Human health risks associated with aerially applied fire retardants

Screening level risk assessment

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Executive summary

Fire retardants are applied during wildfires to wildland fuels to render them non-flammable in an attempt to stop or slow the spread of fire. This report presents the results of a Screening Level Risk Assessment (SLRA) related to the general public being exposed to applied fire retardants when returning to a residential property following a wildfire. The intent of this SLRA is meant to be conservative, applying assumptions that ensure that exposures and risks are not underestimated.

Safety Data Sheets and manufacturer information were relied on to compile the list of contaminants of potential concern present in fire retardants used in Alberta. Chemicals of potential concern (COPC) included ammonium phosphates, sodium hexacyanoferrate, iron oxide and clay.

Human receptors were identified based on residential land use where all age groups and members of the general public are assumed to be potentially present. Exposure pathways assumed to be operative, for which exposure was estimated, included the ingestion of drinking water impacted with fire retardants via an on-property cistern, the ingestion of garden produce where fire retardants have been deposited, and direct contact (incidental ingestion, dermal contact and inhalation of particulates) with residual fire retardants. Residents were assumed to return to their property immediately following the application of fire-retardant products.

Total exposure doses for the noted exposure pathways were calculated for each COPC based on receptor and building characteristics specified by Health Canada and CCME. None of the COPC were classified as carcinogens; however, toxicology information on all COPC was lacking and no published toxicity reference values (TRV) were available. No observed adverse effect limits (NOAEL) from primary literature, along with appropriate uncertainty factors, were applied as TRVs.

Risk in this SLRA was characterised by the outcome of the exposure and toxicity assessments whereby the estimated exposure to a COPC was divided by a TRV specific to that COPC; a ratio greater than 0.2 indicates the potential for human health risk. With results substantially above 0.2 for all COPC except iron oxide, the results clearly indicate that aerial deposition of fire retardants present potential risks of adverse health effects. The predicted risks were driven by direct consumption of the COPCs in drinking water and garden produce.

While a high level of conservatism has been built into the assessment, the magnitude of the predicted risk supports the conclusion that garden produce and water impacted by fire retardants during a wildfire event should not be consumed. Important to keep in mind within the context of the conclusions is that many of the primary constituents of these fire-retardant products are sold in commercially available fertilizers.

Based on these results, the following recommendations were developed for residents returning home after the application of aerially applied fire retardant:

- Direct ingestion of residual fire retardant should be avoided by:
    - disposing of garden produce and drinking water that has been directly impacted;
    - avoiding the harvest of country foods for consumption (i.e., berries, mushrooms, or herbs) that have been directly impacted;
    - cisterns, or other drinking water sources, that may have been impacted should be thoroughly rinsed to remove precipitate on tank bottoms; and
    - surfaces that drain into drinking water surfaces should be cleaned.
- Consideration should be given to cleaning sand boxes, outdoor toys and pools where children may inadvertently ingest residual fire retardant through hand-to-mouth contact and play.

Acknowledgements

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List of abbreviations

AEP – Alberta Environment and Parks

ATSDR – Agency for Toxic Substances and Disease Registry

AH – Alberta Health

CCME – Canadian Council of Ministers of the Environment

COPC – Contaminant of Potential Concern

HQ – Hazard Quotient(s)

HHRA – Human Health Risk Assessment

IARC – International Agency for Research on Cancer

MEMS – Millennium EMS Solutions Ltd.

NOAEL – No Observed Adverse Effect Limit

OEHHA – Office of Environmental Health Hazard Assessment

RIVM – National Institute of Public Health and the Environment

SDS – Safety Data Sheet

SLRA – Screening Level Risk Assessment

TCEQ – Texas Commission on Environmental Quality

TDI – Tolerable Daily Intake

TRV – Toxicity Reference Value

USDA – United States Department of Agriculture

USEPA – United States Environmental Protection Agency

WHO – World Health Organization

1. Introduction

Alberta Health (AH) retained Millennium EMS Solutions Ltd. (MEMS) to prepare a Screening Level Risk Assessment (SLRA) related to the general public being exposed to aerially applied fire retardants used during wildfires. The intent of this SLRA is meant to be conservative, applying assumptions that ensure that exposures and risks are not underestimated. If negligible or acceptable human health risks are indicated using conservative methods, then actual exposure will almost certainly present acceptable risks (Health Canada, 2012). Where SLRA indicates a potential for human health risk, further assessment may be necessary to refine conservatism and add precision, if warranted.

Within this work, a hypothetical exposure scenario considered members of the general public returning to a residential property where aerially released fire retardants were applied during a wildfire. This SLRA followed the four sequential steps of risk assessment - beginning with problem formulation, followed by exposure and toxicity assessments and finally risk characterization. This work provides a scientifically defensible presentation of the potential health risks to the general public from exposure to aerially applied fire retardants in a wildfire scenario.

Safety Data Sheets (SDSs) and manufacturer information were relied on to compile the list of contaminants of potential concern (COPC) present in fire retardants. Chemical and toxicity information from governmental sources were used to complete the exposure and toxicity assessments. The Alberta Forest Service of Alberta Agriculture and Forestry indicated that only Phos-Chek® and Fire-Trol® brands of fire retardant are used in the province of Alberta during wildfires and only these products were considered in this work (G. Boyachuk 2019, personal communication, March 7).

2. Objectives

The objectives of this work were to estimate human exposure to fire retardants in various media following use during a wildfire, to characterise the potential human health risks from these exposures and to provide appropriate and valuable public health advice for residents returning to an area impacted by fire retardant use.

3. Scope of work

The SLRA scope of work consists of the four steps typical for a human health risk assessment (HHRA): problem formulation, exposure assessment, toxicity assessment and risk characterization. The overall SLRA methodology followed guidance published by Health Canada (Health Canada 2012) and is summarized below:

1. Problem formulation - identification of chemicals of potential concern (COPCs), vulnerable human receptors, potentially operative exposure pathways, COPC fate and persistence, and development of a conceptual model;

2. Exposure assessment - estimation of an exposure dose for each receptor, COPC and operative exposure pathway identified in the problem formulation;

3. Toxicity assessment - determination of the relationship between the dose of chemical over a specified exposure duration and the potential for adverse health effects; and

4. Risk characterization - evaluation of potential risks to human receptors based on the outcome of the exposure and toxicity assessments.

3.1 Out of scope items

1. The work focused on constituents listed in Phos-Chek LC95A and Fire-Trol. Fire retardants as gels and foams are not within the scope of this activity.

2. Detailed food chain multimedia modelling was not considered.

3. Fire retardants may contain from 8% to 15% w/w performance additive, which is listed as proprietary. Health risks could not be determined for unknown performance additives.

4. Occupational exposure to aerially applied fire retardants was not considered.

5. Public exposure was considered from a post-release wildfire scenario. Human exposure *via* aerial drenching was not considered.

3.2 Key questions

Four key questions were developed with Alberta Health to focus the SLRA:

1. Are there human health risks predicted from exposure to fire retardants in drinking water sources, animals (*e.g.,* agricultural livestock through irrigation canals), and other media (*e.g.,* ambient air, soil, and food/vegetation)?

2. What are the common contaminants of potential concern (COPCs) or other possible surrogates for health risks associated with fire retardants?

3. What critical considerations should be made in terms of human health risks from exposure to fire retardants?

4. What public health advice and/or management action can be suggested based on the findings from the above?

4. Aerially applied fire retardants

Fire retardants are applied during wildfires to wildland fuels (*i.e.,* vegetation architecture and detritus) to render them non-flammable in an attempt to stop or slow the spread of fire. Fire retardants are classified as short- or long-term; all products applied during wildfires in Alberta are considered long-term. The primary difference between the two classes is how the retardant inhibits combustion, long-term retardants create a barrier between the fuel and the fire, whereas short-term increase water efficiency and relies on cooling the fire (Alberta Wildfire, 2012). Long-term retardants will coat the fuel sources and the water in the retardant will start to evaporate as the fire gets closer. The retardant reacts with cellulose in the vegetation and a non-flammable coating is left behind which insulates and restricts air flow. This process cools and suffocates the fire and creates a fire that is fuel-starved (ICL Performance Products LP, 2009).

Long-term fire retardants are generally comprised of salts like ammonium phosphate, thickening agents, colouring agents, spoilage and corrosion inhibitors (Alberta Wildfire, 2012). Long-term fire retardants come in a concentrated powder or liquid and are mixed with water prior to being aerially dropped. The flow-rate and drop height of the retardant and airspeed will change depending on variables such as wind speed and fire behaviour in order to create the most appropriate coverage area and coverage level (USDA, 2000). Retardants are applied outside the perimeter of the fire to prevent progression of the fire and create a fire break (ICL Performance Products LP, 2009).

5. Risk assessment methodology

HHRA aims to characterise potential risks of adverse health effects from chemical exposure. Risk in this SLRA was characterised by the outcome of the exposure and toxicity assessments whereby the estimated exposure to a COPC was divided by a toxicity metric specific to that COPC; a ratio greater than 0.2 indicates the potential for human health risk. Again, further assessment to refine conservatism and add precision would be recommended where risks are predicted in SLRA. The risk assessment methodology adhered to the standard risk assessment paradigm recommended by Health Canada (2012); hazard assessment in the context of this report is analogous to toxicity assessment (Figure 1 below).

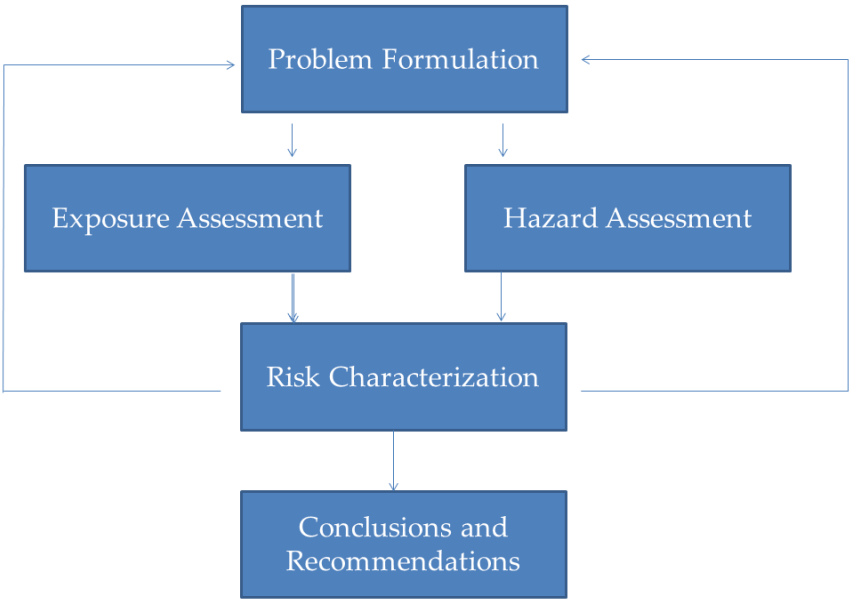

Figure 1: Risk assessment paradigm

6. Problem formulation

6.1 Contaminant of potential concern

The problem formulation involved the identification of COPCs from published ingredients in fire retardants aerially applied in the province of Alberta during wildfires, which was completed through a review of SDSs, and other available information from manufacturers. All listed ingredients in Phos-Chek and Fire-Trol products were carried as COPC. Compound specific physical and chemical properties (*i.e.,* water solubility, half-life) and other characteristics that influence transport and persistence were evaluated to construct a conceptual model of potential exposure.

Products included in the COPC list are constituents listed in the Phos-Chek® and Fire-Trol® SDSs. The SDS reviewed for constituent inclusion included: Phos-Chek LC95A, Phos-Chek LC95A-Fx, Phos-Chek MVP-F, Phos-Chek MVP-Fx, Fire-Trol 931 and Fire-Trol 931 R (Appendix A). All listed ingredients from these products were retained as COPCs, listed below in Table 1. The manufacturer use sheets for these products are provided as Appendix B.

TABLE 1: CHEMICALS OF POTENTIAL CONCERN

COPC	Component Percentage in Product
Ammonium Polyphosphate[1]	> 85%
Monoammonium Phosphate	75 – 85%
Diammonium Phosphate	8 – 12 %
Sodium Hexacyanoferrate	0.1 – 3%
Attapulgus Clay	< 5%
Iron Oxide	< 5%

[1] Fire-Trol 931-R has an Ammonium Polyphosphate range of 80-95%. A value of 85% was applied representative of other products used in the province and within the range of Fire-Trol 931-R.

Phosphate is listed as a component on the Phos-Chek MVP-Fx SDS. The Chemical Abstract Service (CAS) numerical identifier for this compound is 7783-28-0, which is the same as the CAS numerical identifier listed for diammonium phosphate on the Phos-Chek MVP-F SDS. As such, phosphate has not been added to the COPC list. Performance additives were also listed but the identity of propriety compounds were not disclosed and therefore could not be tabulated. Performance additives were listed as including one or more substances to impact various product functionalities including gum thickener, flow conditioner, colouring agent and/or corrosion inhibitors (ICL Performance Products LP, 2009).

6.2 Environmental fate of COPC

To better understand the fate and exposure of COPCs they were divided into three different functional categories based on their compound class, and/or physical properties (Appendix C, Table C.1). These categories are salts, emulsifiers, and smoke suppressants.

Inorganic compounds or conservative solutes like salts and metals do not degrade. The solubility of the COPC are listed in Table C.2. Salts have higher relative solubility and would dissolve when in contact with water (*i.e.,* rain or surface water). Once the fire retardants have been dropped and dried on property surfaces, the salts have the potential to dissolve and migrate with water during rain events, and infiltrate into the soil profile. The potential for these compounds to be translocated into plants *via* shallow groundwater and soil uptake exists; many of these salts are component ingredients in commercial fertilizers. Iron oxide and clay are insoluble and would be expected to primarily stay on surfaces where deposited (see Table C.2, U.S. National Library of Medicine, n.d.d.; U.S. National Library of Medicine, n.d.g.).

6.3 Identification of receptors

Human receptors were identified based on residential land use where all age groups and members of the general public are assumed to be potentially present. Residential exposure has the potential to be daily, year-round exposure. Potential

domestic receptors include all age groups: infants, toddlers, children, teens, and adults who are exposed *via* their age-specific loading or intake rates as defined by Health Canada (2012).

Recently, vulnerable populations have been defined by Health Canada as "a group of individuals within the general Canadian population who, due to either greater susceptibility and/or greater exposure, may be at greater risk than the general population of experiencing adverse health effects from exposure to chemicals" (Government of Canada, 2019). The residential land use scenario as defined by Health Canada considers all age groups and residentially appropriate exposure pathways and is expected to be protective of vulnerable populations. Receptors that may experience higher relative exposure to fire retardants include persons living at residences where garden produce and private water (*i.e.,* cisterns) are relied on.

6.4 Identification of exposure pathways

The exposure scenario thought to represent the highest potential exposure considers the aerial deposit of fire retardant directly onto a residential house, garden, and into a drinking water source. Health Canada and the Canadian Council of Ministers of the Environment (CCME) have identified several human exposure pathways that must be considered for all land uses, including direct contact with soil (comprised of soil ingestion, dermal contact with soil and inhalation of soil particulates), indoor vapour inhalation and the protection of potable water sources (Health Canada, 2010a; CCME, 2006). Additional pathways are also considered in this scenario as outlined below.

Potable water ingestion
Ingestion of groundwater is expected to provide negligible exposure to fire retardants relative to exposure from a domestic cistern and as such was not considered further. Water sources that are likely more of a concern are local cisterns that are either open to the air or collect roof water, as well as local surface water used for drinking, particularly in the north of the province where groundwater supply may not meet domestic needs. The potential for fire retardants to enter drinking water sources exists, and therefore the domestic use of water sourced from an on-property cistern was considered an operative exposure pathway.

Water ingestion was considered to be an operative pathway for infants, who may consume powdered formula mixed with a potable water source.

Ingestion of garden produce
Direct ingestion of garden produce where fire retardants have been deposited, as well as the ingestion of plants where COPC have translocated into tissues from soil and groundwater is possible, this pathway was considered operative. It is possible that impacted water could be used to water vegetable gardens; however, direct deposit of fire retardants onto plants would a greater source of exposure and therefore the uptake of COPC via water into plants was not additionally considered.

Direct contact
For the purposes of this assessment, direct contact with residual fire retardant was assumed to be operative. This pathway includes the incidental ingestion and dermal contact with fire retardants present on the property as well as the inhalation of particulates sourced from dried residual fire retardant (*i.e.,* inhalation of fugitive dust).

Dermal contact via water
Fire retardant could be introduced into residential cisterns or surface water bodies. Receptors could be exposed to the COPC any time skin comes in contact with impacted water (*i.e.,* bathing, swimming). Based on the low dermal contact time of water, the uncertain absorption of inorganic from water exposure from this pathway was not calculated at the screening level stage of this work but expected to be a very low contribution to overall exposure.

Vapour inhalation
None of the COPC reviewed are considered volatile and as such this pathway was not considered operative.

6.5 Conceptual model

Within a risk assessment, the conceptual model provides the basis for the connection between the presence of a COPC in the environment and the exposure of a receptor. A pictorial of the conceptual model for human exposure to aerially applied fire retardants in a residential land use scenario is presented in Appendix D. A tabular summary of the conceptual model is presented below in Table 2.

TABLE 2: CONCEPTUAL MODEL

		Operable Exposure Pathways				
Land Use	**Receptors**	Potable Water Ingestion	Ingestion of Garden Produce	Direct Contact	Dermal Contact *via* Water	Vapour Inhalation
Residential	Infant	✓		✓	✓	
	Toddler	✓	✓	✓	✓	
	Child	✓	✓	✓	✓	
	Teen	✓	✓	✓	✓	
	Adult	✓	✓	✓	✓	

7. Exposure assessment

The objective of the exposure assessment is to estimate the amount of COPC to which a person may be exposed, considering the total contribution of all potentially complete exposure pathways. Total exposure was comprised of contributions from water ingestion, ingestion of garden vegetables, and direct soil contact (inadvertent soil ingestion, particulate dust inhalation and dermal contact with soil).

The human exposure assessment considered the following hypothetical scenario – during a wildfire event, commercially available fire retardants used by the Alberta Wildfire service, as per the manufacturer's specifications, were dropped from the air directly onto a single dwelling residential property resulting in:

- retardant mixture being dropped directly onto the roof of a house;
- all product on the roof being transferred via rainwater into a cistern used for domestic purposes, assumed to be the sole source of domestic water for all age groups.
- Lands around the home, including a vegetable garden, also received the aerially applied fire retardant product at the same rate.

Residents were assumed to return to their property immediately following the application of fire-retardant products. All age groups were assumed to eat unwashed produce from the garden. Dermal exposure was predicted via soil loading to hands, arms and legs for all age groups. This scenario overall is thought to be highly conservative and represent the upper bounds of exposure for all possible age groups present.

