discharge. If this data had been available, it may have added confidence to the lines of evidence which were used to arrive at the proposed conclusion.

8. Potential to cause harm to human health

8.1 Exposure assessment

The focus of the human health exposure assessment is to characterize general population exposure to gas oils and kerosenes from the use of products available to consumers and from environmental media and food. Exposures from industry restricted, site restricted and fuel uses of gas oils and kerosenes have been previously assessed. (Environment Canada, Health Canada 2011, 2013, 2014, 2015)

8.1.1 Environmental media and food

Gas oils and kerosenes are used in a number of industrial applications, such as in the pulp and paper industry. Unintentional releases of gas oils and kerosenes may occur at production facilities (e.g., petroleum refineries), and during loading, transit, and unloading activities. Gas oils and kerosenes in the industrial water stream are typically subject to wastewater treatment, but residual gas oils and kerosenes may be released along post-treatment water into streams, rivers, and lakes. Spills of gas oils and kerosenes may occur during the transportation of these substances during industrial use. These releases are addressed in Sections 5 and 7. There is potential for release of gas oil and kerosene substances in the aquatic environment through wastewater effluents from industrial sources. Implications with regards to drinking water are discussed in Sec. 8.3.6. Exposures via other environmental media are not expected.

8.1.2 Gas oil and kerosene in products available to consumers

Dermal contact with these products is the predominant route of potential exposure to gas oil substances for the general population. Dermal exposures may potentially occur from adhesives and sealants, automotive care and maintenance products, cosmetics, fabric treatments, fuels and solvents, hobby and craft products, household cleaning products, lawn and garden care products, lubricants, natural health products, paints and coatings, and miscellaneous use products. Oral exposure may potentially occur for fabric treatments, hobby and craft products, and household cleaning products. Oral exposure may potentially occur for food packaging. For lubricant and household cleaning products, there is also a possibility of incidental oral exposure to large aerosol droplets for products packaged as spray pumps (ATSDR 1995a). Inhalation exposure may potentially occur to volatile components in the gas oil and kerosene substances.

There is the potential for dermal exposure to carcinogenic polycyclic aromatic hydrocarbons (PAHs) as residuals in gas oil and kerosene products available to the consumer. For inhalation exposures, the total volatile fraction of gas oils and kerosenes as well as the individual substances benzene, toluene, ethylbenzene, xylene (BTEX) fractions were also considered.

8.1.3 PAH compositional analysis of gas oils and kerosene products available to the consumer

PAHs are naturally occurring components of crude oil that co-migrate with normal and branched alkanes of similar molecular weight in the initial stages of refining (i.e., during atmospheric and vacuum distillation). Unrefined gas oil and kerosene streams can therefore contain PAHs. The proportion of PAHs in gas oils and kerosenes varies depending on the source of crude oil used and the severity/type of the refining steps. To produce gas oils and kerosenes for use in the formulation of products available to the consumer, the PAH composition of gas oils and kerosenes can be reduced to residual levels with the most severe refining processes.

Compositional analysis of products available to the consumer was conducted to determine the PAH content of gas oils and kerosenes used. The PAH content of selected products that contain a gas oil or kerosene CAS RNs were determined at two separate labs using different standard analytical methodologies. Gas oils and kerosenes substances with different CAS RNs have similar physicochemical properties and it is possible they are used interchangeably as ingredients in products. To account for interchangeability of CAS RNs in products available to the consumer, whenever a product containing a gas oil or kerosene substance CAS RN was identified, similar use products were also sampled and tested for PAHs, regardless of whether or not the same specific gas oil or kerosene substance was identified in these products. This procedure leads to a functional sampling of typical products which have gas oils or kerosenes with required physical chemical properties in their composition, regardless of the exact CAS RN assigned to the substance.

Products for PAH quantification were chosen based on high gas oil or kerosene content, most common usage, and ready availability at Canadian national retail chains. Products from different manufacturers and suppliers, and products with home use, automotive use, and outdoor use were included in the samples. In total, 28 products were analyzed, seven products with a standard Health Canada chemical laboratory methodology with a resolution in parts 100 per million range, and 21 products with a separate 'high' resolution methodology in the parts per million range. Each of the 28 products were unique, i.e., they have different brand names or originate from different use categories.

The US EPA previously identified PAHs that may be carcinogenic in animals and humans (US EPA 1993), ultimately listing 16 substances that became known as the priority PAHs. These 16 priority PAHs are naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benz[*a*]anthracene, chrysene, benzo[*b+j*]fluoranthene, benzo[*k*]fluoranthene, benzo[*a*]pyrene, indeno[*1,2,3-cd*]pyrene, dibenz[*a,h*]anthracene and benzo[*ghi*]perylene.

The concentrations of 18 PAH species were measured in the seven products using solvent extraction followed by gas chromatography and mass spectrometry detection according to the Health Canada C11.5 method (Health Canada 2017). The highest limit of detection (LoD) for a PAH using this method in the Health Canada laboratory was

303 mg/kg. This analytical procedure was designed to cover regulatory requirements for PAH content in products available to consumers. The global harmonized labelling of carcinogens (UN 2011) required labeling of carcinogens if they are present in a substance at a concentration greater than 0.1%. The specified 0.03 % weight limit of quantification determined by the standard analytical method is able to detect concentrations three times lower than the 0.1% labelling requirement PAH species analysed were acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, retene, benz[*a*]anthracene, chrysene, benzo[*b*]fluoranthene, benzo[*k*]fluoranthene, benzo[*a*]pyrene, benzo[*e*]pyrene, indeno[*1,2,3-cd*]pyrene, dibenz[*a,h*]anthracene, benzo[*ghi*]perylene, and coronene. The LoDs determined for the 16 priority PAHs tested are given in Table C-1 of Appendix C. None of the seven product samples were found to contain any of the 16 priority PAHs at (or higher than) their respective LoDs.

A high resolution PAH compositional analysis was conducted on 21 products available to the consumer in order to quantify the low levels of PAHs in gas oil/kerosene-containing products. This analysis was performed using a dual GC high resolution mass spectroscopy instrument (GC/HRMS). The LoDs for the 16 PAHs tested were 0.5 – 1.0 µg/g (parts-per-million) (0.000001 w/w).

The concentration of each of the 16 PAHs in all 21 products are given in Table C-2 of Appendix C. This analysis confirmed the absence in all products of seven of the 16 priority PAHs, including benzo[a]pyrene and dibenz[a,h]anthracene. Other PAHs that were detected were found at only low levels. The highest concentrations identified in household cleaning products were 630 ppm for naphthalene, 7.5 ppm for fluorene and 1.9 ppm for phenanthrene. As seen in Table C.2 of Appendix C, individual PAHs may be present at very low levels in these products, from less than 12 ppm (<0.0012% w/w) to low parts per billion.

Two sets of compositional analyses did not identify any household use products that contain a high level of PAHs. The very low levels of PAHs found demonstrate that highly refined gas oils are being used to formulate various product types that are available to consumers in Canada. The upper level of PAHs identified in the high resolution testing (Table C.2 of Appendix 2) was seen only in an automotive engine cleaning product, where exposures are considered to be incidental and infrequent. Less amounts of PAHs are seen in other paints and coating products which also have incidental and infrequent use.

8.1.4 Benzene, toluene, ethylbenzene, and the xylenes (BTEX) compositional analysis of gas oil and kerosene products available to the consumer

Given the carbon range of gas oils and kerosenes, there is a potential for the presence of benzene, toluene, ethylbenzene, and the xylenes (BTEX) in these substances. The BTEX content of gas oils and kerosenes can be reduced to residual levels or essentially eliminated with the refining processes for use in the formulation of products available to the consumer.

A total of 24 products available to the general population in Canada were subject to high resolution testing for BTEX substances using a High Speed Gas Chromatography / Field Desorption Mass Spectrometry (HSGC/FDMS) method to analyze the liquid samples. In some cases, samples were diluted prior to analysis and the results adjusted accordingly. The nature of the sample preparation determined the real detection limit (RDL) for the BTEX components for each sample. The values of the BTEX components in the 24 products are given in Table D-1 of Appendix D and ranges of measured BTEX concentrations in different categories of products available to the consumer are given in Table 8-1.

A complication with the attribution of BTEX in some of the products to the gas oil or kerosene substances was that these products often contained CAS RNs of other petroleum substances, not in the gas oil or kerosene category, which could potentially have BTEX components. In these cases, the conservative assumption was made that all the BTEX components can be attributed to the gas oil or kerosene CAS RN.

Furthermore, there are a number of products which list toluene (from 20 to 40%), ethylbenzene (1 to 10%), and xylene (from 10 to 30%) as constituents. In these cases, the specific BTEX component present in the sample was not attributed to the gas oil or kerosene substance.

Table 8-1 The BTEX concentration (μg/g or ppm) of products available to the general Canadian population from different product categories.[a]

Product group	Benzene	Toluene	Ethylbenzene	Xylene
Household cleaning products	ND [b] (0.5 – 5)	ND – 940 (0.5 – 5)	ND – 1200 (0.5 – 5)	ND – 6200 (1.5 – 15)
Automotive uses	ND – 40 (0.5 – 100)	ND – 710 (0.5 – 100)	ND – 470 (0.5 – 5)	ND – 6700 (1.5 – 10)
Rust prevention and penetrants	ND – 0.7 (0.5)	8.2 – 10 (0.5)	8 – 15 (0.5)	40 – 120 (1.5)
Solvents / thinner / fuel	ND – 2 (0.5 – 300)	94 – 690 (0.5 – 5)	ND – 1800 (0.5 – 300)	ND – 7600 (1.5 – 800)

[a] The detection limit is shown in parentheses after highest observed concentration.
[b] ND = not detected

8.1.5 Exposure Characterization

Gas oils and kerosenes may be ingredients in products available to the consumer from various product categories. A list of representative products available in Canada (see Table B.1 in Appendix B) was established by standard Health Canada search strategies, an external contractor report, Health Canada Partner product lists and from company submissions in response to the section 71 survey (Environment Canada 2012). Confirmation of the products available to Canadian consumers, as reported to the section 71 survey, determined that some products which contained gas oils are no longer available, and some products are now being produced with different (i.e., non-gas oil) CAS RNs.

Gas oil and kerosene containing products may contain other petroleum ingredients and evaluation of potential risks to human health from these products as a whole (i.e., from the whole product or from non-gas oil substances that may also be present in the product) is not covered in this assessment. As a conservative assumption, any PAHs that were identified in the product were attributed solely to the gas oil ingredient for the purposes of this assessment.

The mass percentages of gas oil CAS RNs in products available to the consumer were obtained from Materials Safety Data Sheets (MSDS) from the years 2000 to 2017.

An analysis of the use patterns of various gas oil products available to the consumer indicated that exposure of the general population would be via the inhalation route as well as incidental dermal contact, and that this exposure would be intermittent (i.e., infrequent).

Potential exposures to gas oils were estimated using exposure factors and formulas from a variety of sources (Health Canada 1998; RIVM 2006a, 2006b, 2006c; US EPA 2011; Westat 1987). In order to develop human exposure scenarios, products were selected based on the following criteria:

- Availability to Canadians for home use or do-it-yourself projects;
- Those containing the highest concentration of a gas oil CAS RN among products in the same category;
- Potential for repeated uses (e.g., household cleaners).

Across the available gas oil products, there were similarities in use and exposure patterns. The predominant exposure site is expected to be the hands or fingers. The use of household cleaning products may lead to repeated or daily exposures.

No products were identified that, under normal use scenarios, would lead to direct dermal exposures to infants, toddlers or children; exposures are expected to occur only for teenagers and adults.

8.1.6 Dermal exposure to gas oils and kerosenes

There are a variety of products available to consumers that contain gas oils and kerosenes as ingredients.

To estimate exposure to gas oil and kerosene products available to the consumer, the frequencies of use and other exposure factors were taken from the US EPA Versar Manual and ConsExpo Exposure Factor guide (Table E.1 of Appendix E), and based on a thin film approach (US EPA 2011). United States EPA and ConsExpo exposure factors provide for conservative average use frequencies; therefore, exposure estimates derived using these parameters are expected to be conservative (Table 8.2).

Table 8-2 Estimates of intermittent dermal exposure to gas oils or kerosene from products available to consumers ~~and used in the home~~.

Product	Exposure to gas oil (mg/kg-bw)
Car wax	7.8
Special purpose (painter’s) hand cleaner	6.4
Caulking / Adhesive sealant	2.1
Spray furniture polish	1.7
General purpose lubricant	1.4
Glue remover	0.34
Engine Cleaner	0.28

The highest dermal exposure to gas oils and kerosenes was from the use of a car wax and was estimated to be 7.8 mg/kg-bw. Exposures to gas oils from the use of household products used indoors were estimated to range from 0.34 to 6.4 mg/kg-bw.

8.1.6.1 Dermal exposure to PAH residuals

Exposure to products that contain a gas oil or kerosene ingredient carries a potential for exposure to low levels of PAHs that remain after the refining process. Recent high resolution product testing of gas oil products available to the consumer (Table 7-1) indicated that these gas oils and kerosenes contain no PAHs above the detection limits or low residual levels of PAHs.

With a dermal exposure to gas oil and kerosene of 7.8 mg/kg-bw, a 0.0013% w/w PAH content (as identified for the product containing the highest concentration of 16 PAH species quantified) would be equivalent to a dermal PAH exposure of 10.1 ng/kg-bw.

8.1.7 Oral exposure to gas oils and kerosenes

Based on conservative estimates provided by the Health Canada Food Directorate, the Probable Daily Intakes (PDIs) for two substances in the group, namely 64741-44-2 and 64742-46-7, from migration from food packaging were estimated to be 0.33 and 0.26 µg/kg-bw/day, respectively. In the absence of migration data, the exposure assumed a worst case scenario, and as such these should be considered conservative. (Personal communication, from Health Canada Food Directorate to Health Canada Risk Management Bureau, dated November 2017; unreferenced).

For other substances where the potential for direct food contact has been identified, (that is 64742-06-9; 64742-14-9; 64742-46-8; 64742-88-7; 64742-94-5, 64742-96-7), the exposure is considered negligible.

The oral exposures for 8008-20-6 from food packaging, and 64742-46-7, 64742-46-8, 64742-88-7, 64742-94-5, and 68477-31-6 from incidental additives are considered negligible. (Personal communication, from Health Canada Food Directorate to Health Canada Risk Management Bureau, dated November 2017; unreferenced).