Both short- and long-term exposures are potentially applicable to the scenario presented above. Short-term or acute exposure would be immediately after the aerial application and long-term exposure is expected to be represented by exposure extending beyond one year from the aerial application. The reported half-life of the ammonium polyphosphate is 0.49 year. Meaning that for this compound exposure would diminish with time, in roughly 6 months following the aerial application half the mass applied would remain. Notable, iron oxide, like other metals, does not break down over time.

7.1 Exposure calculations

Exposure doses were calculated for each COPC based on receptor characteristics specified by Health Canada and CCME, as summarised in Appendix C, Table C.3. No relative dermal absorption rates were available so a value of 1% was assumed, as per inorganic compounds in Health Canada (2010b). Receptor-specific garden vegetable ingestion rates were applied, with the exception of infants, where no vegetable ingestion was considered (Appendix C, Table C.3).

The exposure term defines the exposure over the time-period for receptors. In this assessment total exposure dose from all pathways is expressed as mg/kg body weight/day. Exposure calculations were performed using equations published by Health Canada (2010a) for detailed quantitative risk assessment; details of the formulas used and a worked example for ammonium polyphosphate are presented in Appendix E.

Prior to estimating the contributions to overall exposure from the identified operative pathways, this assessment first required the calculation of individual COPC concentrations in soil, drinking water and garden produce after the application of aerially applied fire retardants. A full worked calculation for one compound is presented in Appendix E, Section 4.0. The maximum percent composition for each compound was applied to determine the concentration of COPC in the applied mixture. This assessment considered one aerial application only, using the published application rate for a wildland fire of 0.815 L/m^2 (USDA, 2000; Phoschek, n.d.a). For the purposes of the hypothetical scenario, the wildlands in this instance were defined as conifer stands with grass, short-needle closed conifer stands, and summer hardwood. In an actual wildfire event, application rates differ depending on the fire behavior and the amount of expected fire fuel from deadfall. The application rate can in some instances range up to three times the rate applied herein (USDA, 2000; Phoschek, n.d.a). If risks are predicted using the low application rate, it can be assumed that risks would be magnified with higher application rates.

The estimation of COPC concentrations in drinking water considered that the fire retardant applied to the roof of a standard dimension house (AEP, 2019), flowed into a 5,500 L cistern. This size of cistern was selected to represent the minimum volume to support consistent domestic supply requirements (Government of Manitoba, 2014).

Exposure calculations for soil first required a soil concentration for each COPC to be calculated after the fire retardant was deposited. Based on the aerial application soil will not be homogenously impacted but rather the surface horizon of the soil will be disproportionately impacted. Fire-retardant, applied as a liquid to soil will infiltrate slightly into the soil profile. The

eventual infiltration depth, immediately after application, will be a function of complex variables like soil porosity, moisture content, and vegetation cover. Assuming no mixing or infiltration of the fire-retardant applied to soil that people could be exposed to was considered overly conservative and would inaccurately bias risk. As such an infiltration and mixing depth of 15 cm, which aligns with the CCME (2006) mixing depth for agricultural soils, was applied to determine final soil concentrations to which receptors may be exposed.

The majority of fire retardant applied to plants will not be retained due to the hydrophobic properties of plant surfaces. Published data on water retention for vegetable surface is lacking, and no peer reviewed information on plant retention of applied fire retardants were available. Primary literature is focused on the wettability, or agricultural spray adherence through the use of surfactants and are not appropriate for this assessment. Wang *et al*., quantified the average leaf water retention from 60 plants, where leaves were fully submerged in water (Wang *et al*., 2014). Based on the published average retention metric and the large number of plants used in this study, this data source was viewed as the most appropriate for plant retention of fire retardant and applied herein. Exposure concentrations from garden produce is a function of the surface retention and the applied concentration. Literature screening to identify available literature or guidance on soil or dust lost during harvesting was completed, no usable information was identified (Table C.4). To account for the loss of adhered product during food harvesting, and to align possible exposure with reasonable worst-case rather than absolute worst-case exposure, a harvesting loss factor of 0.5 was applied. The exposure scenario and inputs applied in the calculation of exposure are presented in Appendix C, Table C.5.

While plants may uptake COPC from soil and porewater through translocation, concentrations *via* this route would be significantly less than surface retention. Due to the minor contribution plant uptake represents to overall exposure, plant uptake has not been calculated. Additionally, ammonium phosphate compounds are components in fertilisers and are metabolised by plants; therefore, plant tissues are not expected to bioconcentrate these compounds.

Calculated exposure by pathway for each age group are presented for each evaluated COPC in Tables C.6 through C.10; note that risk for attapulgus clay could not be evaluated and is discussed below. Exposure for all age groups is driven by ingestion pathways. The contribution to predicted exposure is largest from the drinking water pathways across all age groups and COPCs, with the exception of ammonium polyphosphate and iron oxide which have lower relative solubility. For these compounds, the ingestion of garden produce drives predicted exposure. Direct soil contact pathways (incidental soil ingestion, inhalation of fugitive dust, and dermal contact) resulted in substantially smaller contributions to overall exposure, by orders of magnitude, and represent negligible contributions to overall exposure.

8. Toxicity assessment

The toxicity assessment involves establishing the relationship between the amount of a chemical to which a person is exposed over a specified duration, and the potential for adverse health effects. The exposure limit, or the amount of chemical identified to be a safe exposure concentration is the toxicity reference value (TRV).

Chemicals are typically divided into two categories for the purposes of human health risk assessment: threshold and non-threshold (carcinogenic) chemicals. Threshold chemicals, which are generally non-carcinogens, are chemicals for which it is believed a certain minimum dose (the "threshold") must be exceeded before adverse effects are expected to occur. In this assessment none of the COPC were classified as carcinogens and a tolerable daily intake (TDI) for threshold chemicals has been applied as the TRV. The TRV is expressed as units of mg chemical/kg body weight/day (Health Canada, 2010b).

Toxicology information on all COPC was lacking and no published TRV were available from the following agencies:

- Health Canada;
- United States Environmental Protection Agency (USEPA);
- Agency for Toxic Substances and Disease Registry (ATSDR);
- National Institute of Public Health and the Environment (RIVM);
- World Health Organization (WHO);
- International Agency for Research on Cancer (IARC);
- Texas Commission on Environmental Quality (TCEQ); and
- California Office of Environmental Health Hazard Assessment (OEHHA)

As per Health Canada guidance, if a TRV is not available from an accepted governmental agency, a TRV can be developed from primary literature. Guidance on the toxicology endpoints, indicate that a no observed adverse effect limit (NOAEL) is preferred along with the application of uncertainty factors as appropriate. A search for available and applicable toxicology information was completed, the results of which demonstrated that toxicology information is lacking for all COPC (Appendix F). However, NOAELs based on two short-term studies on and one chronic study were identified; the NOAELs from the short-term studies apply to the ammonium-based COPC and iron oxide, and the NOAEL from the chronic study applies to sodium hexacyanoferrate. The limitations in toxicity data for each COPC are described below.

No appropriate toxicology information was identified for attapulgus clay, or bentonite clay, which could serve as a possible surrogate. Risk therefore could not be quantified for this COPC; however, the lack of toxicity information indicates that this compound has not been highlighted for toxicology review by regulatory agencies, suggesting it is of low concern. Attapulgus clay is a natural clay substrate, sourced from Attapulgus, Georgia in the United States, that contains the mineral attapulgite believed to be soils sources from marine and lacustrine deposits (Galan and Pozo, 2015).

For ammonium phosphate compounds (CAS 7722-76-1, 7783-28-0, 68333-79-9), a single NOAEL based on blood chemistry deviations in rats following 35-days of oral exposure was identified from the Organisation for Economic Co-operation and Development (OECD) (OECD, 2007). Considering the level of detail provided in the OECD study, the professional reputation of the OECD, and the lack of other publicly available toxicity data for ammonium polyphosphate compounds, this NOAEL was selected for TRV development for ammonium polyphosphate, monoammonium phosphate and diammonium phosphate. However, the primary literature source of this information was not available and the OECD notes that due to proprietary restrictions their cited primary information was not available for review. Notably, the OECD commented that these chemicals are of low priority for further work. The hazards identified included: slight skin and eye irritation, respiratory tract irritation, repeated-dose toxicity and body weight changes in offspring - but these effects were only evident at extreme exposure levels (i.e., well above the NOAEL) (OECD, 2007).

A single NOAEL was identified for sodium hexacyanoferrate based on renal effects in rats exposed in their diet for 2-years. Study details were summarised in a re-evaluation for use as a food additive published by the European Food Safety Authority (a branch of the European Union) (EFSA, 2018). However, the primary reference for the NOAEL provided no study details. Summarized details indicated that rats frequently showed a higher cell (unreported type) excretion rate in urine samples and the kidney was noted as the target organ for ferrocyanide toxicity. Based on the level of detail provided about the study in the

summary, the professional reputation of the EFSA and the lack of publicly available toxicity data, this NOAEL was used to generate the TRV for sodium hexacyanoferrate.

A single NOAEL was identified for iron oxide based on a 13-week oral gavage study in rats, no systemic toxicity was noted at the highest dosing level which was ultimately set as the NOAEL. This NOAEL was reported by the EFSA and the primary information was available for review and selected for TRV development (Yun *et al*., 2015).

A total uncertainty factor of 100 comprised of 10 to account for inter-species variability and 10 to account for intra-species variability was applied to all selected NOAELs. A summary of the TRVs used in the SLRA are presented in Appendix C, Table C.11. Based on the lack of published toxicity information for all COPC, and the conservative use of uncertainty factors, the overall confidence in these TRVs is low.

9. Risk characterization

9.1 Objectives of risk characterization

Risk characterization is the quantification and evaluation of the estimated risks and hazards resulting from exposure to COPCs. It is the stage where the results of the human exposure and chemical toxicity assessments are combined to evaluate potential risk of chemical exposure to human receptors.

9.2 Estimation of risk

Risks are characterized using hazard quotients (HQ). An HQ is simply the ratio of the predicted exposure (dose) to the appropriate toxicity reference value (TRV).

Derivation of HQ quotient value is provided below:

$$HQ = \frac{Exposure\ Dose}{TRV}$$

Where:

HQ	=	hazard quotient
Exposure Dose	=	estimated dose (mg/kg bw-day)
TRV	=	toxicity reference value (mg/kg bw-day)

An HQ less than 1.0 indicates that predicted exposures are less than the applied TRV and adverse effects are not expected. Although the likelihood of these COPCs to exist in multiple environmental compartments outside a wildfire event is low (*i.e.,* soil, water, air, store bought food, commercial products), an HQ value of less than 0.2 was conservatively applied as an acceptable threshold in the SLRA as per guidance from Health Canada (2010).

Overall toddlers were determined to be the critical receptor based on their higher relative exposure based on body weight, and considering infants were assumed not to consume garden produce. HQ values of 194 (sodium hexacyanoferrate), 137 (monoammonium phosphate), 16.0 (ammonium polyphosphate), 29.8 (diammonium phosphate), and 0.00453 (iron oxide) were calculated for toddlers. All calculated HQ values are presented in Table C.12. These HQ results represent an acute exposure scenario, immediately after aerial application of fire retardants.

With HQ results substantially above 0.2 for all COPC except iron oxide, the results clearly indicate that aerial deposition of fire retardants present potential risks of adverse health effects. The predicted risks were driven by direct consumption of the COPCs in drinking water and garden produce.

Although a high level of conservatism has been built into the assessment, the magnitude of the results supports the conclusion that garden produce and water impacted by fire retardants during a wildfire event should not be consumed. Mitigation of these sources (*e.g.,* disposal of impacted garden produce, disposal of water within cisterns and cleaning of cistern and associated collection surfaces) is indicated.

Hazard quotients calculated for dermal exposure and inhalation of residual COPC in soil were well below 0.2. These results indicate a low risk of potential adverse effects associated with dermal or inhalation exposure to residual COPC in soil for both acute and chronic exposures.

In a chronic exposure scenario, post clean-up or remediation, the contribution to overall exposure from the ingestion of drinking water or surface impacted plants would be nil due to remediation requirements (further expansion below). Operative pathways in a chronic exposure scenario would then include contact with impacted soil and the ingestion of plants and animal products that have taken up COPC into tissues from impacted soil. Based on the acute exposure tables (Table C.6 through C.10) exposure from direct contact pathways (dermal soil contact, particulate inhalation, and inadvertent soil ingestion) contribute a very small amount to overall exposure and risk would not be expected following chronic exposure *via* these pathways. Considering the half-life of ammonium polyphosphate, the environmental residence time of the ammonium-based compounds would diminish with time and therefore not pose a concern over the long-term. Iron oxide, like other metals, does not degrade and sodium hexacyanoferrate has no available half-life; these compounds may have the potential for chronic exposure. No information on the uptake and potential bioconcentration of iron oxide or sodium hexacyanoferrate in plant or animal tissues are available; however, based on the chemical properties and existing data on chemical bioconcentration, only

iron oxide is expected to have this potential (Baes *et al*., 1984). While the uptake of COPC into consumable animal or plant tissues is expected to be low, this remains as a data gap. Despite this, chronic exposure following clean-up is not expected to result in HQs above the applied 0.2 threshold.

10. Data gaps and uncertainties

Risk assessments are affected by a variety of uncertainties due to data limitations, uncertainty in various applied parameters and exposure scenario assumptions. Specific uncertainties and data gaps related to the current SLRA, and their potential effects on the results of the risk assessment are discussed below.

- The toxicology data set for all COPC is lacking. Only a single NOAEL was available for many of the COPC and the primary scientific documentation of the NOAELS were in some cases proprietary and not available for review. This leads to a low confidence in the selected TRV.
- No toxicology information was available for attapulgus clay and the health hazard posed by this compound remains as a data gap. However, the lack of toxicity information indicates that this compound has not been highlighted for review by regulatory agencies and is of low overall concern.
- The health risks posed by the proprietary component of evaluated fire retardants could not be evaluated and remains as a data gap.
- The health risks predicted from exposure to individual COPC with limited toxicity data may underestimate risks from combined exposure to all COPC plus the proprietary components present in the fire retardant being applied.
- Compound specific dermal absorption factors are not available for any of the COPCs, as per Health Canada guidance (2010), a default dermal absorption factor of 1% was applied. Exposure from dermal absorption may be over-predicted, the magnitude of which is uncertain.
- The infiltration rate, or soil depth over which the applied compounds would mix within, is uncertain. The assumed depth of 15 cm is believed to be conservative; the infiltration depth would be expected to be much deeper over time. This conservative value was applied at the screening level assessment of this work and likely over-predicts risk as the half-life of ammonium-based COPC is reported to be less than 1 year (Table C.2), the magnitude of which is uncertain.
- Little information is available in the literature on leaf water retention, and no information was available on aerially applied fire retardant retention on plant surfaces. A literature value measuring water retention on plant surfaces was applied, and the appropriateness of this application to fire retardants is uncertain but believed to be appropriate based on the large number of plants presented in the study.
- A preliminary review of plant or animal tissue uptake in primary literature, indicated these metrics are a data gap for iron oxide and sodium hexacyanoferrate. While expected to be low, the contribution of tissue uptake by plants or animals to chronic exposure could not be quantified.
- The ingestion of impacted garden produce assumes that all of the fire retardant that was retained, or portion adhering to plant surface after aerial application, was ingested (*i.e.,* no mass retained on surfaces was physically removed *via* washing or from precipitation). This assumption is believed to be highly conservative and likely over-predicts the contribution of exposure from the ingestion of garden produce, the magnitude of which is uncertain.
- To calculate the concentration represented on garden produce, the area of a lettuce leaf taken from the literature was applied as a surrogate for all vegetables. This is believed to be highly conservative and may over-predict risk for from garden vegetable ingestion, the magnitude of which is uncertain.
- Iron oxide may have the potential to bioconcentrate in plant tissues over-time, relative to soil concentrations. No published bioconcentration factors for iron oxide in garden produce are available. However, while the contribution of plant uptake to overall exposure is uncertain it is expected to be essentially negligible relative to the surface retention of applied retardant.
- Any contribution from background exposure to COPC is believed to be essentially negligible, most COPC are not natively present in the environment. Background exposure has not been considered and the precise contribution to overall exposure from background exposures is unknown.

Overall, the risk assessment is believed to provide a reasonable worst-case estimate of potential exposure and provides a conservative estimate of potential human health risks.

11. Conclusions and recommendations

Risk to all age groups in a residential land use scenario after the aerial application of fire retardants was evaluated. The hypothetical residential exposure scenario assumed that aerially applied fire retardant was dropped directly onto a house impacting a cistern that collected rainwater for domestic purposes and lands surrounding the house including a residential garden. The SLRA was designed to be conservative, aiming to not under-predict exposure. The assessment incorporated a number of conservative assumptions related to exposure, including but not limited to: residents are assumed to spend all their time on the impacted property upon return, garden produce is ingested without washing, and the house-associated cistern is the sole source of water for drinking and domestic purposes. One utility of quantifying potential risks represented by a worst-case exposure scenario is that conclusions are clear and have less ambiguity. Risk in this scenario was quantified after one aerial pass releasing fire retardant at the minimum recommended level for a conifer wildlands fuel source. Therefore, this assessment is thought to represent the worst-case exposure for residents at the minimum application rate of aerially applied retardant. Wildfire response is often urgent and unpredictable – it may be difficult for responders to accurately report on the number of aerial passes or coverage rates that were applied to properties in all circumstances. As such, if risk is predicted after one aerial pass using the minimum application rate, risk would be predicted in all application scenarios.

Important to keep in mind within the context of the conclusions is that many of the primary constituents of these fire-retardant products are fertilizers, sold commercially as a bioavailable form of phosphate that easily blends with nutrient mixes. Exposure protection recommendations in the form of personal protection equipment and product labelling to avoid direct consumption accompany these agricultural products. Environmental residence for these ammonium-based salts, and other fertilizers, diminishes with time through biological uptake and loss through soluble transport.

For an acute exposure scenario where people are exposed immediately after application, hazard quotients greater than 0.2 were calculated across age groups for ammonium polyphosphate, monoammonium polyphosphate, diammonium phosphate and sodium hexacyanoferrate; with the latter resulting in the largest HQ. Exposures, and therefore risk, are driven by the ingestion of impacted drinking water, followed by the ingestion of impacted garden produce for most COPC. Direct contact with impacted soil (comprised of inadvertent ingestion, particulate inhalation and dermal soil contact) contributed a substantially smaller component to overall exposure with HQs orders of magnitude below the accepted threshold (0.2). Exposure from these pathways is considered essentially negligible.

Based on these results, the following recommendations may be appropriate for residents returning home after the application of aerially applied fire retardant:

- Direct ingestion of residual fire retardant should be avoided by:
    - disposing of garden produce and drinking water that has been directly impacted;
    - avoiding the harvest of country foods for consumption (*i.e.,* berries, mushrooms, or herbs) that have been directly impacted;
    - cisterns, or other drinking water sources, that may have been impacted should be thoroughly rinsed to remove precipitate on tank bottoms; and
    - surfaces that drain into drinking water surfaces should be cleaned.
- Consideration should be given to cleaning sand boxes, outdoor toys and pools where children may inadvertently ingest residual fire retardant through hand-to-mouth contact and play.
- Communication to residents that non-ingestion pathways of exposure do not represent a potential health risk.

Within chronic exposure, plant and animal tissue uptake of iron oxide and sodium hexacyanoferrate remains as a data gap but are expected be small contributions to exposure. Tissue sampling and analysis post aerial fire retardant application would close this data gap. Of particular value may be the monitoring of plant tissues which are expected to have higher potential for uptake and potential concentration as plants lack the chemical elimination abilities of animals.

12. References

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APPENDIX A: SAFETY DATA SHEET OF AERIALLY APPLIED FIRE RETARDANTS USED IN ALBERTA

ICL BIOGEMA	**MATERIAL SAFETY DATA SHEET**	
	Updated on: 29/03/2013	Revision n°: 09

1. PRODUCT AND COMPANY IDENTIFICATION	
PRODUCT NAME	FIRE-TROL® 931
PRODUCT USE	Fire retardant used in wildfire control.
SUPPLIER / MANUFACTURER Address : Phone : Fax : E-mail : Web site :	**ICL FRANCE – ICL BIOGEMA S.A.S.** 415, Rue Louis Armand - Pôle d'activités F 13852 AIX EN PROVENCE CEDEX 3 (33) 442 244 508 (33) 442 242 998 adm@biogema.fr www.iclbiogema.com
EMERGENCY TELEPHONE	(0033) 442 244 508 /(0033) 670 647 782 or (0033) 689 104 300
2. MATERIAL IDENTIFICATION AND INFORMATION	
PREPARATION	
Chemical nature:	Mixture of Ammonium polyphosphate, clay, corrosion inhibitor, and coloring agents
Hazardous components :	None
3. HAZARD IDENTIFICATION	
MAIN HAZARDS Harmful effects on health:	None
Physical and chemical hazards: - Unusual Fire or Explosion Hazards	The product is not flammable, have no high or low explosive limit .
- Specific hazards	The product is not considered as a poisonous according to EC regulations.

4. EMERGENCY AND FIRST AID PROCEDURES	
Skin contact:	Wash off with water. Remove contaminated clothing.
Eye contact:	Flush eyes immediately with plenty of water for at least fifteen minutes. Get medical attention.
Inhalation:	Move person to fresh air and provide oxygen if breathing is difficult. Get medical attention.
Ingestion:	Call a doctor immediately.
5. FIRE FIGHTING PROCEDURES	
Extinguishing Media:	Non flammable extinguishing product. Use water to cool containers exposed to fire.
Specific hazards:	When the concentrate is heated to 435°C, hydrogen cyanide may form.
6. PROCEDURES IN CASE OF ACCIDENTAL DISPERSION	
Individual precautions :	Wear boots and exercise caution to prevent slip falls.
Environmental precaution:	Contain the spread.
Methods for cleaning up:	
- Recovery	Retrieve the product with shovels and brushes.
- Cleaning / decontamination	Wash off with plenty of water.
- Elimination	Incinerate in approved installation.
7. HANDLING AND STORAGE	
HANDLING	
Technical measurements:	Follow good industrial practices.
STORAGE	
Technical measurements:	Bulk storage, steel tank.
Recommended storage conditions:	NA.
Packing conditions:	Drums and containers.
Packing materials:	
- Recommended	Plastic, steel, aluminum.
- Not recommended	Avoid contact with zinc and magnesium.
8. EXPOSURE CONTROL / INDIVIDUAL PROTECTION	
INDIVIDUAL PROTECTION	
Hand protection:	Rubber gloves are recommended.
Eyes protection:	Wear safety glasses.
Skin protection:	Wear appropriate work clothes.
Ventilation:	Work in a well aerated area.
COLLECTIVE EMERGENCY MEANS	Water supply.
Hygiene measures	Do not eat, drink, and smoke during handling. Wash hands after work.

9. PHYSICAL AND CHEMICAL PROPERTIES	
GENERAL INFORMATION	
Appearance:	Dark red, high viscosity liquid.
Solubility:	Soluble in water. Contains some insoluble substances (clay, colored pigments).
IMPORTANT HEALTH, SAFETY AND ENVIRONMENTAL INFORMATION	
Specific Gravity (Concentrate):	1.38 to 1.43 kg/dm^3
Specific Gravity (Solution 20%):	1.08 to 1.10 kg/dm^3
pH (Concentrate) at 20°C:	6.0 - 6.5
pH (Solution 20%) at 20°C:	6.4 - 6.6
Freezing point:	NA
Boiling point:	106°C.
Viscosity (concentrate):	> 1000 cP
10. STABILITY AND REACTIVITY	
Stability :	The concentrate has excellent long-term stability. No risk of polymerization.
Incompatibility:	Avoid contact with strong acids to prevent formation of Hydrogen cyanide.
Hazardous decomposition :	Hazardous decomposition products are ammonia and hydrogen cyanide. The latter forms when temperature exceeds 435°C.
11. TOXICOLOGICAL DATA	
Before concentrate is diluted with water:	
- Eye irritation	Mild to Moderate irritation.
- Eye irritation	Mild irritation.
- Skin irritation	May cause throat irritation
- Ingestion	
Tests results on animals ♣	
• Eye irritation (rabbit)	Slight irritation. Cat.3 toxicity[Ù]
• Skin irritation (rabbit)	Practically no irritation Cat.3 toxicity
• Acute Oral Toxicity (rat)	LD_{50} > 5010 mg/kg. Cat.3 toxicity
• Acute Dermal Toxicity (rabbit)	LD_{50} > 2040 mg/kg Cat.2 toxicity
Diluted product (20% by volume):	
- Eye irritation :	Mild to Moderate irritation.
- Skin irritation :	Mild irritation.
- Ingestion :	May cause throat irritation
Tests results on animals	
• Eye irritation (rabbit)	Slight irritation. Cat.3 toxicity
• Skin irritation (rabbit)	Practically no irritation Cat.3 toxicity
• Acute Oral Toxicity (rat)	LD_{50} > 5020 mg/kg. Cat.3 toxicity
• Acute Dermal Toxicity (rabbit)	LD_{50} > 2010 mg/kg Cat.2 toxicity

♣ according to *US Forest Service Specifications* for long term retardants (5100-304a, February 1986)

12. ECOLOGICAL DATA	
ECOTOXICITY Effects on the aquatic environment:	None (Ecotoxicity Tests run in 2005 with ***Daphnia magna* STRAUS** and ***Danio rerio* HAMILTON BUCHANAN**)
PERSISTENCE AND DEGRADABILITY	The chemical base is a fertilizer. All components are entirely biodegradable.
BIO ACCUMULATION	None
13. DISPOSAL INFORMATION	
PRODUCT WASTES - Prohibited:	Do not dispose of large quantities in sewerage system
- Destruction / elimination:	For elimination, comply with applicable local regulations.
14. TRANSPORTATION DATA	
INTERNATIONAL REGULATIONS	
- Road / Rail	RID/ADR/RTMD Not regulated for transportation
- Sea	OMI/IMDG Not regulated for transportation
- Air	OACI/IATA Not regulated for transportation
15. STATUTORY DATA	
LABELING EEC regulation:	None
16. OTHER DATA	
Classifications / Symbols	Liquid concentrate fire retardant designed to be diluted with water and used for aerial applications.
Recommended use	Forest Fire Fighting

This safety data sheet was drafted in compliance with EEC Directive 91/155 of March 5, 1991 as amended by Directive 93/112/CE of December 10, 1993 and Directive 2001/58/CE of July 27, 2001.

Cause for revision: Translation updates Replaces MSDS dated: 22/02/2013

Notice of warranty:

This data sheet supplements the technical notes of use but does not replace them. The information contained herein is based on our knowledge of the product concerned at the date indicated. It is given in good faith. Users are hereby warmed of the possible risks of use of the product for purposes other than intended. Users are expected to know and comply with all statutory obligations relating to their activity. Users are solely responsible for the caution they exercise in using the product.

SECTION 1: PRODUCT IDENTIFICATION AND USE

Product Identifier: **FIRE-TROL(R) 931-R**

Product use: FIRE-TROL(R) 931-R is a liquid concentrate fire retardant designed to be diluted with water and used for aerial application to control wildfire.

Manufacturers name: **FIRE-TROL CANADA COMPANY**
455 DENE DRIVE
KAMLOOPS BC
V2H 1J1

Emergency Telephone Numbers: (24 Hours)

[250] 374-0379 : **FIRE-TROL CANADA COMPANY: KAMLOOPS**

[602] 262-5401 : FIRE-TROL HOLDINGS L.L.C.: PHOENIX

GENERAL INFORMATION

WHMIS CLASSIFICATION: D2b

WARNING STATEMENT

Avoid eye contact, will cause eye irritation. Prolonged contact may be mildly irritating to the skin. Do not ingest.

SECTION 2: HAZARDOUS INGREDIENTS

FIRE-TROL(R) 931-R is a liquid concentrate mixture of Ammonium Polyphosphate (80% to 95%),Sodium Hexacyanoferrate (0.1% to 3%) CAS #13601-19-9, Ferric Oxide (0.1% to 3.0%) CAS #1309-37-1, and a minor amount of a clay thickener. Actual amounts of each ingredient may vary from time to time.

SECTION 3: **PHYSICAL DATA:**

1. Physical State: High viscosity liquid.
2. Odour and Appearance: Bland. Dark red liquid.
3. Odour Threshold (ppm): No data available.
4. Vapor Pressure (mm Hg): <1 at 100 degrees C.
5. Vapor Density (Air = 1): No data available.
6. Evaporation Rate: Not applicable.
7. Boiling Point: 106 degrees C
8. Freezing point: Not applicable.
9. pH: No data available.
10. Specific Gravity: 1.40 to 1.43
11. Coeff. Water/Oil Dist.: No data available.

SECTION 4: FIRE AND EXPLOSION DATA:

1. Flammability: Not flammable

2. Extinguishing Media: Carbon dioxide, dry chemical, foam, or water spray. Class A, BC, or ABC fire extinguishers. Sand/earth.

3. Special Firefighting Procedures in Enclosed Areas:

   In case of accident or fire involving FIRE-TROL 931-R use water to keep fire exposed containers cool. Wear an approved self contained breathing apparatus and protective clothing.

   There are no special hazards involved in fighting fires involving the diluted product.

4. Flashpoint: FIRE-TROL 931-R has no flash point.

5. Upper and Lower Flammable Limits (%): None

6. Autoignition Temp.: Not applicable.

7. Hazardous Combustion Products: When FIRE-TROL 931-R is heated to point of combustion, hydrogen cyanide may be formed.

8. Explosion Data:

   Sensitivity to Impact: Not Applicable
   Sensitivity to Static Discharge: Not Applicable

SECTION 5: REACTIVITY DATA:

1. Stability: Excellent long term stability. Hazardous polymerization will not occur.
2. Incompatibility: Avoid strong acids to prevent formation of hydrogen cyanide.
3. Reactivity: Not Applicable.
4. Hazardous Decomposition Products: Ammonia and Hydrogen Cyanide.

   The latter is formed if the material is heated to over 435 degrees C.
5. Storage: Store concentrate in plastic, aluminum, or steel tanks.

   Avoid contact with zinc coated metals or magnesium due to excessive corrosion rates.

SECTION 6: TOXICOLOGICAL PROPERTIES:

1. Routes of Entry: Skin and eye contact can be expected to be the most common types of exposure to FIRE-TROL 931-R.
2. Toxicological Data:

Concentrate (Acute Exposure)

i)	Rabbit Eye Irritation:	Minimally Irritating
ii)	Rabbit Skin Irritation:	Practically not an Irritant
iii)	Rat Acute Oral:	LD50 > 5010 mg/kg (low toxicity)
iv)	Rabbit acute Dermal:	LD50 > 2010 mg/kg (low toxicity)

Diluted Product (Acute Exposure)

i)	Rabbit Eye Irritation:	Minimally Irritating
ii)	Rabbit Skin Irritation:	Practically not an Irritant
iii)	Rat Acute Oral:	LD50 > 5020 mg/kg (low toxicity)
iv)	Rabbit Acute Dermal:	LD50 > 2010 mg/kg (low toxicity)

All animal tests reported in this section for both concentrated and diluted products were run in accordance with U.S. Forest Service Specifications for long term retardants: 5100-304a, February 1986. The results are all acceptable according to those specifications.

3. Effects of Acute Exposure:

   Skin: Mild Irritation.

   Eyes: Mild to Moderate Irritation. Prolonged exposure to the dry product can cause conjunctivitis.

4. Effects of Chronic Exposure: No data available.

5. Carcinogenicity: Not listed by NTP or IARC.

6. Teratogenicity: Not listed by NTP or IARC.

7. Mutagenicity: Not listed by NTP or IARC.

8. Reproductive toxicity: Not listed by NTP or IARC.

9. Synergistic Products: Not applicable.

SECTION 7: PREVENTIVE MEASURES:

1. Protective clothing and equipment should be utilized when handling FIRE-TROL 931-R.

(i) Gloves: Avoid prolonged skin contact. Use rubber, or plastic gloves when handling concentrate.

(ii) Eye: Avoid eye contact. Use safety goggles offering a full seal around the eyes.

(iii) Clothing: Wear coveralls to minimize exposure to concentrate and dilute product.

2. Ventilation Type Required: Mechanical

3. Leak and Spill Procedure: Spills of FIRE-TROL 931-R should be contained with a physical barrier such as earth or a berm. Product should be recovered for reuse or physically removed. Sand or other absorbent material can be used to facilitate removal. Water can be used to dilute remaining material.

4. Waste Disposal: Dispose of in accordance with all Federal, Provincial and Local regulations.

5. Transportation Information:
   Transport Canada: Not Regulated
   Reportable Quantity: Not Applicable
   Non-flammable, Non-corrosive

SECTION 8: ENVIRONMENTAL EFFECTS:

1. Due to the sensitivity of aquatic life to chemicals, **do not** apply FIRE-TROL 931-R to lakes, streams or watercourses.

2. Fire retardant chemicals applied near streams have been shown to have virtually no impact on them. This is partly because there is a minimum of migration of chemicals from areas as close as 3 metres from the edge of a stream.(Morris et al," The Behavior and Impact of Chemical Retardants in Forest Streams," Forestry Sciences Laboratory, USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, October 20, 1978.)

   Concentrate:
   96 hr. LC50 Juvenile Rainbow Trout: 660 mg/litre.

3. Use and disposal employing proper environmental control practices should not cause significant environmental impact.

SECTION 9: FIRST AID PROCEDURES:

1. Skin Contact: Wash off with water. Remove contaminated clothing. Use medicated lotion if skin becomes dry or chapped.

2. Eye Contact: Flush eyes immediately with large amounts of water for at least 15 minutes. Consult a physician.

3. Inhalation: Remove to fresh air and give oxygen if breathing is difficult. Get medical attention.

4. Ingestion: Give large amounts of water and induce vomiting. Get medical attention.

5. General: Independent laboratory testing has determined that when Sodium Hexacyanoferrate is burned most cyanogens become CO2 rather than poisonous HCN gas. Exposure to a maximum level of 50 mg/m3 can be expected when retardant is applied at 2 litres/100 sq metres. No harmful human or environmental effects are expected. If adverse effects do occur, provide basic life support and seek immediate medical attention.

SECTION 10: PREPARATION DATE

Prepared By: Wally McCulloch
FIRE-TROL CANADA COMPANY [250] 374-0379

Effective Date: March 1, 1999 Supersedes: August 18, 1997

NOTICE OF WARRANTY

FIRE-TROL HOLDINGS L.L.C. warrants that FIRE-TROL(R) products are reasonably fit for the purposes for which they were developed only when used in accordance with manufacturers recommended use practices and when used under normal conditions. The liability of FIRE-TROL HOLDINGS L.L.C. with respect to the use and handling of the product is limited to the amount of the purchase price of the product to the user, and FIRE-TROL HOLDINGS L.L.C. will not be liable for consequential, special, or indirect damages resulting from such use or handling.

FIRE-TROL HOLDINGS L.L.C. MAKES NO WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE NOR ANY OTHER EXPRESS OR IMPLIED WARRANTY EXCEPT AS STATED ABOVE.

Safety Data Sheet

Perimeter SOLUTIONS
Quality Products. Exceptional Response.

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Identification

Product Name: Phos-Chek ® LC95A-Fx
Reference Number: AST10207
Date: August 30, 2016

Use of the substance or preparation

Fire retardant

Company/Undertaking Identification

Perimeter Solutions
622 Emerson Road - Suite 500
St. Louis, Missouri 63141

Emergency telephone: In USA call CHEMTREC: 1 800 424 9300

Outside the USA, including ships at sea, call CHEMTREC's international and maritime telephone number (collect calls accepted): +1 (703) 527-3887

In Canada call CANUTEC: 1 613 996 6666

General Information: +1 800 244 6169 (Worldwide)

2. HAZARDS IDENTIFICATION

GHS – This product does not meet the criteria for classification under GHS

3. COMPOSITION/INFORMATION ON INGREDIENTS

Composition

Substance	CAS No.	%w/w	EINECS No.	Risk Phrase
Ammonium Polyphosphate Solution		> 85.0		none
Attapulgus Clay	8031-18-3	< 5.0	310-127-6	none
Performance additives	Trade Secret	< 8.0	Listed	none

Performance additives are Company Trade Secret – Business Confidential. Perimeter Solutions is withholding the specific chemical identity under provision of the OSHA Hazard Communication Rule Trade Secrets (1910.1200(i)(1)). The specific chemical identity will be made available to health professionals in accordance with 29 CFR 1910.1200(i)(1)(2)(3)(4).

4. FIRST AID MEASURES

General

Likely Routes of Exposure: skin contact and inhalation.

Eye contact

Immediate first aid is not likely to be required. However, this material can be removed with water.

Skin contact

Immediate first aid is not likely to be required. However, this material can be removed with water. Wash heavily contaminated clothing before reuse.

Inhalation

This product is not believed to pose an inhalation hazard. Immediate first aid is not likely to be required. Remove material from eyes, skin and clothing.

Ingestion

Immediate first aid is not likely to be required. A physician or Poison Control Center can be contacted for advice. Wash heavily contaminated clothing before reuse.

5. FIRE FIGHTING MEASURES

Extinguishing media

No special requirement.

Unsuitable extinguishing media

No special requirement.

Exposure hazard

None known.

Protective equipment

As a general precaution, firefighters, and others exposed, wear full protective clothing and a self-contained breathing apparatus.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions

Avoid unnecessary exposure and remove all material from eyes, skin and clothing.

Environmental precaution

Small quantities: See below.
Large quantities: See below.

Methods for cleaning up

Contain large spills with dikes and transfer the material to appropriate containers for reclamation or disposal. Absorb remaining material or small spills with an inert material and then place in a chemical waste container. Flush residual spill area with water.

Refer to Section 13 for disposal information.

7. HANDLING AND STORAGE

Handling

Handle in accordance with good industrial hygiene and safety practices. These practices include avoiding unnecessary exposure and removal of the material from eyes, skin and clothing.