8.1.8 Inhalation exposure to gas oils and kerosenes

Inhalation exposures can occur from products available to consumers which contain kerosene or gas oils. Exposure analysis was conducted for both total kerosene/gas oil as well as BTEX components based upon product testing derived concentrations. Nearly all products tested were found not to contain benzene at levels above the detection limit. The highest benzene concentration determined was 40 µg/g or 0.004% that was found in an engine cleaner. Additionally, for exposure and hazard characterization, consideration was also given to toluene, ethylbenzene and xylene content of the products. A sentinel exposure scenario for the TEX components was developed for a varnish product containing 30% of CAS RN 64742-47-8. Other scenarios considered included a waterproofing spray, polishes and cleaners and the spilling of a small amount of kerosene during the filling of a space heater, however, the limited duration and smaller amount of product used leads to lower inhalation exposures.

Modelling of an engine cleaner for potential benzene exposure to vapour from an increasing surface area was performed. Parameters used include an application time of 5 minutes and an exposure time of 60 min with 481 g or one can of cleaner used in a room volume of 30 m^3 with an air exchange rate of 4 times per hour to mimic a garage setting. The results of modelling for the exposure to the benzene component in this product are presented in Table 8-4.

ConsExpo modelling was performed for inhalation exposures to TEX components in vapour from the paste varnish from an increasing surface area. The application and exposure time was 120 min and an application time of 132 minutes with 500 g of varnish used in a room volume of 20 m^3 with an air exchange rate of 1.5 times per hour. The resulting mean event concentration for the kerosene vapor was estimated to be 1600 mg/m^3 with a mean concentration on the day of exposure to be 140 mg/m^3 for kerosene vapour. Modelling using the same parameters was completed for toluene, ethylbenzene and xylenes varying only their respective physical chemical parameters and their concentration present in the product. The results of the exposure calculations are given in Table 8-3.

Table 8-3 Inhalation exposure concentrations of BTEX concentrations for products

Substance	Product	Concentration in product (µg/g)	Mean event concentration (mg/m^3)
Toluene	Paste varnish	900	1.44
Ethylbenzene	Paste varnish	1200	1.92
Xylenes	Paste varnish	6200	9.92

Benzene	Engine cleaner	40	0.15

As the concentrations of benzene, toluene, ethylbenzene and xylenes in the kerosenes are low in the product formulation, the corresponding air concentrations from product use and evaporation are all less than 10 mg/m^3 during the exposure event.

8.2 Health effects assessment

Gas oils and kerosenes share similar physical-chemical properties, depending on processing steps, level of refinement and identity of blending streams, and can therefore have similar toxicological properties.

In the present document, 42 CASRNs related to gas oils and kerosenes were assessed. Health effects information regarding some of these substances was limited. However, all the available information on substances which are considered similar to those gas oils and kerosenes for which there are potential human exposures were taken into account. This includes the data in the screening assessment reports on other gas oils, fuel oil No. 2, aviation fuels (e.g. Jet-A and kerosene) (Environment Canada, Health Canada 2011, 2013, 2014, 2015). Toxicological studies of diesel fuel are also considered. A summary of key toxicity studies based on this broader group of gas oils and kerosenes is outlined below. Appendix F summarizes toxicology studies that have been conducted specifically on the gas oil and kerosene CAS RNs.

Repeated dose toxicity

A range of NO(A)ELs or LO(A)ELs have been reported in repeated-dose dermal exposure studies based on the testing of different gas oil and kerosene substances. Short-term (14-day) repeat-dose (7 days/week) dermal application of 0.5 ml of gas oil (JP-5 fuel) at 0, 5000, 10,000, 20,000, 30,000 or 40,000 mg/kg-bw/d (in 95% ethanol) caused irritation, hair loss, and acanthosis or inflammation at the site of application (shaved back) at all doses in male or female mice. All mice died in the 40,000 mg/kg-bw/d dose group and only female mice died in the 30,000 mg/kg-bw/day group before study termination. A NOAEL of 5,000 and a LOAEL of 10,000 mg/kg-bw/d was observed in this study based on decreases in body weight in both sexes (NTP 1986). Subchronic (90-day) exposure to undiluted JP-8 fuel at 0, 750, 1500 or 3000 mg/kg-bw/d by gavage in male Sprague-Dawley rats caused a dose-dependent decrease in body weight at 6%, 13%, or 43%, respectively with respect to controls. An increase in liver, spleen and testes weight was seen in the highest dose group but no histopathological changes were observed. No significant effects were seen in this study; however, a LOAEL of 750 mg/kg-bw/d was identified based on decrease in body weight and an increase in relative liver weight. No NOAEL was established (USEPA Chemview 2018 for Kerosene, CAS RN 8008-20-6). In a developmental study, pregnant rats were dermally exposed to 0, 25, 50, 125, 250 or 500 mg/kg-bw/d of light cycle oil from GD 0-19. There was a decrease in maternal body weight and body weight gain at 50 mg/kg-bw/d or higher doses; however, no treatment-related effects were observed at necropsy. Moreover, the decrease in maternal body weight achieved statistical significance at 250 mg/kg-bw/d or higher doses. These findings were not considered adverse and attributed to reduced feed consumption by the authors (Mobil 1988b, cited in API 2012a). A LOAEL of 2000 mg/kg-bw was identified in rabbits exposed to diesel fuel (via skin) for three weeks (5d/wk); this dose elicited decreases in body weight gain and mean corpuscular haemoglobin concentration (IITRI 1984; see Appendix F). Repeat-dose dermal exposure for 28 days (5 d/wk) was reported to cause anorexia, depression and severe skin damage at the treatment area following application of 6400 mg/kg bw/d (LOAEL – only one dose reported) of Jet fuel in rabbits (API 1980). Similarly, a LOAEL of 2000 mg/kg-bw/d was reported in a study where rabbits were exposed dermally to kerosene 3 times/week for 28 days. The treatment-related effects included significantly increased absolute and relative spleen weights in females, decreased haemoglobin and hematocrit, and significantly decreased red blood cells in males; however, a slight decrease in body weight, thinness, lethargy, wheezing, and nasal and anal discharge was observed in both sexes (API 1985). It was noteworthy that inhalation exposure to 0, 500, 100 or 2000 mg/m^3 of jet fuel kerosene for 28 days (6 hr/d) did not cause adverse effects on the immune system in female rats and mice at any dose (White et al 2013).

In a 90-day dermal study, exposure to hydrodesulfurized kerosene (6 hr/d, 5 d/wk) did not cause systemic or neurotoxicity toxicity in male or female rats at 165, 330 or 495 mg/kg-bw/d and the highest dose was considered as the NOAEL. However, a dose-related minimal skin irritation was seen at the application site which was completely reversible in both sexes within 4 weeks (Breglia 2014). Additional dermal exposure studies have been presented in Appendix F with details (Freeman 1993; Ingram 1993; Nessel 1998; Walborg 1998).

Long-term dermal or occupational exposures to kerosene (for 5 hr/d, dose not known) produced dermatosis and erythema in factory workers (Jee 1985, cited in ATSDR 1995b). However, no studies were found to show the ability of fuel oils to cause hepatic, musculoskeletal, reproductive, developmental, or immunological effects following dermal exposure in humans (ATSDR 1995b). Similarly, chronic dermal exposure to fuel oils caused dermatitis in mice and the NOAELs for systemic effects were reported ranging from 250 – 500 mg/kg-bw/d in 84-103 week exposure studies (NTP 1986).

Subchronic (28-day) inhalation exposure (6 hr/d for 5 days/week) to 25 mg/m^3 (nominal dose = 32 mg/m^3) of hydrodesulfurized kerosene did not cause any physiological, haematological, or histological changes in males or female SD rats (API 1986).

Reproductive toxicity

A limited number of reproductive and developmental studies were identified for the broader group of gas oils and kerosenes. No developmental or reproductive effects were found for CAS RN 64741-82-8 in three dermal exposure studies in rats with doses up to 2000 mg/kg-bw/d (Mobil 1988b, 1991; Feuston 1994). Likewise, dermal application (1 ml/kg) of 165, 330 or 494 mg/kg-bw/d of kerosene for 7 weeks during premating and mating to GD19 did not cause maternal, reproductive, or developmental toxicity in male or female rats. The highest dose (494 mg/kg-bw/d was reported as

NOAEL in this study (Schreiner 1997). Other gas oils administered dermally were noted to have no effect on maternal or fetal health. The available data indicate that gas oils have low reproductive and developmental toxicity.

Inhalation exposure to kerosene (106 or 364 ppm for 6 hr/d) from GD 6-15 in pregnant female SD rats did not cause any adverse developmental effects in the offspring. A maternal or a teratogen NOAEL of 364 ppm was reported in this study (API 1979a, cited in API 2010b). Similarly, inhalation exposure to Jet Fuel A (102.5 or 394.7 ppm) in pregnant female SD rats for 6 hr/d through GD 6-15 did not cause adverse effects on fetal growth or development and it was not considered teratogenic. A maternal or teratogenic NOAEL of 394.7 ppm was reported in this study (API 1979, cited in API 2010b).

A limited number of reproductive or developmental studies were identified for the broader group of gas oils and kerosenes. In a developmental study, oral (gavage) exposure to 0, 500, 1000, 1500 or 2000 mg/kg-bw/d of JP-8 fuel on GD 6-15 (once/day) caused 31%, 70% or 85% reduction in body weight gain, respectively in pregnant rats. Moreover, a decrease in fetal body weight was observed in males (15%) and females (13%) in the 1500 mg/kg-bw/d dose group. A developmental LOAEL of 1500 and a NOAEL of 1000 mg/kg-bw/d was reported in this study based on decrease in fetal body weight (USEPA Chemview 2018). For this assessment, the 500 mg/kg-bw/d dose was considered as the LOAEL for maternal toxicity.

A LOAEL of 1000 mg/kg-bw/d was established for developmental toxicity based on statistically significant decreased fetal body weights after pregnant rats were dermally exposed to light cycle oil on gestation days 0–6 and 6–15. Fetal body weights also trended lower in the group exposed to 500 mg/kg-bw per day on gestation days 0–19. (Mobil 1988b). No developmental or reproductive effects were found for CAS RN 64741-82-8 in three dermal exposure studies in rats with doses up to 2000 mg/kg-bw/d (Mobil 1988b, 1991; Feuston 1994). The available 4-week dermal studies have shown slight to moderate skin irritation following exposure to gas oils; however, no significant adverse effects have been reported on the reproductive system in rats (API 2011).

In another developmental study, inhalation exposure to kerosene at concentrations of 738.5 or 2536 mg/m^3 (106 or 364 ppm) for 6 hr/d from GD 6-15 in pregnant female SD rats did not cause any adverse developmental effects in the offspring. A maternal or a teratogen NOAEL of 2536 mg/m^3 was reported in this study (API 1979a, cited in API 2010b). Similarly, inhalation exposure to Jet Fuel A dose of 714.1 or 2750 mg/m^3 (102.5 or 394.7 ppm) in pregnant female SD rats for 6 hr/d through GD 6-15 did not cause adverse effects on fetal growth or development and it was not considered teratogenic. A maternal or teratogenic NOAEL of 2750 mg/m^3 was reported in this study (API 1979b, cited in API 2010b). The available data indicate that gas oils have low reproductive and developmental toxicity.

Carcinogenicity

Ten of the gas oil and kerosene substances are classified as Category 1B “may cause cancer” (Table F-2 Appendix F) (European Commission 2008, ECHA 2012). However, the European commission (Regulation EC No. 1272/2008, Annex VI) states the classification as a 1B carcinogen does not apply to these gas oils if the refining history is known and the substance(s) from which they are produced can be shown to not be carcinogenic. This is typically demonstrated by containing less than 0.1% individual carcinogens and/or less than 3% w/w DMSO extractable total PAH/aromatic content (Clark et al. 2013, CONCAWE 2012).

BTEX components in gas oil and kerosene

Briefly, benzene was added to the List of Toxic Substances under Schedule 1 of CEPA by Health Canada following a Priority Substance List (PSL) assessment as this substance has been reported to cause cancer in humans and experimental animals (PSL 1993). In the current assessment, a short-term study inhalation exposure study was selected as critical in which exposure to 10, 100 or 300 ppm of benzene for 6 hr/d for 6 days caused depressed response of B cells and T cells of the immune system in male mice (Rozen 1984). The lowest dose of 32 mg/m^3 (10 ppm) was identified as the LOAEC. Another BTEX component, toluene, was assessed in a residential indoor air quality guideline and a tolerable daily intake (TDI) of 0.0097 mg/kg-bw/d was estimated (Health Canada 2011) based on a study in which symptoms of headaches, dizziness and feeling of intoxication were reported following short-term (6 hr/d for 4 days) inhalation exposure to toluene (Andersen 1983). A NOAEC of 151 mg/m^3 was identified from this study based on a LOAEC of 377 mg/m^3.

Ethylbenzene was previously assessed by Health Canada (ECCC, HC 2016a). Studies have shown that short-term inhalation (6 hr/d for 5 days) exposure to ethylbenzene yielded a NOAEC of 1305 mg/m^3 for hearing loss in rats at the LOAEC of 1740 mg/m^3 (Cappaert 2000).

A NOAEC of 217 mg/m^3 was reported for neurological effects (decreased motor coordination) following inhalation exposure (6 hr/f, 5 d/wk) to xylene in rats for 3 months (Korsak 1994) and a TDI value of 0.013 mg/kg-bw/d was reported (Health Canada 2015). In the present assessment a NOAEC of 217 mg/m^3 is used.

Polycyclic Aromatic Hydrocarbons

PAH species that have sufficient toxicological information can be ranked according to toxicological potency relative to benzo[a]pyrene (B[a]P) (see Table 8.5).

The Government of Canada previously completed a human health risk assessment of certain PAHs, including B[a]P, under the Priority Substances List Program. Based primarily on the results of carcinogenicity bioassays in animal models, five PAHs were considered “probably carcinogenic to humans”, substances for which there is believed to be some chance of adverse effects at any level of exposure (Environment Canada, Health Canada 1994). PAHs were added to the List of Toxic Substances in Schedule 1 of CEPA 1999.

The US EPA previously identified PAHs that may be carcinogenic in animals and humans (US EPA 1993), ultimately listing 16 substances that became known as the ‘priority pollutant’ PAHs (Menzie 1992; US EPA 2013). They are naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benz[*a*]anthracene, chrysene, benzo[*b*+*j*]fluoranthene, benzo[*k*]fluoranthene, benzo[*a*]pyrene, indeno[*1,2,3-cd*]pyrene, dibenz[*a,h*]anthracene and benzo[*ghi*]perylene.

In vitro **and** ***in vivo*** **genotoxicity**

Gas oils and kerosenes have demonstrated genotoxic potential in *in vitro* and *in vivo* assays of genetic toxicity, although results are mixed depending on substance and assay type. Results from multiple assays have been reviewed in previous gas oil screening assessments (Environment Canada Health Canada 2011, 2013, 2015).