Engineering measures

Provide natural or mechanical ventilation to minimize exposure. The use of local mechanical exhaust ventilation is preferred at sources of air contamination such as open process equipment. Consult National Fire Protection Association (NFPA) Standard 91 for design of exhaust systems.

Storage

Emptied container retains product residue. Observe all labeled safeguards until container is cleaned, reconditioned, or destroyed. The reuse of this material's container for non-industrial purposes is prohibited and any reuse must be in consideration of the data provided in the MSDS.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Occupational Exposure Limits

OSHA and ACGIH have not established specific exposure limits for this material. This product is a water solution.

Respiratory protection

Avoid breathing vapor or mist. Use NIOSH/MSHA approved respiratory protection equipment when airborne exposure limits are exceeded. Consult respirator manufacturer to determine appropriate type equipment for given application. Observe respirator use limitations specified by NIOSH / MSHA or the manufacturer. Refer to U.S. OSHA regulations 29 CFR 1910.134 or European Standard EN 149.

Hand/Skin protection

Although this material does not present a significant skin concern, skin contamination should be minimized as good industrial practice. Wearing of protective gloves is recommended. Wash hands and contaminated skin after handling.

Eye protection

Although this material does not cause significant eye irritation or eye toxicity requiring special protection, good industrial practice should be used to avoid eye contact.

Components referred to herein may be regulated by specific Canadian provincial legislation. Please refer to exposure limits legislated for the province in which the substance will be used.

9. PHYSICAL AND CHEMICAL PROPERTIES

a) Appearance: pinkish liquid
b) Odor: None
c) Odor threshold: Undetermined.
d) pH: 5.0 – 6.5
e) Melting point/freezing point: Undetermined
f) Initial boiling point and boiling range: Undetermined.
g) Flash point: Undetermined
h) Evaporation rate: Undetermined.
i) Flammability (solid, gas) : Undetermined.
j) Upper/lower flammability or explosive limits: Undetermined.
k) Vapor pressure: Undetermined.

l) Vapor density: Undetermined.
m) Relative density: Undetermined
n) Solubility(ies) : > 95 %
o) Partition coefficient: n-octanol/water: Undetermined.
p) Auto-ignition temperature: Undetermined.
q) Decomposition temperature: Undetermined.
r) Viscosity: > 100 cps
s) Specific Gravity: 1.40 - 1.50 @ 25 ºC

NOTE: These physical data are typical values based on material tested but may vary from sample to sample. Typical values should not be construed as a guaranteed analysis of any specific lot or as specifications for the product.

10. STABILITY AND REACTIVITY

Product is stable under normal conditions of storage and handling.

Conditions to avoid

None known.

Materials to avoid

None known.

Hazardous decomposition

None known.

11. TOXICOLOGICAL INFORMATION

Testing Data:

Oral - rat LD_{50}: > 5,050 mg/kg practically nontoxic.
Dermal - rabbit LD_{50}: > 2,020 mg/kg; No More Than Slightly Toxic
Eye Irritation – rabbit - Single washed eyes: Mildly irritating – Toxicity Category IV.
Eye Irritation – rabbit - Double washed eyes: Mildly irritating – Toxicity Category IV.
Skin Irritation - rabbit: Non-irritating – Category IV

12. ECOLOGICAL INFORMATION

Testing Data:

LC_{50} (Rainbow Trout) = 399 mg/L

13. DISPOSAL CONSIDERATIONS

Consult your attorney or appropriate regulatory official for information on disposal and on the recycling exemption. Recycle or dispose of in accordance with local, state, provincial, and federal regulations.

14. TRANSPORT INFORMATION

The data provided in this section is for information only. Please apply the appropriate regulations to properly classify your shipment for transportation.

Road/Rail, Sea and Air

IMDG/UN	not regulated for transportation
ICOA/IATA	not regulated for transportation
RID/ADR	not regulated for transportation
Canadian TDG	not regulated for transportation

US DOT not regulated for transportation

15. REGULATORY INFORMATION

Chemical Inventory

USA TSCA	Listed
EU EINECS	Listed
Canada DSL/NDSL	Listed

WHMIS Classification: Not Controlled

Additional information

SARA Hazard Notification

Hazard Categories Under Title III Rules (40 CFR 370):	Not applicable
Section 302 Extremely Hazardous Substances:	Not applicable
Section 313 Toxic Chemical(s):	Not applicable

CERCLA Reportable Quantity: Not applicable

This product has been classified in accordance with the hazard criteria of the Canadian Controlled Products Regulation and the MSDS contains all the information required by the Canadian Controlled Products Regulation.

Refer to Section 11 for OSHA/HPA Hazardous Chemical(s) and Section 13 for RCRA classification.

16. OTHER INFORMATION

	Health	Fire	Reactivity	Additional Information
Suggested NFPA Rating	0	0	0	
Suggested HMIS Rating	0	0	0	

Reason for revision: New. Supersedes MSDS dated: n/a

Phos-Chek ® is a registered trademark of Perimeter Solutions.

Safety Data Sheet

Perimeter SOLUTIONS
Quality Products. Exceptional Response.

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Identification

Product Name: Phos-Chek ® LC95A-Fx
Reference Number: AST10207
Date: August 30, 2016

Use of the substance or preparation

Fire retardant

Company/Undertaking Identification

Perimeter Solutions
622 Emerson Road - Suite 500
St. Louis, Missouri 63141

Emergency telephone: In USA call CHEMTREC: 1 800 424 9300

Outside the USA, including ships at sea, call CHEMTREC's international and maritime telephone number (collect calls accepted): +1 (703) 527-3887

In Canada call CANUTEC: 1 613 996 6666

General Information: +1 800 244 6169 (Worldwide)

2. HAZARDS IDENTIFICATION

GHS – This product does not meet the criteria for classification under GHS

3. COMPOSITION/INFORMATION ON INGREDIENTS

Composition

Substance	CAS No.	%w/w	EINECS No.	Risk Phrase
Ammonium Polyphosphate Solution		> 85.0		none
Attapulgus Clay	8031-18-3	< 5.0	310-127-6	none
Performance additives	Trade Secret	< 8.0	Listed	none

Performance additives are Company Trade Secret – Business Confidential. Perimeter Solutions is withholding the specific chemical identity under provision of the OSHA Hazard Communication Rule Trade Secrets (1910.1200(i)(1)). The specific chemical identity will be made available to health professionals in accordance with 29 CFR 1910.1200(i)(1)(2)(3)(4).

4. FIRST AID MEASURES

General

Likely Routes of Exposure: skin contact and inhalation.

Eye contact

Immediate first aid is not likely to be required. However, this material can be removed with water.

Skin contact

Immediate first aid is not likely to be required. However, this material can be removed with water. Wash heavily contaminated clothing before reuse.

Inhalation

This product is not believed to pose an inhalation hazard. Immediate first aid is not likely to be required. Remove material from eyes, skin and clothing.

Ingestion

Immediate first aid is not likely to be required. A physician or Poison Control Center can be contacted for advice. Wash heavily contaminated clothing before reuse.

5. FIRE FIGHTING MEASURES

Extinguishing media

No special requirement.

Unsuitable extinguishing media

No special requirement.

Exposure hazard

None known.

Protective equipment

As a general precaution, firefighters, and others exposed, wear full protective clothing and a self-contained breathing apparatus.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions

Avoid unnecessary exposure and remove all material from eyes, skin and clothing.

Environmental precaution

Small quantities: See below.
Large quantities: See below.

Methods for cleaning up

Contain large spills with dikes and transfer the material to appropriate containers for reclamation or disposal. Absorb remaining material or small spills with an inert material and then place in a chemical waste container. Flush residual spill area with water.

Refer to Section 13 for disposal information.

7. HANDLING AND STORAGE

Handling

Handle in accordance with good industrial hygiene and safety practices. These practices include avoiding unnecessary exposure and removal of the material from eyes, skin and clothing.

Engineering measures

Provide natural or mechanical ventilation to minimize exposure. The use of local mechanical exhaust ventilation is preferred at sources of air contamination such as open process equipment. Consult National Fire Protection Association (NFPA) Standard 91 for design of exhaust systems.

Storage

Emptied container retains product residue. Observe all labeled safeguards until container is cleaned, reconditioned, or destroyed. The reuse of this material's container for non-industrial purposes is prohibited and any reuse must be in consideration of the data provided in the MSDS.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Occupational Exposure Limits

OSHA and ACGIH have not established specific exposure limits for this material. This product is a water solution.

Respiratory protection

Avoid breathing vapor or mist. Use NIOSH/MSHA approved respiratory protection equipment when airborne exposure limits are exceeded. Consult respirator manufacturer to determine appropriate type equipment for given application. Observe respirator use limitations specified by NIOSH / MSHA or the manufacturer. Refer to U.S. OSHA regulations 29 CFR 1910.134 or European Standard EN 149.

Hand/Skin protection

Although this material does not present a significant skin concern, skin contamination should be minimized as good industrial practice. Wearing of protective gloves is recommended. Wash hands and contaminated skin after handling.

Eye protection

Although this material does not cause significant eye irritation or eye toxicity requiring special protection, good industrial practice should be used to avoid eye contact.

Components referred to herein may be regulated by specific Canadian provincial legislation. Please refer to exposure limits legislated for the province in which the substance will be used.

9. PHYSICAL AND CHEMICAL PROPERTIES

a) Appearance: pinkish liquid
b) Odor: None
c) Odor threshold: Undetermined.
d) pH: 5.0 – 6.5
e) Melting point/freezing point: Undetermined
f) Initial boiling point and boiling range: Undetermined.
g) Flash point: Undetermined
h) Evaporation rate: Undetermined.
i) Flammability (solid, gas) : Undetermined.
j) Upper/lower flammability or explosive limits: Undetermined.
k) Vapor pressure: Undetermined.

l) Vapor density: Undetermined.
m) Relative density: Undetermined
n) Solubility(ies) : > 95 %
o) Partition coefficient: n-octanol/water: Undetermined.
p) Auto-ignition temperature: Undetermined.
q) Decomposition temperature: Undetermined.
r) Viscosity: > 100 cps
s) Specific Gravity: 1.40 - 1.50 @ 25 ºC

NOTE: These physical data are typical values based on material tested but may vary from sample to sample. Typical values should not be construed as a guaranteed analysis of any specific lot or as specifications for the product.

10. STABILITY AND REACTIVITY

Product is stable under normal conditions of storage and handling.

Conditions to avoid

None known.

Materials to avoid

None known.

Hazardous decomposition

None known.

11. TOXICOLOGICAL INFORMATION

Testing Data:

Oral - rat LD_{50}: > 5,050 mg/kg practically nontoxic.
Dermal - rabbit LD_{50}: > 2,020 mg/kg; No More Than Slightly Toxic
Eye Irritation – rabbit - Single washed eyes: Mildly irritating – Toxicity Category IV.
Eye Irritation – rabbit - Double washed eyes: Mildly irritating – Toxicity Category IV.
Skin Irritation - rabbit: Non-irritating – Category IV

12. ECOLOGICAL INFORMATION

Testing Data:

LC_{50} (Rainbow Trout) = 399 mg/L

13. DISPOSAL CONSIDERATIONS

Consult your attorney or appropriate regulatory official for information on disposal and on the recycling exemption. Recycle or dispose of in accordance with local, state, provincial, and federal regulations.

14. TRANSPORT INFORMATION

The data provided in this section is for information only. Please apply the appropriate regulations to properly classify your shipment for transportation.

Road/Rail, Sea and Air

IMDG/UN	not regulated for transportation
ICOA/IATA	not regulated for transportation
RID/ADR	not regulated for transportation
Canadian TDG	not regulated for transportation

US DOT not regulated for transportation

15. REGULATORY INFORMATION

Chemical Inventory

USA TSCA	Listed
EU EINECS	Listed
Canada DSL/NDSL	Listed

WHMIS Classification: Not Controlled

Additional information

SARA Hazard Notification

Hazard Categories Under Title III Rules (40 CFR 370):	Not applicable
Section 302 Extremely Hazardous Substances:	Not applicable
Section 313 Toxic Chemical(s):	Not applicable

CERCLA Reportable Quantity: Not applicable

This product has been classified in accordance with the hazard criteria of the Canadian Controlled Products Regulation and the MSDS contains all the information required by the Canadian Controlled Products Regulation.

Refer to Section 11 for OSHA/HPA Hazardous Chemical(s) and Section 13 for RCRA classification.

16. OTHER INFORMATION

	Health	Fire	Reactivity	Additional Information
Suggested NFPA Rating	0	0	0	
Suggested HMIS Rating	0	0	0	

Reason for revision: New. Supersedes MSDS dated: n/a

Phos-Chek ® is a registered trademark of Perimeter Solutions.

Safety Data Sheet

Perimeter SOLUTIONS
Quality Products. Exceptional Response.

RESPONSIBLE CARE®
OUR COMMITMENT TO SUSTAINABILITY

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Name: PHOS-CHEK® MVP-F
Reference Number: AST10176
Date: May 8, 2015

Company Information:

Perimeter Solutions
622 Emerson Road - Suite 500
St. Louis, Missouri 63141

Emergency telephone: In USA call CHEMTREC: 1 800 424 9300

Outside the USA, including ships at sea, call CHEMTREC's international and maritime telephone number (collect calls accepted): +1 (703) 527-3887

In Canada call CANUTEC: 1 613 996 6666

General Information: +1 800 424 6169 (Worldwide)

2. HAZARDS IDENTIFICATION

GHS – This product does not meet the criteria for classification under GHS

3. COMPOSITION/INFORMATION ON INGREDIENTS

Component	CAS No.	% w/w
Monoammonium Phosphate	7722-76-1	75-85
Diammonium Phosphate	7783-28-0	8-12
Performance Additives+	Trade Secret	< 15

+ Components are Company Trade Secret - Business Confidential. Perimeter Solutions is withholding the specific chemical identity under provision of the OSHA Hazard Communication Rule Trade Secrets (1910.1200(i)(1)). The specific chemical identity will be made available to health professionals in accordance with 29 CFR 1910.1200 (i)(1) (2) (3) (4)..

4. FIRST AID MEASURES

IF IN EYES OR ON SKIN, immediate first aid is not likely to be required. However, this material can be removed with water. Remove material from eyes, skin and clothing. Wash heavily contaminated clothing before reuse.

IF INHALED, remove to fresh air. If breathing, immediate first aid is not likely to be required. If breathing is difficult, give oxygen. If not breathing give artificial respiration. Get medical attention.

IF SWALLOWED, immediate first aid is not likely to be required. A physician or Poison Control Center can be contacted for advice.

5. FIRE FIGHTING MEASURES

FLASH POINT: Not combustible

HAZARDOUS PRODUCTS OF COMBUSTION: Not applicable

EXTINGUISHING MEDIA: Not applicable

UNUSUAL FIRE AND EXPLOSION HAZARDS: None known

FIRE FIGHTING EQUIPMENT: Not applicable

6. ACCIDENTAL RELEASE MEASURES

In case of spill, sweep, scoop or vacuum and remove. Flush residual spill area with water.

Refer to Section 13 for disposal information and Sections 14 and 15 for reportable quantity information.

7. HANDLING AND STORAGE

HANDLING

Avoid breathing dust. Keep container closed. Use with adequate ventilation.

Emptied container retains dust and product residue. Observe all labeled safeguards until container is cleaned, reconditioned, or destroyed. The reuse of this material's container for nonindustrial purposes is prohibited and any reuse must be in consideration of the data provided in the MSDS.

STORAGE: Product is stable under normal conditions of storage and handling.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

EYE PROTECTION: This product does not cause significant eye irritation or eye toxicity requiring special protection. Use good industrial practice to avoid eye contact.

SKIN PROTECTION: Although this product does not present a significant skin concern, minimize skin contamination by following good industrial practice. Wearing protective gloves is recommended. Wash hands and contaminated skin thoroughly after handling.

RESPIRATORY PROTECTION: Avoid breathing dust. Use NIOSH/MSHA approved respiratory protection equipment when airborne exposure is excessive. Consult respirator manufacturer to determine appropriate type equipment for given application. Observe respirator use limitations specified by NIOSH/MSHA or the manufacturer. Respiratory protection programs must comply with 29 CFR 1910.134.

VENTILATION: Provide natural or mechanical ventilation to minimize exposure. If practical, use local mechanical exhaust ventilation at sources of air contamination such as open process equipment.

AIRBORNE EXPOSURE LIMITS:

OSHA and ACGIH have not established specific exposure limits for this material. However, OSHA and ACGIH have established limits for particulates not otherwise classified (PNOC) which are the least stringent exposure limits applicable to dusts.

OSHA PEL	ACGIH TLV
15 mg/m^3 (total dust) 8-hr TWA	10 mg/m^3 (inhalable) 8-hr TWA
5 mg/m^3 (respirable) 8-hr TWA	3 mg/m^3 (respirable) 8-hr TWA

Components referred to herein may be regulated by specific Canadian provincial legislation.
Please refer to exposure limits legislated for the province in which the substance will be used.

9. PHYSICAL AND CHEMICAL PROPERTIES

a) Appearance: Reddish powder
b) Odor: None
c) Odor threshold: Undetermined.
d) pH: 5.0-6.0
e) Melting point/freezing point: Undetermined
f) Initial boiling point and boiling range: Undetermined.
g) Flash point: Undetermined
h) Evaporation rate: Undetermined.
i) Flammability (solid, gas) : Undetermined.
j) Upper/lower flammability or explosive limits: Undetermined.
k) Vapor pressure: Undetermined.
l) Vapor density: Undetermined.
m) Relative density: Undetermined.
n) Solubility(ies) : Undetermined
o) Partition coefficient: n-octanol/water: Undetermined.
p) Auto-ignition temperature: Undetermined.
q) Decomposition temperature: Undetermined.
r) Viscosity: 401-800 centipoise @ 21ºC (70ºF) when dissolved in water at the recommended level of 0.95 lbs./gal. of water.

NOTE: These physical data are typical values based on material tested but may vary from sample to sample. Typical values should not be construed as a guaranteed analysis of any specific lot or as specifications for the product.

10. STABILITY AND REACTIVITY

STABILITY: Product is stable under normal conditions of storage and handling.

MATERIALS TO AVOID: None known

HAZARDOUS DECOMPOSITION PRODUCTS: Ammonia and phosphoric acid may be formed when these products are heated above 90ºC (194ºF).

HAZARDOUS POLYMERIZATION: Does not occur.

11. TOXICOLOGICAL INFORMATION

Oral - rat LD50: > 5,050 mg/kg practically nontoxic
Dermal - rabbit LD50: > 2,020 mg/kg; No More Than Slightly Toxic
Eye Irritation - rabbit: 4/110.0; minimally irritating
Skin Irritation - rabbit: 0.0/8.0 (24-hr. exp.); nonirritating

12. ECOLOGICAL INFORMATION

Coldwater fish: 96-hr LC_{50} Rainbow trout: 1845 mg/L, Practically Nontoxic

13. DISPOSAL CONSIDERATIONS

This material when discarded is not a hazardous waste as that term is defined by the Resource, Conservation and Recovery Act (RCRA), 40 CFR 261. Dry material may be landfilled or recycled in accordance with local, state and federal regulations. Consult your attorney or appropriate regulatory officials for information on such disposal.