Using a modification of the standard *Salmonella* test, there was a high correlation between mutagenic activity and % DMSO extractable PAC in base oils, with activity noted at 3% DMSO extractable PAC and above. The modified assays were different from the standard assay in three ways. The first was the tests were performed on the DMSO extractable fraction only. The second was to use S-9 from aroclor-induced hamster liver at eight times the recommended concentration, and lastly was the exclusive use of TA98, the tester strain most responsive to complex mixtures of PAC (Chasey 1993).

Similar to base oils the genotoxicity potential of the gas oils and kerosenes is related to their PAH content, with increasing PAH content related to increasing genotoxicity (API 2013b).

Epidemiology studies

A limited number of studies in humans, including case reports and studies conducted on volunteers, were identified for gas oils. One case report describes substantial and prolonged dermal exposure to ‘diesel oil’, where it was used over several weeks as an arm and hand cleaner. Development of epigastric and loin pains, nausea, anorexia, degeneration of kidney tubular epithelium and reversible renal failure were observed (Crisp et al. 1979). With respect to occupational exposures to diesel fuels, a case-control study of male cancer patients revealed a combined adjusted odds ratio of 1.9 (90% confidence interval = 1.2-3.0) for prostate cancer in men with non-substantial or substantial exposures to diesel fuel. However, there is no evidence of a positive dose-response relationship in this study, and the results are confounded by exposures to other petroleum substances and unknown routes of exposure (Siemiatycki 1987).

Human Volunteer Studies

The irritant properties of diesel fuels have been assessed in studies of short-term dermal exposures of human volunteers. No visible skin effects were seen after 15 minutes of dermal exposure to 1.5 mL (approximately 18 mg/kg-bw) of six diesel fuel samples over an area of 3.1 cm^2; however, a slight increase in blood flow to the area was noted in some cases (Wahlberg 1995). Another dermal study in human volunteers observed increased skin irritancy with cumulative exposure time, when diesel fuel samples were applied for time points ranging from 15 minutes to 48 hours. Irritation was first noted after 4 hours of exposure. Occlusion of the application site and the application of 'newer' (i.e., lower sulphur and aromatic content) blends of diesel fuels (samples MK I and MK II) produced greater irritancy (Fischer and Bjarnason 1996). Adverse systemic effects were not noted in these studies.

8.3 Characterization of risk to human health

8.3.1 Exposure from environmental media

Potential risks to the general population from possible exposure to gas oils from their production, use, and transport between petroleum facilities have been previously addressed (Environment Canada Health Canada 2013). This assessment did not identify a risk to human health from these activities. The same conclusion is considered to apply to the 42 gas oil and kerosene substances of this assessment for these scenarios.

As described in Section 8.1.1, there is the potential for gas oils and kerosenes to be released to water bodies via wastewater releases. There is a potential concern for human health if these base oils are released in water bodies which become a source of drinking water. Of particular concern would be if any of these gas oils and kerosenes contained PAH or BTEX components. Canadian Federal guidelines and provincial / municipal regulations are in place for both industrial discharges to water, and for drinking water itself, for many potential constituents of gas oils and kerosenes, including PAHs and BTEX. Examples of some of these at the federal, provincial and municipal level include: (CCME 1999; CCME 2004 a, b, c, d; CCME 2008; Ontario 1994; Ontario 2017; Ottawa 2011; Ottawa 2018). It is expected that after being processed through a water treatment facility, that any water intended for use for drinking will not contain gas oil and kerosene components at a level that would be considered to be of concern for human health.

8.3.2 Dermal exposure to gas oils and kerosenes

Dermal exposures to gas oils and kerosenes from products available to consumers are expected to be limited and to occur on an intermittent basis (for example, applying car wax). Short-term dermal exposure of human volunteers to gas oil substances did not result in adverse systemic effects (Walhberg 1995, Fischer 1996), and gas oils tested over the short term at high concentrations in laboratory animals exhibited low dermal toxicity (with irritancy and skin inflammation common application site effects). The absence of adverse effects in the short-term dermal exposure studies in volunteers, together with a lack of overt toxicity in animal studies, supports the low acute toxicity of gas oils. Although some adverse effects were observed in laboratory animals following two to three week continuous dermal exposure to high doses (1000 to 2000 mg/kg-bw/d), these effects was not considered relevant to the exposure scenarios identified herein.

As such dermal exposure to gas oils from products available to consumers were not considered to be of concern for human health.

8.3.3 Dermal exposure to PAH components of gas oils and kerosenes

Compositional analyses of 28 products available to the consumer that contain a gas oil or kerosene ingredient showed that they may contain certain PAH species on the order of low parts per billion to parts per million. The highest combined level of PAHs contained in any product was 0.0013% by weight, predominantly due to the presence of naphthalene with a smaller contribution from fluorene. In order to evaluate the potential risk to human health potency equivalence factors noted in Section xxx were used. These PEFs are given in Table 8.4. The PAHs found at the highest concentrations in Table 8.5 have low toxicological potency relative to B[a]P.

Table 8-4 PAH compositional analysis (mg/g or in ppm) from high resolution testing of 28 gas oil or kerosene-based products available to consumers

PAH	**C_{max} in high resolution testing of 21 products [a]**	**Potency equivalency factor (PEF) relative to B[*a*]P [b]**
Naphthalene	11.6	0.001
Acenaphthylene	0.004	0.001
Acenaphthene	0.014	0.001
Fluorene	1.29	0.001
Phenanthrene	0.128	0.001
Anthracene	0.038	0.01
Fluoranthene	0.003	0.001
Pyrene	0.004	0.001
Benz[a]anthracene	0.002	0.1
Chrysene	ND [c]	0.01
Benzo[b+j]fluoranthene	ND	0.1
Benzo[k]fluoranthene	ND	0.1
Benzo[a]pyrene	ND	1
Indeno[1,2,3-cd]pyrene	ND	0.1
Dibenz[a,h]anthracene	ND	5
Benzo[g,h,i]perylene	ND	0.01

[a] Health Canada, unpublished (compositional analyses conducted in 2014-2015). Limit of detection (LoD) of the methodology is 0.5 or 1.0 ppb

[b] From Nesbit and LaGoy (1992)

[c] ND = not detected

Converting the highest PAH concentrations detected for each PAH into B[*a*]P equivalents and applying that to the highest dermal exposure scenario (car wax) of 7.8 mg/kg-bw per exposure results in an upper bounding B[*a*]P concentration of 1×10^{-4} mg/kg-bw, or 0.1 µg/kg-bw. The risk from potential incidental dermal exposure to low levels of PAHs resulting from exposure to gas oils in products available to the consumer is therefore considered to be low.

8.3.4 Oral exposures to gas oils and kerosenes

Comparing the Probable Daily Intakes (PDIs) from migration from food packaging determined as 0.33 µg/kg-bw/day (for 64741-44-2) and 0.26 µg/kg-bw/day (for 64742-46-7) with a LOAEL of 500 mg/kg-bw/day for maternal reduction in weight gain from an oral developmental study of jet fuel in rats results in MOEs of 1,500,000 and 1,900,000 respectively, for the two CAS RNs. Based on the available toxicology data predictions for this class of compounds and the PDIs for the two gas oil and kerosene substances, the MOEs are considered adequate and therefore the risk to the general population from oral exposure to gas oil and kerosene substances in food packaging materials are considered to be low.

8.3.5 Inhalation exposure to gas oils and kerosenes

Inhalation exposure to kerosene vapour from products resulted (varnish and engine cleaner) in an air concentration of 1600 mg/m^3 for 2 hours and 140 mg/m^3 on the day of exposure. Inhalation exposures for the study of developmental effects in animals for 6 hours per day for 10 days at concentrations ranging from 2530 to 2744 mg/m^3 did not result in adverse effects. Given the short duration of inhalation exposure from product use and the lack adverse health effects at much higher does for longer periods of time the risk to humans from periodic short-term exposure to kerosene vapour is considered to be low.

8.3.6 Inhalation of BTEX components of gas oils and kerosenes

Short term exposures to benzene, toluene, ethylbenzene and xylenes from marketplace product use, the critical hazard point of departure and MOE are presented in Table 8-5.

Table 8-5 Margins of exposure to benzene, toluene, ethylbenzene and xylenes

Substance	Hazard adjusted exposure concentration* (mg/m^3)	Hazard end point (mg/m^3)	Margin of exposure
Toluene	0.24	Short-term NOAEC = 151 mg/m^3 (based reversible on neurological effects – dizziness, headaches, intoxication in volunteers)	630
Ethylbenzene	0.24	Acute and short-term NOAEC = 1305 mg/m^3 (based on reversible	5440

Substance	Hazard adjusted exposure concentration* (mg/m^3)	Hazard end point (mg/m^3)	Margin of exposure
		hearing loss in rats of exposure for 5 days)	
Xylenes	1.65	NOAEC = 217 mg/m^3 (based on reversible neurological effects in rats)	130
Benzene	0.0025	Short-term LOAC = 32 mg/m^3 (based on immunological effects in mice after inhalation exposure for 6 hours per day for 6 days.)	12800

*Event concentrations were amortized to match the duration of the critical endpoint for each substance; 6 hour duration for toluene, xylenes and benzene with 8 hours duration for ethylbenzene.

The resulting the resulting margins of exposure (MOEs) are considered to be adequate to address the uncertainty in both the hazard and exposure databases.

8.4 Uncertainties in evaluation of risk to human health

While effort was made to make the selection of products for exposure modelling representative of the most widely used products, there is uncertainty in the extent to which the chosen products represent the cross section of all products containing gas oils and kerosenes available to the Canadian consumer (i.e., regarding the amount of gas oil and kerosene present in the product and the PAH and BTEX composition of the gas oil and kerosene ingredient).

There is a lack of specific hazard data for a large set of the gas oil and kerosene substances of this assessment. Substances which were more data rich such as kerosene, jet fuel and diesel fuel were considered to be representative of the substances in products available to the consumer. Toxicological information for those substances were used to inform the hazard characterization of the substances seen in products available to the consumer. There is also a lack of substance specific information on environmental media exposures to gas oils and kerosenes.

The application of biosolids containing gas oils and kerosenes to agricultural land was not evaluated, but is not expected to be a significant source of exposure to the general population. There is, however, a lack of data on this source of exposure.

9. Conclusion

Considering all available lines of evidence presented in this draft screening assessment, there is risk of harm to the environment from gas oils and kerosenes with aromatic contents of 20 % by weight or greater. It is proposed to conclude that gas oils and kerosenes with aromatic contents of 20 % by weight or greater meet the criteria under paragraph 64(*a*) of CEPA as they are entering or may enter the environment in a quantity or concentration or under conditions that have or may have an immediate or long-term harmful effect on the environment or its biological diversity. However, it is proposed to conclude that gas oils and kerosenes with aromatic contents of 20 % by weight or greater do not meet the criteria under paragraph 64(*b*) of CEPA as they are not entering the environment in a quantity or concentration or under conditions that constitute or may constitute a danger to the environment on which life depends.

On the basis of the information presented in this draft screening assessment, it is proposed to conclude that the 42 gas oils and kerosenes listed in Appendix A do not meet the criteria under paragraph 64(*c*) of CEPA as they are not entering the environment in a quantity or concentration or under conditions that constitute or may constitute a danger in Canada to human life or health.

Therefore, it is proposed to conclude that gas oils and kerosenes with aromatic contents of 20 % by weight or greater meet one or more of the criteria set out in section 64 of CEPA.

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Appendices

Appendix A. Gas oils and kerosenes on the DSL identified as priorities for assessment

Table A.1. Chemical Abstracts Service Registry Number (CAS RN) and Domestic Substance List (DSL) name of priority gas oils and kerosenes

CAS RN	DSL Name
8008-20-6	Kerosene (petroleum)
64741-43-1	Gas oils (petroleum), straight-run
64741-44-2	Distillates (petroleum), straight-run middle
64741-49-7	Condensates (petroleum), vacuum tower
64741-58-8	Gas oils (petroleum), light vacuum
64741-60-2	Distillates (petroleum), intermediate catalytic cracked
64741-77-1	Distillates (petroleum), light hydrocracked
64741-85-1	Raffinates (petroleum), sorption process
64741-90-8	Gas oils (petroleum), solvent-refined
64741-91-9	Distillates (petroleum), solvent-refined middle
64742-06-9	Extracts (petroleum), middle distillate solvent
64742-13-8	Distillates (petroleum), acid-treated middle
64742-14-9	Distillates (petroleum), acid-treated light
64742-30-9	Distillates (petroleum), chemically neutralized middle
64742-31-0	Distillates (petroleum), chemically neutralized light
64742-38-7	Distillates (petroleum), clay-treated middle
64742-46-7	Distillates (petroleum), hydrotreated middle
64742-47-8	Distillates (petroleum), hydrotreated light
64742-72-9	Distillates (petroleum),catalytic dewaxed middle
64742-77-4	Distillates (petroleum), complex dewaxed middle
64742-79-6	Gas oils (petroleum), hydrodesulfurized
64742-81-0	Kerosine (petroleum), hydrodesulfurized
64742-87-6	Gas oils (petroleum), hydrodesulfurized light vacuum
64742-88-7	Solvent naphtha (petroleum), medium aliph.
64742-91-2	Distillates (petroleum), steam-cracked
64742-94-5	Solvent naphtha (petroleum), heavy arom.
64742-96-7	Solvent naphtha (petroleum), heavy aliph.
68333-88-0	Aromatic hydrocarbons, C9-17
68477-30-5	Distillates (petroleum), catalytic reformer fractionator residue, intermediate-boiling
68477-31-6	Distillates (petroleum), catalytic reformer fractionator residue, low-boiling
68814-87-9	Distillates (petroleum), full-range straight-run middle
68915-96-8	Distillates (petroleum), heavy straight-run
68915-97-9	Gas Oils (petroleum) straight-run, high-boiling
68919-17-5	Hydrocarbons, C12-20, catalytic alkylation by-products
68921-07-3[a]	Distillates (petroleum), hydrotreated light catalytic cracked

CAS RN	DSL Name
92704-36-4	Gas oils (petroleum), straight-run, clay-treated
128683-26-1	Distillates (petroleum), full-range atm.
128683-27-2	Distillates (oil sand), straight-run middle
128683-28-3	Gas oils (petroleum), full-range
128683-29-4	Gas oils (oil sand), hydrotreated
128683-30-7	Gas oils (oil sand)
129893-10-3	Residues (petroleum), vacuum, hydrocracked, middle distillate fraction

[a] This substance was not identified under subsection 73(1) of CEPA but was included in this assessment as it was considered a priority on the basis of other human health concerns.

Appendix B. Product category and uses of gas oils and kerosenes by CAS RN

Table B-1. Product categories containing gas oil and kerosene substances. Not all products are found in Canada.