14. TRANSPORT INFORMATION

The data provided in this section is for information only. Please apply the appropriate regulations to properly classify your shipment for transportation.

US DOT: Not regulated for transportation
Canadian TDG: Not regulated for transportation

15. REGULATORY INFORMATION

TSCA Inventory: All Components Listed
DSL Inventory: Listed
WHMIS Classification: Not Controlled

SARA Hazard Notification
Hazard Categories Under Title III Rules (40 CFR 370): Not Applicable
Section 302 Extremely Hazardous Substances: Not Applicable
Section 313 Toxic Chemical(s): Not Applicable

CERCLA Reportable Quantity: Not applicable

This product has been classified in accordance with the hazard criteria of the Canadian Controlled Products Regulation and the MSDS contains all the information required by the Canadian Controlled Products Regulation.

Refer to Section 11 for OSHA/HPA Hazardous Chemical(s) and Section 13 for RCRA classification.

16. OTHER INFORMATION

	Health	Fire	Reactivity	Additional Information
Suggested NFPA Rating	1	1	0	
Suggested HMIS Rating	1	1	0	E

Reason for revision: Sections 2, 3, 9 Supersedes MSDS dated: April 27, 2012
Product Use: Fire Retardant

Safety Data Sheet

Perimeter SOLUTIONS
Quality Products. Exceptional Response.

RESPONSIBLE CARE®
OUR COMMITMENT TO SUSTAINABILITY

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Name: PHOS-CHEK® MVP-Fx
Reference Number: AST10195
Date: October 2, 2015

Company Information:

Perimeter Solutions
622 Emerson Road - Suite 500
St. Louis, Missouri 63141

Emergency telephone: In USA call CHEMTREC: 1 800 424 9300

Outside the USA, including ships at sea, call CHEMTREC's international and maritime telephone number (collect calls accepted): +1 (703) 527-3887

In Canada call CANUTEC: 1 613 996 6666

General Information: +1 800 424 6169 (Worldwide)

2. HAZARDS IDENTIFICATION

GHS – This product does not meet the criteria for classification under GHS

3. COMPOSITION/INFORMATION ON INGREDIENTS

Component	CAS No.	% w/w	
Monoammonium Phosphate	7722-76-1	75-85	Diammonium
Phosphate	7783-28-0	8-12	
Performance Additives+	Trade Secret	< 15	

+ Components are Company Trade Secret - Business Confidential. Perimeter Solutions is withholding the specific chemical identity under provision of the OSHA Hazard Communication Rule Trade Secrets (1910.1200(i)(1)). The specific chemical identity will be made available to health professionals in accordance with 29 CFR 1910.1200 (i)(1) (2) (3) (4)..

4. FIRST AID MEASURES

IF IN EYES OR ON SKIN, immediate first aid is not likely to be required. However, this material can be removed with water. Remove material from eyes, skin and clothing. Wash heavily contaminated clothing before reuse.

IF INHALED, remove to fresh air. If breathing, immediate first aid is not likely to be required. If breathing is difficult, give oxygen. If not breathing give artificial respiration. Get medical attention.

IF SWALLOWED, immediate first aid is not likely to be required. A physician or Poison Control Center can be contacted for advice.

5. FIRE FIGHTING MEASURES

FLASH POINT: Not combustible

HAZARDOUS PRODUCTS OF COMBUSTION: Not applicable

EXTINGUISHING MEDIA: Not applicable

UNUSUAL FIRE AND EXPLOSION HAZARDS: None known

FIRE FIGHTING EQUIPMENT: Not applicable

6. ACCIDENTAL RELEASE MEASURES

In case of spill, sweep, scoop or vacuum and remove. Flush residual spill area with water.

Refer to Section 13 for disposal information and Sections 14 and 15 for reportable quantity information.

7. HANDLING AND STORAGE

HANDLING

Avoid breathing dust. Keep container closed. Use with adequate ventilation.

Emptied container retains dust and product residue. Observe all labeled safeguards until container is cleaned, reconditioned, or destroyed. The reuse of this material's container for nonindustrial purposes is prohibited and any reuse must be in consideration of the data provided in the MSDS.

STORAGE: Product is stable under normal conditions of storage and handling.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

EYE PROTECTION: This product does not cause significant eye irritation or eye toxicity requiring special protection. Use good industrial practice to avoid eye contact.

SKIN PROTECTION: Although this product does not present a significant skin concern, minimize skin contamination by following good industrial practice. Wearing protective gloves is recommended. Wash hands and contaminated skin thoroughly after handling.

RESPIRATORY PROTECTION: Avoid breathing dust. Use NIOSH/MSHA approved respiratory protection equipment when airborne exposure is excessive. Consult respirator manufacturer to determine appropriate type equipment for given application. Observe respirator use limitations specified by NIOSH/MSHA or the manufacturer. Respiratory protection programs must comply with 29 CFR 1910.134.

VENTILATION: Provide natural or mechanical ventilation to minimize exposure. If practical, use local mechanical exhaust ventilation at sources of air contamination such as open process equipment.

AIRBORNE EXPOSURE LIMITS:

OSHA and ACGIH have not established specific exposure limits for this material. However, OSHA and ACGIH have established limits for particulates not otherwise classified (PNOC) which are the least stringent exposure limits applicable to dusts.

OSHA PEL	ACGIH TLV
15 mg/m^3 (total dust) 8-hr TWA	10 mg/m^3 (inhalable) 8-hr TWA
5 mg/m^3 (respirable) 8-hr TWA	3 mg/m^3 (respirable) 8-hr TWA

Components referred to herein may be regulated by specific Canadian provincial legislation.
Please refer to exposure limits legislated for the province in which the substance will be used.

9. PHYSICAL AND CHEMICAL PROPERTIES

a) Appearance: Pinkish powder
b) Odor: None
c) Odor threshold: Undetermined.
d) pH: 5.0-6.0
e) Melting point/freezing point: Undetermined
f) Initial boiling point and boiling range: Undetermined.
g) Flash point: Undetermined
h) Evaporation rate: Undetermined.
i) Flammability (solid, gas) : Undetermined.
j) Upper/lower flammability or explosive limits: Undetermined.
k) Vapor pressure: Undetermined.
l) Vapor density: Undetermined.
m) Relative density: Undetermined.
n) Solubility(ies) : Undetermined
o) Partition coefficient: n-octanol/water: Undetermined.
p) Auto-ignition temperature: Undetermined.
q) Decomposition temperature: Undetermined.
r) Viscosity: 401-800 centipoise @ 21°C (70°F) when dissolved in water at the recommended level of 0.96 lbs./gal. of water.

NOTE: These physical data are typical values based on material tested but may vary from sample to sample. Typical values should not be construed as a guaranteed analysis of any specific lot or as specifications for the product.

10. STABILITY AND REACTIVITY

STABILITY: Product is stable under normal conditions of storage and handling.

MATERIALS TO AVOID: None known

HAZARDOUS DECOMPOSITION PRODUCTS: Ammonia and phosphoric acid may be formed when these products are heated above 90°C (194°F).

HAZARDOUS POLYMERIZATION: Does not occur.

11. TOXICOLOGICAL INFORMATION

Oral - rat LD50: > 5,050 mg/kg practically nontoxic
Dermal - rabbit LD50: > 2,020 mg/kg; No More Than Slightly Toxic
Eye Irritation - rabbit: 6/110.0; minimally irritating
Skin Irritation - rabbit: 0.0/8.0 (24-hr. exp.); nonirritating

12. ECOLOGICAL INFORMATION

Coldwater fish: 96-hr LC_{50} Rainbow trout: 2183 mg/L, Practically Nontoxic

13. DISPOSAL CONSIDERATIONS

This material when discarded is not a hazardous waste as that term is defined by the Resource, Conservation and Recovery Act (RCRA), 40 CFR 261. Dry material may be landfilled or recycled in accordance with local, state and federal regulations. Consult your attorney or appropriate regulatory officials for information on such disposal.

14. TRANSPORT INFORMATION

The data provided in this section is for information only. Please apply the appropriate regulations to properly classify your shipment for transportation.

US DOT: Not regulated for transportation
Canadian TDG: Not regulated for transportation

15. REGULATORY INFORMATION

TSCA Inventory: All components listed
DSL Inventory: Listed
WHMIS Classification: Not controlled

SARA Hazard Notification
Hazard Categories Under Title III Rules (40 CFR 370): Not Applicable
Section 302 Extremely Hazardous Substances: Not Applicable
Section 313 Toxic Chemical(s): Not Applicable

CERCLA Reportable Quantity: Not applicable

This product has been classified in accordance with the hazard criteria of the Canadian Controlled Products Regulation and the MSDS contains all the information required by the Canadian Controlled Products Regulation.

Refer to Section 11 for OSHA/HPA Hazardous Chemical(s) and Section 13 for RCRA classification.

16. OTHER INFORMATION

	Health	Fire	Reactivity	Additional Information
Suggested NFPA Rating	1	1	0	
Suggested HMIS Rating	1	1	0	E

Reason for revision: Section 9. Supersedes MSDS dated: May 8, 2015
Product Use: Fire Retardant

APPENDIX B: PRODUCT PROFILES OF AERIALLY APPLIED FIRE RETARDANTS USED IN ALBERTA

FIRE-TROL® 931

LONG-TERM RETARDANT - AERIAL APPLICATION

Revision: 12 (03/2013)

Liquid concentrate mixed with water, used for aerial applications by fixed wing aircraft and helicopters to control wildfires.

Composition:
Ammonium polyphosphate, clay, corrosion inhibitor, coloring agents.

Physical data:

- Specific gravity (concentrate) : 1.38 - 1.43 kg/dm^3
- Specific gravity (solution 20%) : 1.08 - 1.10 kg/dm^3
- pH at 20°C (concentrate) : 6.0 - 6.5
- pH at 20°C (solution 20%) : 6.4 - 6.6
- Viscosity of the concentrate (cps) : Higher than 1000
- Mix ratio : 20% (v/v)

FIRE-TROL® 931 dropped from a Tracker
-Copyright Communication Sapeurs Pompiers 13-

Effectiveness:
Has been tested on the thermal tunnel (CEREN research laboratory tests). The experiments determined the inhibiting capacity of the retardant by simulating the arrival of flames on a treated area and comparing this with the spontaneous dehydration of the product, which occurs after application.

The solution's extinguishing capacity is evaluated by the mass of concentrate required to stop the spread of flames under precise operating conditions.
These tests demonstrated that FIRE-TROL® 931 at 20% (v:v) dilution rate is an excellent long-term retardant.

Coating and coloration:
The solution of FIRE-TROL® 931 clings very well to the fuel source.
Bright intense coloration makes the patterns quite visible from the air tankers.

Effects on environment:
Evaluations have been made of the effect of FIRE-TROL® 931 on germination, growth and re-growing of the plants.
When used at the same dilution rate as in fire suppression, FIRE-TROL® 931 stimulates fuel yield.

Corrosion:

FIRE-TROL® 931 has been tested either electro chemically or using « coupons » methods. These tests have shown good inhibition action of the product on aluminum, steel and brass (CEREN and University of Provence in France and Italian Air Force Lab).
Approved for use by CONAIR,BOMBARDIER and AIR TRACTOR.

Toxicological properties:
FIRE-TROL® 931 is considered non-toxic. It has been submitted to toxicological and eco-toxicological testing in accordance with the OECD guidelines applicable European Directives (2005).

Tests show :

- **Concentrate:** mild eye and skin irritation
  LD_{50} acute dermal toxicity on rabbit : > 2040 mg/kg
- **Diluted product:** minimal eye and skin irritation
  LD_{50} acute dermal toxicity on rabbit : >2020 mg/kg

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LC95

PHOS-CHEK®
FIRE RETARDANT | FOAM | GEL

(LC95A-R, LC95A-FX, LC95A-MV, LC95W) LONG-TERM FIRE RETARDANT

LOW/MEDIUM VISCOSITY LIQUID CONCENTRATE

DESCRIPTION

Phos-Chek® LC95 fire retardants are concentrated liquids that mix readily with water by recirculation, agitation or with mechanical or electronic Phos-Chek liquid proportioning systems. Phos-Chek LC95 fire retardant solutions are the only liquid concentrate (LC) ammonium polyphosphate retardants that offer both the ease of mixing and handling of a liquid and the aerial drop advantages of a gum-thickened retardant. The elastic nature of the thickener in Phos-Chek retardants reduces drift, dispersion and evaporation and facilitates increased fuel coverage, wrap around and penetration through canopy and ladder fuels to ground vegetation. Recovery can exceed 90%.

Phos-Chek LC95 is available in red iron oxide (R), fugitive (F) color, and uncolored (W). The fugitive color maintains visibility during application, but slowly fades after exposure to sunlight. LC95A-R is available as low viscosity or medium viscosity. Medium viscosity is ideal for higher altitude drops or where higher coverage levels are desired.

PACKAGING

Phos-Chek LC95 is available in bulk trucks, 260 gal. totes, 30 and 55 gal. drums and 5 gal. pails. Special package sizes available.

PRODUCT CHARACTERISTICS

Color	Red (R), Fugitive (MV), Uncolored (W)
Mix Ratio	5.5 gal. of water/gal. concentrate
Yield	1054 gal./ton of concentrate, 4398 liters/metric ton of concentrate
Concentrate Density	12.29 lbs./gal., 1,476 kg/liter
Solution Density	8.97 lbs./gal. of mixed retardant, 1.077 kg./liter
Viscosity	100-400 centipoise (cP)
Refractometer	12.75-14.50

APPLICATION

	Long-Term Retardant	Gel	Class A Foam	Water
Indirect Attack	✓✓✓✓	✓✓	✓	
Direct/Parallel Attack	✓✓✓✓	✓✓✓	✓✓	✓
Interior Structure Attack		✓✓	✓✓✓✓	✓
Structure Protection-Indirect Application	✓✓✓✓	✓✓✓	✓✓	✓
Structure Protection-Direct Application		✓✓✓✓	✓✓✓	✓
Mop Up	✓✓	✓✓	✓✓✓✓	✓
Prescribed Burn Control	✓✓✓✓	✓✓✓	✓✓	✓

✓✓✓✓ = Superior Effectiveness
✓✓✓ = Excellent Effectiveness
✓✓ = Good Effectiveness
✓ = Baseline Effectiveness

For more information, contact any of our worldwide Perimeter Solutions Fire Safety offices or visit us at Phos-Chek.com or Perimeter-Solutions.com

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LC95

PHOS-CHEK
FIRE RETARDANT | FOAM | GEL

(LC95A-R, LC95A-FX, LC95A-MV, LC95W) LONG-TERM FIRE RETARDANT

LOW/MEDIUM VISCOSITY LIQUID CONCENTRATE

USES

Phos-Chek LC95A-R fire retardants are qualified by the USDA Forest Service under specification 5100-304c for use in fixed-wing air tankers and helicopters with buckets and ground engines. LC95A-R is ideal for use in multi-engine, fixed-wing air tankers and single-engine air-tankers (SEATS). The concentrate is delivered to the using location as a low viscosity liquid and is stored in the concentrate form. It is diluted and mixed with water as it is transferred to the delivery system. LC95A-R and LC95A-MV are colored to provide effective aerial application. LC95A-Fx provides ultra-high visibility when dropped, but slowly fades after exposure to sunlight.

Uncolored Phos-Chek LC95W is ideal for ground application where color is not required or is undesirable.

Phos-Chek fire retardants are used for wildland fire control in forest, brush or grassland. Functionally, Phos-Chek retardants react with and alter the thermal decomposition of wildland fuels so that they do not support flaming or glowing combustion. This deprives the fire of fuel, reducing fire intensity and the rate of flame spread. They are useful as well in prescribed burning. When applied at low application rates, fire intensity is dramatically decreased while slow burning is allowed.

HANDLING PRECAUTIONS

- FOR DETAILED SAFETY INFORMATION, please refer to the SDS.
- Minimally irritating to eyes; non-irritating to skin.
- If in eyes: Flush with plenty of water.
- Precautionary Measures: Handle in accordance with good industrial hygiene and safety practices. These practices include avoiding unnecessary contact and removal of the material from the eyes, skin and clothing.
- Eye Protection: As a good industrial practice, the use of chemical goggles is recommended. Eye flushing equipment should also be available.
- Skin Protection: As a good industrial practice, wear protective gloves to minimize skin contact. Wash hands and contaminated skin after handling.
- Respiratory Protection: Wear dust mask if dusty conditions exist. Avoid breathing vapor or mist.
- For complete SDS, visit www.phos-chek.com

NOTICE

Although the information and recommendations set forth herein (hereinafter "information") are presented in good faith and believed to be correct as of the date hereof, Perimeter Solutions LP and its affiliates makes no representations or warranties as to the completeness or accuracy thereof. Information is supplied on the condition that the persons receiving same will make their own determination as to its suitability for their purposes prior to use. In no event will Perimeter Solutions LP be responsible for damages of any nature whatsoever resulting from the use of or reliance upon information or the product to which the information refers. Nothing contained herein is to be construed as a recommendation to use any product, process, equipment or formulation in conflict with any patent, and Perimeter Solutions LP makes no representation or warranty, express or implied, that the use thereof will not infringe any patent. NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESSED OR IMPLIED, OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR OF ANY OTHER NATURE ARE MADE HEREUNDER WITH RESPECT TO INFORMATION OR THE PRODUCT TO WHICH INFORMATION REFERS.

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Good Chemistry at Work

PHOS-CHEK® MVP-F Long-Term Fire Retardant

Medium Viscosity Powder Concentrate

PHOS-CHEK
FIRE RETARDANT | FOAM | GEL

Description

Phos-Chek MVP-F is a highly soluble powder that mixes readily with water by recirculation, agitation or Phos-Chek eductor-mixing systems. MVP-F is a fugitive color retardant that maintains visibility during application, but slowly fades during exposure to sunlight.

Phos-Chek MVP-F is a gum-thickened, medium viscosity retardant that provides highly effective and accurate aerial drops from all airtankers. The elastic nature of Phos-Chek MVP-F solution improves aerial delivery performance by reducing drift, dispersion, and evaporation, and facilitates increased fuel coverage, wrap around and penetration through canopy and ladder fuels to ground vegetation. Recovery can exceed 90%. It is ideal for use in multi-engine airtankers, Very Large Air Tankers (VLATs) and Single Engine Air Tankers (SEATS), and can be accurately dropped at higher drop heights.

Uses

Phos-Chek MVP-F long-term retardant is qualified by the USDA Forest Service under specification 5100-304c for use in fixed wing air tankers and helicopters with buckets. MVP-F is an all-phosphate, gum thickened, fugitive colored retardant. It is a highly effective long-term retardant with a higher yield than any other retardant on the market.