Marketplace product categories with gas oil and kerosene substances	• Adhesives and sealants (construction adhesive, silicone sealants, bathroom caulking) • Air freshener • Automotive care and maintenance (engine cleaner, car waxes, car polish, boat polish, oxidation remover, motor oil, transmission fluid) • Fabric treatment • Food packaging (paper/cardboard, adhesive, textile/textile fiber manufacture) • Fuels (firelighter, camping fuel / kerosene fuel) • Hobby and craft (metallic paint) • Household cleaning product (furniture polish, paint brush cleaner, tar cleaner, counter-top polish, stainless steel cleaner, shoe polish) • Lubricants, penetrants, degreasers (spray, general and bike chain) • Paints, coatings, sealants (wood stain, varnish, primer, rust preventer, wood finish, water seal, canvas waterproofing) • Solvents (Penetrant, Professional use)
Gas oil and kerosene CAS RNs found in marketplace products	8008-20-6; 64741-77-1; 64741-85-1; 64741-91-9; 64742-13-8; 64742-14-9; 64742-30-9; 64742-46-7; 64742-47-8; 64742-79-6; 64742-81-0; 64742-88-7; 64742-94-5; 64742-96-7; 68477-31-6

Appendix C. PAH compositional testing of products available to consumers in Canada

Table C-1. Standard testing results[a] for the priority PAHs in seven Canadian household products containing gas oils and kerosenes (µg PAH per g sample)

Priority PAH species	LoQ for standard testing of seven marketplace products [c]
Naphthalene	Not measured
Acenaphthalene	195
Acenaphthene	200
Fluorene	193
Phenanthrene	195
Anthracene	185
Fluoranthene	197
Pyrene	196
Benz[*a*]anthracene	222
Chrysene	230
Benzo[*b*+*j*]fluoranthene	Not measured
Benzo[*k*]fluoranthene	252
Benzo[*a*]pyrene	243
Indeno[*1,2,3-cd*]pyrene	298
Dibenz[*a,h*]anthracene	303
Benzo[*ghi*]perylene	291

[a] Health Canada, unpublished (compositional analyses conducted in 2014-2015)

[b] Lower end based on limit of detection (LoD) of the methodology; “ND” indicates not detected at an LoD of 0.5 or 1.0 ppb

[c] The standard testing method results are in terms of the limit of quantification (LoQ) of the methodology. All products had measured PAH concentrations below the listed limits of quantification.

[d] ND indicates not detected at an limit of detection (LoD) of 0.5 or 1.0 ppb

Table C.2. Results of high-resolution testing for the 16 priority PAHs[a] in 21 Canadian products available to the consumer[b] (μg PAH / g sample)

Product (physical state)	Product type	NA	AY	AN	FE	PA	AA	FA	PY
Detection limit (μg/g)		1	1	1	0.5	0.5	0.5	0.5	0.5
Lemon oil	HCP[c]	9.9	ND[d]	ND	2.0	1.9	ND	ND	ND
Mirror glaze	HCP	28.5	2.4	ND	0.7	ND	ND	2.5	2.6
Anti-rust	HCP	35.3	ND	ND	ND	ND	ND	ND	ND
Paste varnish	HCP	19.2	ND	ND	ND	ND	ND	ND	ND
Color restorer and cleaner	HCP	111	ND	ND	ND	ND	ND	ND	ND
Lemon oil	HCP	ND	ND	ND	ND	ND	ND	ND	ND
Wood conditioner	HCP	628	ND	ND	ND	ND	ND	ND	ND
Glue remover	HCP	1.2	ND	ND	ND	ND	ND	ND	ND
Glue remover spray gel	HCP	ND	ND	ND	ND	ND	ND	ND	ND
Stainless steel cleaner	HCP	18	2.5	ND	7.5	ND	ND	ND	ND
Hand cleaner	HCP	ND	ND	ND	ND	ND	ND	ND	ND
Hand cleaner	HCP	ND	ND	ND	ND	ND	ND	ND	ND
Fuel kerosene	Fuel	6450	ND	ND	ND	ND	ND	ND	ND
Penetrant oil	Paints & coating	177	ND	ND	916	109	29.7	ND	ND
Firearms cleaning solvent	Paints & coating	1030	4.0	ND	49.7	ND	ND	ND	ND
Mineral spirits	Paints & coating	6200	ND	ND	ND	ND	ND	ND	ND
Liquid sander	Paints & coating	476	ND	ND	ND	ND	ND	ND	ND
Engine cleaner	Automotive	4900	ND	ND	ND	ND	ND	ND	ND
Car polish	Automotive	4.5	1.4	ND	3.4	ND	ND	3.4	3.5
Car polish	Automotive	7.4	ND	ND	ND	ND	ND	ND	ND
Engine cleaner	Automotive	11600	ND	13.9	1290	128	38.2	ND	ND

Product (physical state)	**Product type**	**BA**	**CH**	**BF**	**BK**	**BP**	**IP**	**DA**	**BG**
Detection limit (µg/g)		1	1	1	1	1	1	1	1
Lemon oil	HCP[c]	ND	ND	ND	ND	ND	ND	ND	ND
Mirror glaze	HCP	1.8	ND	ND	ND	ND	ND	ND	ND
Anti-rust	HCP	ND	ND	ND	ND	ND	ND	ND	ND
Paste varnish	HCP	ND	ND	ND	ND	ND	ND	ND	ND
Color restorer and cleaner	HCP	ND	ND	ND	ND	ND	ND	ND	ND
Lemon oil	HCP	ND	ND	ND	ND	ND	ND	ND	ND
Wood conditioner	HCP	ND	ND	ND	ND	ND	ND	ND	ND
Glue remover	HCP	ND	ND	ND	ND	ND	ND	ND	ND
Glue remover spray	HCP	ND	ND	ND	ND	ND	ND	ND	ND
Stainless steel cleaner	HCP	ND	ND	ND	ND	ND	ND	ND	ND
Hand cleaner	HCP	ND	ND	ND	ND	ND	ND	ND	ND
Hand cleaner	HCP	ND	ND	ND	ND	ND	ND	ND	ND
Fuel kerosene	Fuel	ND	ND	ND	ND	ND	ND	ND	ND
Penetrant oil	Paints & coating	ND	ND	ND	ND	ND	ND	ND	ND
Solvent	Paints & coating	ND	ND	ND	ND	ND	ND	ND	ND
Mineral spirits	Paints & coating	ND	ND	ND	ND	ND	ND	ND	ND
Liquid sander	Paints & coating	ND	ND	ND	ND	ND	ND	ND	ND
Engine cleaner	Automotive	ND	ND	ND	ND	ND	ND	ND	ND
Car polish	Automotive	ND	ND	ND	ND	ND	ND	ND	ND
Car polish	Automotive	ND	ND	ND	ND	ND	ND	ND	ND
Engine cleaner	Automotive	ND	ND	ND	ND	ND	ND	ND	ND

[a] PAHs tested were naphthalene (NA), acenaphthylene (AY), acenaphthene (AN), fluorene (FE), phenanthrene (PA), anthracene (AA), fluoranthene (FA), pyrene (PY), benz[*a*]anthracene (BA), chrysene (CH), benzo[*b+j*]fluoranthene (BF), benzo[*k*]fluoranthene (BK), benzo[*a*]pyrene (BP), indeno[*1,2,3-cd*]pyrene (IP), dibenz[*a,h*]anthracene (DA) and benzo[*ghi*]perylene (BG).