Phos-Chek long-term fire retardants are used for wildland fire control in forest, brush or grassland. Functionally, Phos-Chek retardants react with, and alter the decomposition of wildland fuels, so that when used at the qualified mix ratio they do not support flaming or glowing combustion. This deprives the fire of fuel, reducing fire intensity and rate of spread. Long-term retardants are useful in prescribed burning. When applied at low application rates, fire intensity can be dramatically decreased while slow burning continues.

Packaging

Phos-Chek MVP-F is available in 2000 lbs. Phos-Bin containers, 2000 lbs. bulk bags, and 50 lbs. pails. Special package sizes available.

Product Characteristics	
Color	Fugitive (F)
Mix Ratio	0.95 lbs./gal. water
	0.11 kg per liter
Yield	2225 gal./ton of concentrate
	9285 liters/1000 kilograms
Solution Density	8.79 lbs. per gallon
	1.05 kilogram's/liter
Viscosity	400-800 centipoise (cP) specification
	400-600 cP Typical
Refractometer	7.75-9.75

PHOS-CHEK® MVP-F Long-Term Fire Retardant

Medium Viscosity Powder Concentrate

PHOS-CHEK® FIRE RETARDANT | FOAM | GEL

Always use the right tool for the job

Application	Long-Term Retardant	Gel	Class A Foam	Water
Indirect Attack	✓✓✓✓	✓✓	✓	
Direct/Parallel Attack	✓✓✓✓	✓✓✓	✓✓	✓
Interior Structure Attack		✓✓	✓✓✓✓	✓
Structure Protection-Indirect Application	✓✓✓✓	✓✓✓	✓✓	✓
Structure Protection-Direct Application		✓✓✓✓	✓✓✓	✓
Mop Up	✓✓	✓✓	✓✓✓✓	✓
Prescribed Burn Control	✓✓✓✓	✓✓✓	✓✓	✓

✓✓✓✓ = Superior Effectiveness ✓✓✓= Excellent Effectiveness ✓✓= Good Effectiveness ✓ = Baseline Effectiveness

Handling Precautions

- For detailed safety information, please refer to the MSDS.
- Minimally irritating to the eyes, non-irritating to skin.
- **Eye Protection:** As a good industrial practice, the use of chemical goggles is recommended.
- **Precautionary Measures:** Handle in accordance with good industrial hygiene and safety practices. These practices include avoiding unnecessary contact and removal of the material from the eyes, skin and clothing.
- **If in eyes:** Flush with plenty of water.
- **Skin Protection:** As a good industrial practice, wear protective gloves to minimize skin contact. Wash hands and exposed skin after handling.
- **Respiratory Protection:** Avoid breathing dust. Respiratory protection should be worn when airborne exposure is excessive. See MSDS for further guidance.
- For complete MSDS, visit **www.phoschek.com**.

For more information, contact any of our worldwide ICL Fire Safety offices.

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Where needs take us

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Our commitment to sustainability

MVP-FX

PHOS-CHEK®
FIRE RETARDANT | FOAM | GEL

LONG-TERM FIRE RETARDANT

HIGH VISIBILITY MV POWDER CONCENTRATE

DESCRIPTION

Phos-Chek® MVP-Fx is an ultra high visibility powder concentrate that mixes readily with water by recirculation, agitation or Phos-Chek eductor-mixing systems. MVP-Fx is a highly visible, fugitive color retardant that provides superior visibility in the air and on the ground when applied, but slowly fades during exposure to sunlight.

Phos-Chek MVP-Fx is a gum-thickened, medium viscosity retardant that provides highly effective and accurate aerial drops from all airtankers. The elastic nature of Phos-Chek MVP-Fx solution improves aerial delivery performance by reducing drift, dispersion, and evaporation, and facilitates increased fuel coverage, wrap around and penetration through canopy and ladder fuels to ground vegetation. Recovery can exceed 90%. It is ideal for use in multi-engine airtankers, Very Large Air Tankers (VLATs) and Single Engine Air Tankers (SEATS), and can be accurately dropped at higher drop heights.

PACKAGING

Phos-Chek MVP-Fx is available in 2000 lbs. Phos-Bin containers, 2000 lbs. bulk bags, and 50 lbs. pails. Special package sizes available.

PRODUCT CHARACTERISTICS

Color	Fugitive (F)
Mix Ratio	0.96 lbs./gal. of water, 0.11 kg per liter
Yield	2209 gal. per ton of concentrate, 9189 liters/1000 kilograms
Solution Density	8.75 lbs. per gallon, 1.05 kilograms/liter
Viscosity	401-800 centipoise (cP) specification, 401-600 cP Typical
Refractometer	8.0-9.75

APPLICATION

	Long-Term Retardant	Gel	Class A Foam	Water
Indirect Attack	✓✓✓✓	✓✓	✓	
Direct/Parallel Attack	✓✓✓✓	✓✓✓	✓✓	✓
Interior Structure Attack		✓✓	✓✓✓✓	✓
Structure Protection-Indirect Application	✓✓✓✓	✓✓✓	✓✓	✓
Structure Protection-Direct Application		✓✓✓✓	✓✓✓	✓
Mop Up	✓✓	✓✓	✓✓✓✓	✓
Prescribed Burn Control	✓✓✓✓	✓✓✓	✓✓	✓

✓✓✓✓ = Superior Effectiveness
✓✓✓ = Excellent Effectiveness
✓✓ = Good Effectiveness
✓ = Baseline Effectiveness

For more information, contact any of our worldwide Perimeter Solutions Fire Safety offices or visit us at Phos-Chek.com or Perimeter-Solutions.com

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MVP-FX

PHOS-CHEK®
FIRE RETARDANT | FOAM | GEL

LONG-TERM FIRE RETARDANT

HIGH VISIBILITY MV POWDER CONCENTRATE

USES

Phos-Chek MVP-Fx long-term retardant is qualified by the USDA Forest Service under specification 5100-304c for use in fixed wing air tankers and helicopters with buckets. MVP-F is an all-phosphate, gum thickened, fugitive colored retardant. It is a highly effective long-term retardant with a higher yield than any other retardant on the market.

Phos-Chek long-term fire retardants are used for wildland fire control in forest, brush or grassland. Functionally, Phos-Chek retardants react with, and alter the decomposition of wildland fuels, so that when used at the qualified mix ratio they do not support flaming or glowing combustion. This deprives the fire of fuel, reducing fire intensity and rate of spread. Long-term retardants are useful in prescribed burning. When applied at low application rates, fire intensity can be dramatically decreased while slow burning continues.

HANDLING PRECAUTIONS

- FOR DETAILED SAFETY INFORMATION, please refer to the SDS.
- Minimally irritating to the eyes, non-irritating to skin.
- Eye Protection: As a good industrial practice, the use of chemical goggles is recommended.
- Precautionary Measures: Handle in accordance with good industrial hygiene and safety practices. These practices include avoiding unnecessary contact and removal of the material from the eyes, skin and clothing.
- If in eyes: Flush with plenty of water.
- Skin Protection: As a good industrial practice, wear protective gloves to minimize skin contact. Wash hands and exposed skin after handling.
- Respiratory Protection: Avoid breathing dust. Respiratory protection should be worn when airborne exposure is excessive. See SDS for further guidance.
- For complete SDS, visit www.phos-chek.com

NOTICE

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Perimeter SOLUTIONS
Quality Products. Exceptional Response.

Responsible Care®
Good Chemistry at Work

April 2018

Products Meeting the Canadian Specification for Long-Term Retardants

(Meets Qualifying Performance Requirements for Long-Term Fire Retardants, US Forest Service 5100-304c, amended)

Chemical	Mix Ratio	Qualified/Approved Applications[1]			
	(Pounds concentrate per gallon water or gallons of water: gallons concentrate)	Fixed-Wing	Fixed-Tank Helicopter	Helicopter Bucket	Ground
LONG-TERM FIRE RETARDANTS (Qualified or Approved and commercially available)					
Dry Concentrate - Gum-thickened; Permanent or Temporary Base					
Phos-Chek MVP-Fx	0.96 lb/gal (115.0 g/L)	●		●	●
Phos-Chek MVP-F	0.95 lb/gal (113.8 g/L)	●		●	●
Dry Concentrate - Gum-thickened; Temporary Base					
Phos-Chek 259-Fx	1.01 lb/gal (121.0 g/L)	●	●	●	●
Dry Concentrate - Unthickened - None available					
Wet Concentrate - Gum-thickened; Permanent or Temporary Base					
Phos-Chek LC-95A-R	5.5:1	●		●	●
Phos-Chek LC-95A-Fx	5.5:1	●		●	●
Phos-Chek LC-95A-F	5.5:1	●		●	●
Wet Concentrate – Gum-thickened; Temporary Base					
Phos-Chek LC-95-W	5.5:1	●		●	●

1 ● Fully Qualified ○ Conditional Approval

APPENDIX C: TABLES

Table C.1 Chemical Identities of Chemicals of Potential Concern

Chemical of Potential Concern	CAS Number	Fire Retardant Products	Synonyms	Functional Category	Concentration in Manufacturer Product	Concentration in Reformulated Product (kg/L)	Reference
Ammonium Polyphosphate	68333-79-9	Phos-Chek LC95A Phos-Chek LC95A-Fx Fire-Trol 931-R[1]	Polyphosphoric acids, ammonium salts; Ammonium polyphosphate; Ammonium polyphosphates; Polymetaphosphoric acid, ammonium salt, Polyphosphoric acid, ammonium salt	Salts	>85%, liquid	0.91545	US EPA, 2015
Monoammonium Phosphate	7722-76-1	Phos-ChekMVP-F Phos-ChekMVP-Fx	azanium; ammonium dihydrogen phosphate; ammonium hydrogen phosphate; ammonium orthophosphate; ammonium phosphate; ammonium phosphate, monobasic; monoammonium phosphate; monobasic ammonium phosphate; phosphoric acid, ammonium salt; primary ammonum phosphate	Salts	75 to 85%, dry	0.8925	U.S. National Library of Medicine, n.d.e
Diammonium Phosphate	7783-28-0	Phos-ChekMVP-F Phos-ChekMVP-Fx	diazanium;hydrogen phosphate; ammonium orthophosphate; ammonium phosphate ((NH4)3PO4); ammonium phosphate, dibasic; diammonium hydrogen phosphate; diammonium phosphate; phosphoric acid, ammonium salt; DAP	Salts	8 to 12%, dry	0.126	U.S. National Library of Medicine, n.d.c
Sodium Hexacyanoferrate	13601-19-9	Fire-Trol 931-R	tetrasodium;iron(2+);hexacyanide, Sodium ferrocyanide, Sodium prussiate yellow, Tetrasodium hexacyanoferrate, Tetrasodium ferrocyanide, tetrasodium hexacyanidoferrate	Salts	0.1 to 3%, liquid	N/AV	ECHA, n.d.c; U.S. National Library of Medicine, n.d.f
Attapulgus Clay	8031-18-3	Phos-Chek LC95A Phos-Chek LC95A-Fx	Fuller's earth; Attapulgite Clay; Hydrous Alumino Silicate, Polygorskite	Emulsifier	<5.0 %, liquid	0.05385	Santa Cruz Biotechnology, Inc., 2016
Iron Oxide	1309-37-1	Phos-Chek LC95A Fire-Trol 931-R	Hydrous ferric oxide; Ferric oxide; Hydrous ferric oxide; diferric oxygen(2-) hydrate; iron (III) oxide monohydrate; Iron oxide (Fe203), hydrate; Diiron trioxide	Smoke Suppressant	<5.0%, liquid	0.05385	EHCA, n.d.a; New Jersey Department of Health and Senior Services, 2007; U.S. National Library of Medicine, n.d.d

N/AV - Not available

N/AP - Not applicable

1 - a range of ammonium polyphosphate is listed from 80 - 95%, the value of 85% is representative of the other products used and within the range of provided for Fire-Trol 931R

Table C.2 Physical Properties of Chemicals of Potential Concern

Chemical of Potential Concern	Chemical Class	Molecular Weight (g/mol)	Melting Point (°C)	Normal Boiling Point, T_B (°C)	Normal Boiling Point, T_B (K)	Henry's Law Constant (atm-m^3/mol)	Volatility	Half-Life (yr)	Solubility (mg/L)	Reference
Ammonium Polyphosphate	Inorganic	149.087	275	275	548.15	$<10^{-8}$	non-volatile	0.49315	0.5 % (w/w) at 25°C in 10% suspension (Measured)	US EPA, 2015 and SinoHarvest (volatility)
Monoammonium Phosphate	Inorganic	115.025	190				non-volatile	N/AV	40.4 g/100 g water at 25°C 404000 mg/L	U.S. National Library of Medicine, n.d.e; Pubchem and Chemical Book; Anmol Chemicals (volatility)
Diammonium Phosphate	Inorganic	132.056	155				non-volatile	N/AV	69.5 g/100 g water at 25°C 695000 mg/L	U.S. National Library of Medicine, n.d.c; Santa Cruz Biotechnology (volatility); PubChem
Sodium Hexacyanoferrate	Inorganic	303.91						N/AV	31.85 g/100 g water at 20°C 318500 mg/L	ECHA, n.d.c; U.S. National Library of Medicine, n.d.f; Pubchem and Chemical Book
Attapulgus Clay								N/AV	Insoluble	U.S. National Library of Medicine, n.d.g.
Bentonite (surrogate for Attapulgus Clay)	Inorganic	180.0598					non-volatile			ChemIDplus, ChemicalLand21; IPCS Inchem
Iron Oxide	Inorganic	159.69	1538					N/AV	Insoluble	EHCA, n.d.a; New Jersey Department of Health and Senior Services, 2007; U.S. National Library of Medicine, n.d.d; Pubchem and Chemical Book
Iron (surrogate for Iron Oxide)	Inorganic	55.845	1538	2861	3134.15					PubChem

N/AV - Not available
N/AP - Not applicable

Table C.3 Human Receptor Characteristics and Exposure Scenario Parameters

Characteristic	Infant	Toddler	Child	Teen	Adult
Active	Yes	Yes	Yes	Yes	Yes
Age	0 - 6 mo.	7 mo. - 4 y	5 - 11 y	12 - 19 y	>= 20 y
Lifestage Length (y)	0.5	4.5	7	8	60
Body Weight (kg)	8.2	16.5	32.9	59.7	70.7
Soil Ingestion Rate (g/d)	0.02	0.08	0.02	0.02	0.02
Inhalation Rate (m^3/d)	2.2	8.3	14.5	15.6	16.6
Water Ingestion Rate (L/d)	0.3	0.6	0.8	1	1.5
Time spent outdoors (h/d)	1.5	1.5	1.5	1.5	1.5
Skin Surface Area (cm^2)					
-hands	320	430	590	800	890
-arms	550	890	1480	2230	2500
-legs	910	1690	3070	4970	5720
-total	3620	6130	10140	15470	17640
Soil Loading to Skin (g/cm^2/event)					
-hands	0.0001	0.0001	0.0001	0.0001	0.0001
-surfaces other than hands	0.00001	0.00001	0.00001	0.00001	0.00001
Vegetable Ingestion Rate (g/day)[1]	72	67	98	120	137

Health Canada, 2012

1 - This ingestion rate references above ground vegetables only which would receive higher relative coverage with aerially applied fire retardants; exposure from below ground root vegetables was assumed to be negligible.

Table C.4 Literature Screening for Soil or Dust Loss During Harvesting

Google Search Terms	Date Searched
Dust loss on leaf surfaces from harvesting	2021-01-15
Pesticide loss from surface during harvesting	2021-01-15
Plant dust loss from harvesting	2021-01-15
Proportion of dust that adheres to plant surface after harvest	2021-01-15
Ash retention on leaf surfaces	2021-01-15
Ash retention on plant surfaces	2021-01-15
Pesticide retention on leaf surfaces	2021-01-15
Soil loss factor from root vegetables	2021-01-15
Salt on leaf surface	2021-01-15
Salt loss from leaf surface when harvested	2021-01-15
Human health risk assessment for aerial applied chemicals	2021-01-15
Soil adherence garden vegetable harvesting	2021-01-15
Guidance Documents Checked	**Date Searched**
US EPA, 2011	2021-01-16
CCME, 2006	2021-01-16

Table C.5 Exposure Scenario and Calculation Inputs			
Exposure Scenario			
Hours per day at site	24		
Days per week	7		
Weeks per year	52		
Dermal exposure events per day	1		
Water contact events per day	1		
Duration of water contact event (h)	0.5		
Days/year of contaminated food ingestion	365		
Exposure Calculation Inputs	**Abbreviation**	**Value Applied**	**Reference**
Product Application Rate (kg/L)	PAR	1.077	Phos-Chek, n.d.a (Appendix B)
Cistern volume (L)	CV	5500	Government of Manitoba, 2014
Area of residential basement (m^2)	RA	150.0625	AEP, 2019
Application rate of applied solution (L/m^2)	AR	0.815	USDA, 2000
Soil bulk density (kg/m^3)	ϱb	1400	AEP, 2019
Soil mixing and infiltration depth (m)	M	0.15	CCME, 2006
Average retention on leaf (L/m^2)	R	0.033	Wang et al., 2014
Average area of one lettuce leaf (m^2)	LA	0.014	Abro et al., 2014
Mass of one lettuce leaf (wet weight) (kg)	LM	0.024	Hannone, 2019
Food harvesting product loss factor	HF	0.5	No reference
Component percentage in product	%w/w	0.85, 0.12, 0.03, 0.05	Safety Data Sheets (Appendix A)
Solubility percent (unitless)	Solubility %	0.005	Safety Data Sheets (Appendix A)
Particulate concentration in outdoor air (kg/m^3)	P	7.6E-10	Health Canada, 2004
Absorption factor (unitless)	AF	1	Health Canada, 2012
Dermal absorption factor (unitless)	AFDer	1	Health Canada, 2012

Table C.6 Ammonium Polyphosphate Predicted Human Exposure Doses (mg/kg/d)

Pathway Results	Infant	Toddler	Child	Teen	Adult
Inadvertent Ingestion of contaminated soil	8.67E-03	1.72E-02	2.16E-03	1.19E-03	1.01E-03
Inhalation of fugitive dust	4.53E-08	8.49E-08	7.44E-08	4.41E-08	3.96E-08
Ingestion of contaminated drinking water	3.80E+00	3.78E+00	2.53E+00	1.74E+00	2.21E+00
Dermal contact with contaminated soil	2.02E-02	1.48E-02	1.13E-02	9.05E-03	8.60E-03
Ingestion of contaminated food	0.00E+00	3.62E+01	2.66E+01	1.79E+01	1.73E+01
Total ingestion exposure	3.81E+00	4.00E+01	2.91E+01	1.97E+01	1.95E+01
Total dermal exposure	2.02E-02	1.48E-02	1.13E-02	9.05E-03	8.60E-03
Ingestion + dermal exposure	3.83E+00	4.00E+01	2.91E+01	1.97E+01	1.95E+01
Total inhalation exposure	4.53E-08	8.49E-08	7.44E-08	4.41E-08	3.96E-08
Total exposure (sum of all pathways)	3.83E+00	4.00E+01	2.91E+01	1.97E+01	1.95E+01

Table C.7 Monoammonium Polyphosphate Predicted Human Exposure Doses (mg/kg/d)

Pathway Results	Infant	Toddler	Child	Teen	Adult
Inadvertent Ingestion of contaminated soil	8.67E-03	1.72E-02	2.16E-03	1.19E-03	1.01E-03
Inhalation of fugitive dust	4.53E-08	8.49E-08	7.44E-08	4.41E-08	3.96E-08
Ingestion of contaminated drinking water	3.08E+02	3.06E+02	2.05E+02	1.41E+02	1.78E+02
Dermal contact with contaminated soil	2.02E-02	1.48E-02	1.13E-02	9.05E-03	8.60E-03
Ingestion of contaminated food	0.00E+00	3.62E+01	2.66E+01	1.79E+01	1.73E+01
Total ingestion exposure	3.08E+02	3.42E+02	2.31E+02	1.59E+02	1.96E+02
Total dermal exposure	2.02E-02	1.48E-02	1.13E-02	9.05E-03	8.60E-03
Ingestion + dermal exposure	3.08E+02	3.42E+02	2.31E+02	1.59E+02	1.96E+02
Total inhalation exposure	4.53E-08	8.49E-08	7.44E-08	4.41E-08	3.96E-08
Total exposure (sum of all pathways)	3.08E+02	3.42E+02	2.31E+02	1.59E+02	1.96E+02

Table C.8 Diammonium Phosphate Predicted Human Exposure Doses (mg/kg/d)

Pathway Results for	Infant	Toddler	Child	Teen	Adult
Inadvertent Ingestion of contaminated soil	1.22E-03	2.43E-03	3.05E-04	1.68E-04	1.42E-04
Inhalation of fugitive dust	6.39E-09	1.20E-08	1.05E-08	6.22E-09	5.59E-09
Ingestion of contaminated drinking water	7.47E+01	7.43E+01	4.97E+01	3.42E+01	4.33E+01
Dermal contact with contaminated soil	2.85E-03	2.09E-03	1.59E-03	1.28E-03	1.21E-03
Ingestion of contaminated food	0.00E+00	1.04E-01	7.64E-02	5.16E-02	4.97E-02
Total ingestion exposure	7.47E+01	7.44E+01	4.97E+01	3.43E+01	4.34E+01
Total dermal exposure	2.85E-03	2.09E-03	1.59E-03	1.28E-03	1.21E-03
Ingestion + dermal exposure	7.47E+01	7.44E+01	4.97E+01	3.43E+01	4.34E+01
Total inhalation exposure	6.39E-09	1.20E-08	1.05E-08	6.22E-09	5.59E-09
Total exposure (sum of all pathways)	7.47E+01	7.44E+01	4.97E+01	3.43E+01	4.34E+01

Table C.9 Sodium Hexacyanoferrate Predicted Human Exposure Doses (mg/kg/d)

Pathway Results	Infant	Toddler	Child	Teen	Adult
Inadvertent Ingestion of contaminated soil	3.06E-04	6.08E-04	7.62E-05	4.20E-05	3.55E-05
Soil Particulate Inhalation	1.60E-09	3.00E-09	2.62E-09	1.56E-09	1.40E-09
Ingestion of contaminated drinking water	8.56E+00	8.51E+00	5.69E+00	3.92E+00	4.97E+00
Dermal contact with contaminated soil	7.12E-04	5.23E-04	3.98E-04	3.19E-04	3.04E-04
Ingestion of contaminated food	0.00E+00	2.60E-02	1.91E-02	1.29E-02	1.24E-02
Total ingestion exposure	8.56E+00	8.54E+00	5.71E+00	3.93E+00	4.98E+00
Total dermal exposure	7.12E-04	5.23E-04	3.98E-04	3.19E-04	3.04E-04
Ingestion + dermal exposure	8.56E+00	8.54E+00	5.71E+00	3.93E+00	4.98E+00
Total inhalation exposure	1.60E-09	3.00E-09	2.62E-09	1.56E-09	1.40E-09
Total exposure (sum of all pathways)	8.56E+00	8.54E+00	5.71E+00	3.93E+00	4.98E+00

Table C.10 Iron Oxide Predicted Human Exposure Doses (mg/kg/d)

Pathway Results	Infant	Toddler	Child	Teen	Adult
Inadvertent Ingestion of contaminated soil	5.10E-04	1.01E-03	1.27E-04	7.00E-05	5.91E-05
Inhalation of fugitive dust	2.66E-09	4.99E-09	4.37E-09	2.59E-09	2.33E-09
Ingestion of contaminated drinking water	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Dermal contact with contaminated soil	1.19E-03	8.71E-04	6.64E-04	5.32E-04	5.06E-04
Ingestion of contaminated food	0.00E+00	4.34E-02	3.18E-02	2.15E-02	2.07E-02
Total ingestion exposure	5.10E-04	4.44E-02	3.20E-02	2.16E-02	2.08E-02
Total dermal exposure	1.19E-03	8.71E-04	6.64E-04	5.32E-04	5.06E-04
Ingestion + dermal exposure	1.70E-03	4.53E-02	3.26E-02	2.21E-02	2.13E-02
Total inhalation exposure	2.66E-09	4.99E-09	4.37E-09	2.59E-09	2.33E-09
Total exposure (sum of all pathways)	1.70E-03	4.53E-02	3.26E-02	2.21E-02	2.13E-02

Note that iron oxide is insoluble and as such product introduced to water is expected to settle out from the water column.

Table C.11 TRV Selected for Chemicals of Potential Concern

Chemical of Potential Concern	CAS Number	TRV Selected (mg/kg/d)	References
Ammonium Polyphosphate	68333-79-9	2.5	OECD, 2007
Monoammonium Phosphate	7722-76-1	2.5	OECD, 2007
Diammonium Phosphate	7783-28-0	2.5	OECD, 2007
Sodium Hexacyanoferrate	13601-19-9	0.044	EFSA et al., 2018
Attapulgus Clay	8031-18-3	N/AV	N/AV
Iron Oxide	1309-37-1	10	EFSA et al., 2018

Table C.12 Hazard Quotients

Hazard Quotient by Exposure Pathway	Infant	Toddler	Child	Teen	Adult
Ammonium Polyphosphate					
Inadvertent Ingestion of Contaminated Soil	**3.47E-03**	**6.89E-03**	**8.64E-04**	**4.76E-04**	**4.02E-04**
Ingestion of Contaminated Drinking Water	**1.52E+00**	**1.51E+00**	**1.01E+00**	**6.97E-01**	**8.83E-01**
Ingestion of Contaminated Food	**0.00E+00**	**1.45E+01**	**1.06E+01**	**7.17E+00**	**6.91E+00**
Dermal Contact	8.08E-03	5.93E-03	4.51E-03	3.62E-03	3.44E-03
Inhalation	1.81E-08	3.40E-08	2.98E-08	1.76E-08	1.58E-08
Hazard Quotient - Total	**1.53E+00**	**1.60E+01**	**1.16E+01**	**7.87E+00**	**7.80E+00**
Monoammonium Polyphosphate					
Inadvertent Ingestion of Contaminated Soil	**3.47E-03**	**6.89E-03**	**8.64E-04**	**4.76E-04**	**4.02E-04**
Ingestion of Contaminated Drinking Water	**1.23E+02**	**1.22E+02**	**8.18E+01**	**5.64E+01**	**7.12E+01**
Ingestion of Contaminated Food	**0.00E+00**	**1.45E+01**	**1.06E+01**	**7.17E+00**	**6.91E+00**
Dermal Contact	8.08E-03	5.93E-03	4.51E-03	3.62E-03	3.44E-03
Inhalation	1.81E-08	3.40E-08	2.98E-08	1.76E-08	1.58E-08
Hazard Quotient - Total	**1.23E+02**	**1.37E+02**	**9.24E+01**	**6.36E+01**	**7.81E+01**
Diammonium Phosphate					
Inadvertent Ingestion of Contaminated Soil	**4.89E-04**	**9.73E-04**	**1.22E-04**	**6.72E-05**	**5.67E-05**
Ingestion of Contaminated Drinking Water	**2.99E+01**	**2.97E+01**	**1.99E+01**	**1.37E+01**	**1.73E+01**
Ingestion of Contaminated Food	**0.00E+00**	**4.17E-02**	**3.06E-02**	**2.06E-02**	**1.99E-02**
Dermal Contact	1.14E-03	8.36E-04	6.37E-04	5.11E-04	4.86E-04
Inhalation	2.56E-09	4.79E-09	4.20E-09	2.49E-09	2.24E-09
Hazard Quotient - Total	**2.99E+01**	**2.98E+01**	**1.99E+01**	**1.37E+01**	**1.74E+01**
Sodium Hexacyanoferrate					
Inadvertent Ingestion of Contaminated Soil	**6.95E-03**	**1.38E-02**	**1.73E-03**	**9.55E-04**	**8.06E-04**
Ingestion of Contaminated Drinking Water	**1.95E+02**	**1.93E+02**	**1.29E+02**	**8.91E+01**	**1.13E+02**
Ingestion of Contaminated Food	**0.00E+00**	**5.92E-01**	**4.34E-01**	**2.93E-01**	**2.82E-01**
Dermal Contact	1.62E-02	1.19E-02	9.05E-03	7.25E-03	6.90E-03
Inhalation	3.63E-08	6.81E-08	5.96E-08	3.54E-08	3.18E-08
Hazard Quotient - Total	**1.95E+02**	**1.94E+02**	**1.30E+02**	**8.94E+01**	**1.13E+02**
Iron Oxide					
Inadvertent Ingestion of Contaminated Soil	5.10E-05	1.01E-04	1.27E-05	7.00E-06	5.91E-06
Ingestion of Contaminated Drinking Water	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ingestion of Contaminated Food	0.00E+00	4.34E-03	3.18E-03	2.15E-03	2.07E-03
Dermal Contact	1.19E-04	8.71E-05	6.64E-05	5.32E-05	5.06E-05
Inhalation	2.66E-10	4.99E-10	4.37E-10	2.59E-10	2.33E-10
Hazard Quotient - Total	1.70E-04	4.53E-03	3.26E-03	2.21E-03	2.13E-03

Bold indicates values greater than a threshold of 0.2

APPENDIX D: CONCEPTUAL MODEL – RESIDENTIAL LAND USE EXPOSURE TO AERIALLY APPLIED FIRE RETARDANT

Ingestion of Garden Foods

Water Ingestion

Direct Contact

Fire Retardant

Receptors

Dermal Contact with Water

LEGEND

- Vegetation
- Pond
- Fire Retardant
- Cistern

Direct Contact Includes: Dermal Contact, Incidental Ingestion, and Particulate Inhalation.

ALBERTA HEALTH ACTIVITY 8

CONCEPTUAL MODEL - RESIDENTIAL LAND USE EXPOSURE TO AERIALLY APPLIED FIRE RETARDANT

MEMS, 2018;

SCALE NA

MILLENNIUM EMS Solutions Ltd.

PROJECT: 17-00095-15

DRAWN BY: EPITTMAN

CHECKED BY: LM

DATE: JULY 24, 2019

FIGURE

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APPENDIX E: EQUATION PRESENTATION

APPENDIX E – EQUATION PRESENTATION

Table of Contents

1.0 CALCULATION OF PARAMETERS IN SELECT MEDIA

Equations presented in Section 1 below were developed to estimate hypothetical worst-case media concentration to enable the evaluation of risk and are mathematic based.

1.1 Drinking Water

$$C_{DW} = C_{solution(DW)} \times AV \times \frac{1}{(CV-AV)} \quad \text{Equation 1.}$$

$$C_{solution(DW)} = PAR \times \%\frac{w}{w} \times 1{,}000{,}000 \times solubility\ \% \quad \text{Equation 2.}$$

$$AV = RA \times AR \quad \text{Equation 3.}$$

Where:

C_{DW}	=	*concentration in drinking water (mg/L)*
$C_{solution(DW)}$	=	*concentration of chemical in applied solution (mg/L)*
PAR	=	*Product Application Rate (kg/L)*
AV	=	*application volume (L)*
CV	=	*cistern volume (L)*
%w/w	=	*component percentage of COPC in applied solution*
Solubility %	=	*0.005 (unitless)_*
1,000,000	=	*unit conversion (kg/L to mg/L)*
RA	=	*area of residential basement (m^2) (AEP 2019)*
AR	=	*application rate of applied solution (L/m^2)*

1.2 Soil

$$C_{soil} = \frac{C_{solution} \times AR}{\rho b \times M} \quad \text{Equation 4.0}$$

$$C_{solution} = PAR \times \%\frac{w}{w} \times 1{,}000{,}000 \quad \text{Equation 5.0}$$

Where:

C_{soil}	=	*concentration in soil (mg/kg)*
$C_{solution(soil)}$	=	*concentration of chemical in applied solution (mg/L)*
AR	=	*application rate of applied solution (L/m^2)*
ρb	=	*soil bulk density (kg/m^3) = 1,400 (AEP 2019)*
M	=	*mixing and infiltration depth (m)*
PAR	=	*Product Application Rate (kg/L)*
%w/w	=	*component percentage of COPC in applied solution (unitless)*
1,000,000	=	*unit conversion (kg/L to mg/L)*

1.3 Leafy Vegetables

$$C_{leaf} = \frac{C_{solution} \times R \times LA}{LM} \quad \text{Equation 6.0}$$

$$C_{solution} = PAR \times \%\frac{w}{w} \times 1{,}000{,}000 \qquad \text{Equation 5.0}$$

Where:

C_{leaf}	=	*concentration in leaf (mg/kg)*
$C_{solution}$	=	*concentration of chemical in applied solution (mg/L)*
R	=	*average retention on leaf = 0.033 L/m² (Wang et al. 2014)*
LA	=	*average area of one lettuce leaf = 0.014 m² (Abro et al., 2014)*
LM	=	*mass of one lettuce leaf (wet weight) = 0.024 kg (Hannone, 2019)*
PAR	=	*Product Application Rate (kg/L)*
%w/w	=	*component percentage of COPC in applied solution (unitless)*
1,000,000	=	*unit conversion (kg/L to mg/L)*

2.0 CALCULATION OF EXPOSURE (DOSE)

All equations presented below in Sections 2 and 3 are referenced from Health Canada, 2010 and 2012.

2.1 Soil Particulate Inhalation (Fugitive Dust)

$$Dose_{fugitive\ dust} = \frac{Csoil \times P \times AF \times IR \times D1 \times D2 \times D3}{BW} \qquad \text{Equation 7.}$$

Where:

Csoil	=	*concentration of chemical in soil (mg/kg)*
P	=	*particulate concentration in outdoor air (kg/m³)*
IR	=	*inhalation rate (m³/d)*
AF	=	*absorption factor (unitless) = 1 (Health Canada, 2010)*
D1	=	*hours per day outdoors/24 hours (unitless)*
D2	=	*days per week exposed/7 days (unitless)*
D3	=	*weeks per year exposed/52 weeks (unitless)*
BW	=	*body weight (kg)*

2.2 Dermal Soil or Sediment Contact

$$Dose_{dermal} = \frac{Csoil \times \frac{[(DAH \times SAH) + ((SAA + SAL) \times DAO)]}{1000} \times AFDer \times D2 \times D3}{BW} \qquad \text{Equation 8.}$$

Where:

Csoil	=	*concentration of chemical in soil (mg/kg)*
SAH	=	*surface area of hands (cm²)*
DAH	=	*soil loading to hands (g/cm²/event)*
SAA	=	*surface area of arms (cm²)*
SAL	=	*surface area of legs (cm²)*

DAO	=	*soil loading to arms and legs (g/cm2/event)*
AFDer	=	*dermal absorption factor (unitless)*
D2	=	*days per week exposed/7 days (unitless)*
D3	=	*weeks per year exposed/52 weeks (unitless)*
BW	=	*body weight (kg)*

2.3 Inadvertent Soil or Sediment Ingestion

$$Dose_{soil\ ingestion} = \frac{Csoil \times \frac{SIR}{1000} \times AF \times D2 \times D3}{BW}$$ Equation 9.

Where:

Csoil	=	*concentration of chemical in soil (mg/kg)*
SIR	=	*soil ingestion rate (kg/d)*
AF	=	*oral absorption factor (unitless) = 1*
D2	=	*days per week exposed/7 days (unitless)*
D3	=	*weeks per year exposed/52 weeks (unitless)*
BW	=	*body weight (kg)*

2.4 Water Ingestion

$$Dose_{water\ ingestion} = \frac{C_{DW} \times WIR \times AF \times D2 \times D3}{BW}$$ Equation 10.

Where:

C_{DW}	=	*concentration of chemical in water (mg/L)*
WIR	=	*water ingestion rate (L/d)*
AF	=	*absorption factor (unitless) = 1*
D2	=	*days per week exposed/7 days (unitless)*
D3	=	*weeks per year exposed/52 weeks(unitless)*
BW	=	*body weight (kg)*

2.5 Garden Food Ingestion

$$Dose_{food\ ingestion} = \frac{C_{leaf} \times HF \times FIR \times AF \times Meals}{BW}$$ Equation 11.

Where:

C_{leaf}	=	*concentration of chemical in food (mg/kg)*
HF	=	*food harvesting product loss factor (0.5, unitless)*

FIR	=	*food ingestion rate (kg/d)*
AF	=	*absorption factor (unitless) = 1*
Meals	=	*Days per 365 of contaminated food ingestion*
BW	=	*body weight (kg)*

3.0 RISK CHARACTERIZATION

3.1 Exposure (Dose) Vs. Toxicological Reference Value (TRV)

$$HQ = \frac{Dose_{dermal}+Dose_{soil\ ingestion}+Dose_{water\ ingestion}+Dose_{food\ ingestion}+Dose_{fugitive\ dust}}{TRV}$$ Equation 12.