[b] Health Canada, 2014 (unpublished study)

[c] Household cleaning product (HCP)

[d] ND = Not detected

Appendix D. BTEX compositional testing of products available to the consumer

Table D.1. Results of testing for BTEX[a] in 24 Canadian products available to the consumer[b] (µg PAH per g sample) containing gas oils and kerosenes

Product (physical state)	Benzene	Ethyl-benzene	o-Xylene	m+p-Xylene	Toluene
Detection limit (µg/g)	0.5 / 5	0.5 / 5	0.5 / 5	1 / 10	0.5 / 5
Lemon oil	ND	ND	ND	ND	ND
Paste varnish [c]	ND	1200	1550	4700	943
Lemon oil	ND	7.8	27	25	9.0
Wood conditioner	ND	5	32	77	15
Glue remover	ND	ND	ND	ND	ND
Glue remover spray gel	ND	ND	ND	ND	1.1
Stainless steel cleaner [d]	ND	ND	ND	ND	ND
Hand cleaner	ND	ND	ND	ND	ND
Hand cleaner	ND	ND	ND	ND	ND
Mirror glaze [e]	ND	22	48	89	ND
Engine cleaner [f]	ND	290	2200	4100	49
Car polish [g]	ND	0.8	1	3	1.8
Car polish [h]	ND	ND	ND	ND	ND
Engine cleaner [i]	36	480	740	1500	530
Engine cleaner [j]	ND	36000	41000	120000	625
Color restorer and cleaner [k]	ND	9	19	38	3.7
Anti-rust [l]	0.6	15	34	88	7.2
Penetration oil [m]	ND	7.9	12	28	8.6
Blaster compound [n]	ND	14	19	52	9.4
Fuel kerosene	ND	1800	2800	4900	690
Mineral spirits	ND	1600	2550	4400	630
Liquid sander [o]	ND	ND	ND	ND	180000
Solvent	1.8	230	470	890	92
Waterproofing spray [p]	ND	26	37	117	8450

[a] Benzene, Toluene, Ethylbenzene, and Xylenes
[b] Health Canada, 2014 (unpublished study)
c Contains 8052-41-3 (10-30%)
d Contains 64742-52-5 (60-70%) and 64742-89-8 (10-20%)
e Contains 64742-14-9 (10-15%)
f Contains 64742-47-8 (60-100%) and 47-98-6 (7-13%)
g Contains 64742-48-9 (3-7%) and 8-12-95-1 (1-5%)
h Contains8052-95-1 (< 10%)
i Contains 68476-34-6 (60-100%), xylene (0.1 – 1%), naphthalene (1-5%)

j Includes xylene (10-30%) and ethylbenzene (1-10%) as ingredient in addition to GO and K
k Contains 8008-20-6 (10-15%)
l Contains 8052-41-3 (1-5%), 64742-81-0 / 64742-54-7 / 64742-52-5 / 64742-53-6 (3-7%), 74-98-6 (5-15%), 75-28-5 (5-10%)
m Contains 64742-52-5 and 64742-53-6 (30-60%)
n Contains 64742-65-0 (20-30%) and 64742-47-8 (30-40%)
o Contains toluene (20-40%)
p Contains 110-54-2 (70-90%) and 68476-86-8 (10-25%)

ND – Not detected

Appendix E. Exposure factors used in determining exposure of the general population to gas oils and kerosene products

Table E-1. Exposure factors for gas oil and kerosene components of products available to the consumer leading to general population exposure. The average Canadian adult weight of 70.9 kg was considered in all cases.

Product	Exposure factor / unit	Value
Car wax [a]	Product deposited on skin (g) Weight fraction of CAS RN	5.5 0.1
Special purpose (painters) hand cleaner [b]	Product amount (g) Weight fraction of CAS RN	1.5 0.1
Caulking / Adhesive sealant [c]	Product amount (g) Weight fraction of CAS RN	1.5 0.1
Spray Furniture polish [d]	Frequency of use per year Product amount on skin (g) Weight fraction of CAS RN	6 0.3 0.4
Multipurpose lubricant [e]	Surface area of finger tips both hands (cm^2) Thickness of oil film on hand (cm) Density of product (g/cm^3) Weight fraction of CAS RN	12 1.59×10^{-2} 0.85 0.98
Glue remover [f]	Product amount on skin (g) Weight fraction of CAS RN	0.08 0.3

[a] ConsExpo scenario for floor polish [RIVM 2006b]

[b] ConsExpo liquid soap hand wash scenario [RIVM 2006c

[c] ConsExpo joint sealant scenario [RIVM 2007]

[d] Based on ConsExpo scenario for all-purpose spray cleaner application [RIVM 2006b]

[e] Versar handbook thin film, instant application scenario [US EPA 2011]

[f] ConsExpo scenario for glue application from glue tube [RIVM 2007]

Table F-1. Gas oil and kerosene substances in ECHA carcinogenic, mutagenic, or reproductive toxin (CMR) list

CAS RN	CMR	Common name
8008-20-6	No	Kerosene
64741-43-1	No	NA
64741-44-2	No	Gas oil Middle petroleum distillate
64741-49-7	No	Vacuum tower condensate
64741-58-8	No	Light vacuum gas oils
64741-60-2	Yes - Carc. 1B	Cracked gasoil
64741-77-1	No	Cracked gasoil
64741-85-1	No	NA
64741-90-8	Yes	Solvent-refined gas oils
64741-91-9	Yes – Carc. 1B	Gasoil – unspecified
64742-06-9	No	Middle distillate solvent extract (petroleum)
64742-13-8	Yes - Carc. 1B	Acid-treated middle distillate (petroleum) Gasoil - unspecified
64742-14-9	Yes - Carc. 1B	Acid-treated light distillate (petroleum) Gasoil - unspecified
64742-30-9	Yes - Carc. 1B	NA
64742-31-0	No	Chemically neutralized light distillate (petroleum), Kerosene - unspecified
64742-38-7	Yes - Carc. 1B	NA
64742-46-7	Yes - Carc. 1B	NA
64742-47-8	No	dearomatized kerosene, deodorized kerosene
64742-72-9	No	NA
64742-77-4	No	Complex dewaxed middle distillate (petroleum)
64742-79-6	Yes - Carc. 1B	Hydrodesulfurized gas oils
64742-81-0	No	Kerosene - unspecified
64742-87-6	No	Hydrodesulfurized light vacuum gas oil (petroleum)
64742-88-7	No	Medium aliphatic naphtha, straight run kerosene, straight run white spirit
64742-91-2	No	Cracked kerosene
64742-94-5	No	Heavy aromatic naphtha
64742-96-7	No	straight run kerosene
68333-88-0	No	NA
68477-30-5	Yes - Carc. 1B	Gasoil – unspecified, light aromatic (petroleum)
68477-31-6	Yes - Carc. 1B	Aromatic solvent (petroleum) Gasoil - unspecified Steam-cracked petroleum distillates
68814-87-9	No	Full range straight run middle distillate (Petroleum)
68915-96-8	No	NA

CAS RN	CMR	Common name
68915-97-9	No	NA
68919-17-5	No	Heavy alkylate hydrocarbons
68921-07-3	No	Light catalytic cracked petroleum distillate, hydrotreated
92704-36-4	No	NA
128683-26-1	No	NA
128683-27-2	No	NA
128683-28-3	No	NA
128683-29-4	No	NA
128683-30-7	No	NA
129893-10-3	No	NA