Where:

HQ	=	*hazard quotient (unitless)*
TRV	=	*toxicity reference value (mg/kg/day)*

4.0 WORKED EXAMPLE (AMMONIUM POLYPHOSPHATE) – TODDLER

4.1 Calculate Concentration in Drinking Water (C_{DW})

$$AV = RA \times AR$$ Equation 3.

$$AV = 150.0625\ m^2 \times 0.815\ \frac{L}{m^2}$$

$$AV = 122.3\ L$$

$$C_{solution(DW)} = PAR\ \times \%\frac{w}{w} \times 1{,}000{,}000 \times solubility\ \%$$ Equation 2.

$$C_{solution} = 1.077\ kg/L \times 0.85 \times 1{,}000{,}000 \times 0.005$$

$$C_{solution} = 4{,}577.25\ mg/L$$

$$C_{DW} = C_{solution(DW)} \times AV \times \frac{1}{(CV-AV)}$$ Equation 1.

$$C_{DW} = 4{,}577.25\frac{mg}{L} \times 122.3L \times \frac{1}{(5{,}500L - 122.3L)}$$

$$C_{DW} = 104\frac{mg}{L}$$

4.2 Calculate Concentration in Soil (C_{soil})

$$C_{solution} = PAR \times \%\frac{w}{w} \times 1{,}000{,}000 \qquad \text{Equation 5.}$$

$$C_{solution(soil)} = 1.077\ kg/L \times 0.85 \times 1{,}000{,}000$$

$$C_{solution(soil)} = 915{,}450\ mg/L$$

$$C_{soil} = \frac{C_{solution} \times AR}{\rho b \times M} \qquad \text{Equation 4.}$$

$$C_{soil} = \frac{915{,}450\frac{mg}{L} \times 0.815\ \frac{L}{m^2}}{1{,}400\ \frac{kg}{m^3} \times 0.15\ m}$$

$$C_{soil} = 3{,}552.8\frac{mg}{kg}$$

4.3 Concentration in Leafy Vegetables (C_{leaf})

$$C_{solution} = PAR \times \%\frac{w}{w} \times 1{,}000{,}000 \qquad \text{Equation 5.}$$

$$C_{solution} = 1.077\ kg/L \times 0.85 \times 1{,}000{,}000$$

$$C_{solution} = 915{,}450\ mg/L$$

$$C_{leaf} = \frac{C_{solution} \times R \times LA}{LM} \qquad \text{Equation 6.}$$

$$C_{leaf} = \frac{915{,}450\frac{mg}{L} \times 0.03341\frac{L}{m^2} \times 0.014 m^2}{0.024\ kg}$$

$$C_{leaf} = 17{,}841\frac{mg}{kg}$$

4.4 Soil Particulate Inhalation (Fugitive Dust)

$$Dose_{fugitive\ dust} = \frac{Csoil \times P \times AF \times IR \times D1 \times D2 \times D3}{BW} \qquad \text{Equation 7.}$$

$$Dose_{fugitive\ dust} = \frac{3{,}552.8\frac{mg}{kg} \times \frac{7.6E^{-10}kg}{m^3} \times 1 \times \frac{8.3m^3}{d} \times \frac{24}{24} \times \frac{7}{7} \times \frac{52}{52}}{16.5kg}$$

$$Dose_{fugitive\ dust} = 8.49E^{-8}\ \text{mg/kg/d}$$

4.5 Dermal Soil or Sediment Contact (Dose)

$$Dose_{dermal} = \frac{Csoil \times \frac{[(DAH \times SAH) + ((SAA + SAL) \times DAO)]}{1000} \times AFDer \times D2 \times D3}{BW}$$ Equation 8.

$$= \frac{3{,}552.8\frac{mg}{kg} \times \frac{\left[\left(\frac{0.0001g}{cm^2}/event\ \times 430\ cm^2\right) + \left(\frac{0.00001g}{cm^2}/event \times (890\ cm^2 + 1690\ cm^2)\right)\right]}{1000}}{16.5kg} \times 1 \times \frac{7}{7} \times \frac{52}{52}$$

$$Dose_{Dermal} = 0.0148\ \text{mg/kg/day}$$

4.6 Inadvertent Soil or Sediment Ingestion (Dose)

$$Dose_{soil\ ingestion} = \frac{Csoil \times \frac{SIR}{1000} \times AF \times D2 \times D3}{BW}$$ Equation 9.

$$Dose_{soil\ ingestion} = \frac{3{,}552.8\frac{mg}{kg} \times \frac{0.08kg/d}{1000} \times 1 \times \frac{7}{7} \times \frac{52}{52}}{16.5\ kg}$$

$$Dose_{soil\ ingestion} = 0.0172\ mg/kg/d$$

4.7 Water Ingestion (Dose)

$$Dose_{water\ ingestion} = \frac{C_{DW} \times WIR \times AF \times D2 \times D3}{BW}$$ Equation 10.

$$Dose_{water\ ingestion} = \frac{104mg/L \times 0.6L/d \times 1 \times \frac{7}{7} \times \frac{52}{52}}{16.5kg}$$

$$Dose_{water\ ingestion} = 3.78\ \text{mg/kg/d}$$

4.8 Garden Food Ingestion

$$Dose_{food\ ingestion} = \frac{C_{leaf} \times HF \times \frac{FIR}{1000} \times AF \times Meals}{BW}$$ Equation 11.

$$Dose_{food\ ingestion} = \frac{\frac{17{,}841mg}{kg} \times 0.5 \times \frac{67kg/d}{1000} \times 1 \times \frac{365}{365}}{16.5kg}$$

$$Dose_{food\ ingestion} = 36.22\ \text{mg/kg/d}$$

4.9 Risk Characterization (Hazard Quotient)

$$HQ = \frac{Dose_{dermal} + Dose_{soil\ ingestion} + Dose_{water\ ingestion} + Dose_{food\ ingestion} + Dose_{fugitive\ dust}}{TRV}$$ Equation 12.

$$\frac{HQ = 0.0148mg/kg/d + 0.0172mg/kg/d + 3.78mg/kg/d + 36.22mg/kg/d\ + 8.49E^{-8}mg/kg/d}{2.5mg/kg/d}$$

$$HQ = \ 1.60E1$$

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APPENDIX F: TOXICITY OF CHEMICALS OF POTENTIAL CONCERN

Table F.1 Toxicity of Chemicals of Potential Concern

Chemical of Potential Concern	CAS Number	TRV Selected (mg/kg/d)	Reference Searched	Chronic Oral Reference Dose (mg/kg-day)	Subchronic Oral Reference Dose (mg/kg-day)	Short-Term Oral	RFD (mg/kg-d)	LC50	LD50 Oral	LD50 Dermal	LD50 Intravenous	Carcinogen Group	Occupational Exposure	LOEL/LOEC	NOEL or NOAEL	Study Length	Primary Literature	References	Date Searched
Ammonium Polyphosphate	68333-79-9	2.5	Risk Assessment Information System	48.6	48.6	-	-	-	-	-	-	-	-	-	-	-	-	University of Tennessee, 2018	24-Jun-19
			Haz-Map from U.S. National Library of Medicine	-	-	-	-	5090 mg/m^3/4 hour (rat)	-	-	-	-	-	-	-	-	-	US National Library of Medicine, 2018	1-Apr-19
			Subcommittee on Flame Retardant Chemicals	-	-	-	300 (oral, calcification of the kidney)	-	>2000 mg/kg bw	-	-	-	-	-	-	-	-	National Research Council (US) Subcommittee on Flame Retardant Chemicals, 2000	25-Jun-19
			Screening Information Dataset Initial Assessment Profile	-	-	-	-	-	-	-	-	-	-	-	NOAEL: 250 mg/kg bw/day rats gavage study. Blood chemistry deviations noted at higher concentrations.	35 days (7days/week)	No information	OECD, 2007	17-Jul-19
Monoammonium Phosphate	7722-76-1	2.5	Risk Assessment Information System	48.6	48.6	-	-	-	-	-	-	-	-	-	-	-	-	University of Tennessee, 2018	24-Jun-19
			Hazardous Substances Data Bank From U.S. National Library of Medicine	-	-	-	-	-	6500 mg/kg bw	>7950 mg/kg bw	-	-	-	-	-	-	-	US National Library of Medicine, n.d.e	1-Apr-19
			Screening Information Dataset Initial Assessment Profile	-	-	-	-	-		-	-	-	-	-	NOAEL: 250 mg/kg bw/day rats gavage study. Blood chemistry deviations noted at higher concentrations.	35 days (7days/week)	No information	OECD, 2007	17-Jul-19
Diammonium Phosphate	7783-28-0	2.5	Risk Assessment Information System	48.6	48.6	-	-	-	-	-	-	-	-	-	-	-	-	University of Tennessee, 2018	24-Jun-19
			Hazardous Substances Data Bank From U.S. National Library of Medicine	-	-	-	-	-	5750 mg/kg bw	>7940 mg/kg bw	-	-	-	-	-	-	-	US National Library of Medicine, n.d.c	1-Apr-19
			Screening Information Dataset Initial Assessment Profile	-	-	-	-	-	-	-	-	-	-	-	NOAEL: 250 mg/kg bw/day rats gavage study. Blood chemistry deviations noted at higher concentrations.	35 days (7days/week)	No information	OECD, 2007	17-Jul-19
			Cosmetic Ingredient Review	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Cosmetic Ingredient Review, 2017	17-Jul-19
Sodium Hexacyanoferrate	13601-19-9	0.044	Risk Assessment Information System	-	-	-	-	-	-	-	-	-	-	-	-	-	-	University of Tennessee, 2018	24-Jun-19
			TOXNET	-	-	-	-	-	-	-	-	-	-	-	-	-	-	US National Library of Medicine, n.d.f	1-Apr-19
			European Food Safety Authority	-	-	-	-	-	-	-	-	-	-	-	NOAEL of 1,000 mg sodium ferrocyanide/kg bw per day for reproductive study and NOAEL of **4.4 mg sodium ferrocyanide/kg bw per day** for the renal effects in a chronic study in rats	Reproductive study: Pregnant rats gestational day 6 to 15 (10 days) Kidney Study: 2 years	Reproductive study: COT (1994) Kidney Study: COT (1994)	EFSA et al., 2018	17-Jul-19
Attapulgus Clay	8031-18-3	N/AV	Risk Assessment Information System	-	-	-	-	-	-	-	-	-	-	-	-	-	-	University of Tennessee, 2018	24-Jun-19
			Cosmetic Ingredient Review	-	-	-	-	-	-	-	-	-	Single employee diagnosed with aspiration pneumonia and pneumoconiosis after long-term exposure (15 years)	-	-	-	-	Cosmetic Ingredient Review Expert, 2003	17-Jul-19
Iron Oxide	1309-37-1	10	Risk Assessment Information System	-	-	-	-	-	-	-	-	-	-	-	-	-	-	University of Tennessee, 2018	24-Jun-19
			International Agency for Research on Cancer	-	-	-	-	-	-	-	-	3	-	-	-	-	-	IARC, 2018	24-Jun-19
			Hazardous Substances Data Bank From U.S. National Library of Medicine	-	-	<40 kg/mg	-	-	-	-	-	-	-	-	-	-	-	US National Library of Medicine, n.d.d	1-Apr-19
			Ontario Ministry of Labour	-	-	-	-	-	-	-	-	-	5 mg/m3 (TWA)	-	-	-	-	Ontario Ministry of Labour, 2017	17-Jul-19
			European Food Safety Authority	-	-	-	-	-	-	-	-	-	-	-	NOAEL for micronsized red iron oxide of **1,000 mg/kg bw per day** (rats, subacute oral)	Rat study: 13 weeks	Rat study: Yun et al 2015	EFSA et al., 2018	17-Jul-19
			European Chemicals Agency	-	-	-	-	-	-	-	-	-	-	-	-	-	-	ECHA, n.d.a	11-Apr-19
Bentonite (surrogate for Attapulgus Clay)	1302-78-9	-	Risk Assessment Information System	-	-	-	-	-	-	-	-	-	-	-	-	-	-	University of Tennessee, 2018	24-Jun-19
			Hazardous Substances Data Bank From U.S. National Library of Medicine	-	-	-	-	-	-	-	35 mg/kg (rat, intravenous)	-	-	-	-	-	-	US National Library of Medicine, n.d.b	1-Apr-19
			Cosmetic Ingredient Review Expert Panel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Cosmetic Ingredient Review Expert Panel, 2003	17-Jul-19
Iron (surrogate for Iron Oxide)	7439-89-6	-	Risk Assessment Information System	0.7	0.7	-	-	-	-	-	-	-	-	-	-	-	-	University of Tennessee, 2018	24-Jun-19
			Hazardous Substances Data Bank From U.S. National Library of Medicine	-	-	<40 mg/kg	-	-	-	-	-	-	8 hr Time Weighted Avg (TWA): 5 mg/cu m /Iron oxide, respirable fraction	-	-	-	-	US National Library of Medicine, n.d.b	1-Apr-19
			US EPA Provisional Peer Reviewed Toxicity Values	-	-	-	-	-	-	-	-	-	-	LOAEL: 3.1 mg/m is a LOAEL for adverse lung effects in rabbits	NOAEL: **of 0.27** is established for chronic iron toxicity (human study) and 1.4 mg/m^3 is a NOAEL for rabbit study	Human study: 4 years Survey (NHANES II) data base Rabbit study: 6 hours/day, 5 days/week for 2 months	Human Study: Looker et al (1988) Rabbit Study: Johansson et al (1992)	US EPA, 2006	24-Jun-19

1 - A search of the US EPA ECOTOX database included resuls only for terrestrial mammalian receptors.

Key Words searched: CAS number 68333-79-9, 7722-76-1, 7783-28-0, 13601-19-9, 8031-18-3, 1309-37-1, 1302-78-9 or Ammonium Polyphosphate, Monoammonium Phosphate, Diammonium Phosphate, Sodium Hexacyanoferrate, Attapulgus Clay, Iron Oxide, Bentonite and toxicity or NOEL or LOEL

Abbreviations:

CAS= Chemical Abstracts Service
LC= Lethal Concentration
LD= Lethal Dose
LOEC= Lowest Observed Effect Concentration
LOEL= Lowest Observed Effect Level
NOAEL= No Observed Adverse Effect Level
NOEL= No Observed Effect Level
OECD= Organisation for Economic Co-operation and Development
OEHHA= Office of Environmental Health Hazard Assessment
RFD= Reference Dose
SIDS= Screening Information Dataset
TRV= Toxicity Reference Value
US EPA= United States Environmental Protection Agency

Table F.2 Toxicity References Searched with No Information

Reference	Key Words	Date Searched
WHO, 2000	CAS number 68333-79-9, 7722-76-1, 7783-28-0, 13601-19-9, 8031-18-3, 1309-37-1, 1302-78-9 or Ammonium Polyphosphate, Monoammonium Phosphate, Diammonium Phosphate, Sodium Hexacyanoferrate, Attapulgus Clay, Iron Oxide, Bentonite and toxicity or NOEL or LOEL	25-Jun-19
US EPA IRIS, 2019	CAS number 68333-79-9, 7722-76-1, 7783-28-0, 13601-19-9, 8031-18-3, 1309-37-1, 1302-78-9 or Ammonium Polyphosphate, Monoammonium Phosphate, Diammonium Phosphate, Sodium Hexacyanoferrate, Attapulgus Clay, Iron Oxide, Bentonite	24-Jun-19
ATSDR MRL, 2019	CAS number 68333-79-9, 7722-76-1, 7783-28-0, 13601-19-9, 8031-18-3, 1309-37-1, 1302-78-9 or Ammonium Polyphosphate, Monoammonium Phosphate, Diammonium Phosphate, Sodium Hexacyanoferrate, Attapulgus Clay, Iron Oxide, Bentonite	24-Jun-19
ATSDR Tox Profiles, 2019	CAS number 68333-79-9, 7722-76-1, 7783-28-0, 13601-19-9, 8031-18-3, 1309-37-1, 1302-78-9 or Ammonium Polyphosphate, Monoammonium Phosphate, Diammonium Phosphate, Sodium Hexacyanoferrate, Attapulgus Clay, Iron Oxide, Bentonite	24-Jun-19
RIVM, 2001	CAS number 68333-79-9, 7722-76-1, 7783-28-0, 13601-19-9, 8031-18-3, 1309-37-1, 1302-78-9 or Ammonium Polyphosphate, Monoammonium Phosphate, Diammonium Phosphate, Sodium Hexacyanoferrate, Attapulgus Clay, Iron Oxide, Bentonite	11-Apr-19
TCEQ, 2019	CAS number 68333-79-9, 7722-76-1, 7783-28-0, 13601-19-9, 8031-18-3, 1309-37-1, 1302-78-9 or Ammonium Polyphosphate, Monoammonium Phosphate, Diammonium Phosphate, Sodium Hexacyanoferrate, Attapulgus Clay, Iron Oxide, Bentonite	24-Jun-19
OEHHA, 2019	CAS number 68333-79-9, 7722-76-1, 7783-28-0, 13601-19-9, 8031-18-3, 1309-37-1, 1302-78-9 or Ammonium Polyphosphate, Monoammonium Phosphate, Diammonium Phosphate, Sodium Hexacyanoferrate, Attapulgus Clay, Iron Oxide, Bentonite	11-Apr-19
IARC, 2019	CAS number 68333-79-9, 7722-76-1, 7783-28-0, 13601-19-9, 8031-18-3, 1309-37-1, 1302-78-9 or Ammonium Polyphosphate, Monoammonium Phosphate, Diammonium Phosphate, Sodium Hexacyanoferrate, Attapulgus Clay, Iron Oxide, Bentonite	24-Jun-19

Table F.2 Toxicity References Searched with No Information

Reference	Key Words	Date Searched
PubMed, n.d.	CAS number 68333-79-9, 7722-76-1, 7783-28-0, 13601-19-9, 8031-18-3, 1309-37-1, 1302-78-9 or Ammonium Polyphosphate, Monoammonium Phosphate, Diammonium Phosphate, Sodium Hexacyanoferrate, Attapulgus Clay, Iron Oxide, Bentonite and toxicity or NOEL or LOEL	11-Apr-19
Safe Work Australia, n.d	CAS number 68333-79-9, 7722-76-1, 7783-28-0, 13601-19-9, 8031-18-3, 1309-37-1, 1302-78-9 or Ammonium Polyphosphate, Monoammonium Phosphate, Diammonium Phosphate, Sodium Hexacyanoferrate, Attapulgus Clay, Iron Oxide, Bentonite	24-Jun-19
Australian Government, 2019	CAS number 68333-79-9, 7722-76-1, 7783-28-0, 13601-19-9, 8031-18-3, 1309-37-1, 1302-78-9 or Ammonium Polyphosphate, Monoammonium Phosphate, Diammonium Phosphate, Sodium Hexacyanoferrate, Attapulgus Clay, Iron Oxide, Bentonite	25-Jun-19
Incorporated Administrative Agency National Institute of Technology and Evaluation, 2016	CAS number 68333-79-9, 7722-76-1, 7783-28-0, 13601-19-9, 8031-18-3, 1309-37-1, 1302-78-9 or Ammonium Polyphosphate, Monoammonium Phosphate, Diammonium Phosphate, Sodium Hexacyanoferrate, Attapulgus Clay, Iron Oxide, Bentonite	25-Jun-19
US EPA ECOTOX Knowledgebase[1]	CAS number 68333-79-9, 7722-76-1, 7783-28-0, 13601-19-9, 8031-18-3, 1309-37-1, 1302-78-9. This database searched by CAS number.	25-Jun-19

1 - A search of the US EPA ECOTOX database included resuls only for terrestrial mammalian receptors.

Abbreviations:

ATSDR= Agency for Toxic Substances and Disease Registry

CAS= Chemical Abstracts Service

IARC= International Agency for Research on Cancer

IRIS= Integrated Risk Information System

LOEL= Lowest Observed Effect Level

NOEL= No Observed Effect Level

OEHHA= California Office of Environmental Health Hazard Assessment

RIVM= Netherlands National Institute for Public Health and the Environment

NOEL= No Observed Effect Level

TCEQ= Texas Commission on Environmental Quality

US EPA= United States Environmental Protection Agency

WHO= World Health Organization