March 30, 2024

SARAH ARULANANDAM
SARAH.ARULANANDAM@GMAIL.COM

800460 Ontario Limited
1701 Thorold Townline Road
Niagara Falls, ON L2E 6S5

Attention: Eric Henry, 800460 Ontario Limited

Prepared by: Sarah Arulanandam, M.A.Sc., ICD.D, P.Eng.

RE: Screening Level Quantitative Risk Assessment – **9304 McLeod Road Risk Assessment**

This risk assessment was requested by 800460 Ontario Ltd. for the proposed residential development at 9304 McLeod Road. This assessment may be used to assist Niagara Region and the City of Niagara Falls in evaluating the potential risks to public safety from the proposed residential land uses and to address the requirements of the City of Niagara Falls Official Plan Policy 13.87 – Special Policy Area "87".

This memo summarizes the scope of work, assumptions, methodology, and results for a screening level risk analysis of the existing and potential future operations at Cytec Canada, concerning the potential for accidental releases of hazardous materials from their phosphine manufacturing facility. A residential development is proposed at 9304 McLeod Road, north of the Cytec property line. The purpose of this assessment is to consider whether the risks due to operations at Cytec are acceptable concerning the existing and proposed residential land uses at 9304 McLeod Road.

Executive Summary

A screening level risk assessment of the potential risks to public safety concerning the proposed development at 9304 McLeod Road was completed following engineering best practices and standards. A risk matrix, a semi-quantitative risk assessment approach, was used to rank the potential risks and consider the suitability of existing mitigation measures. Despite repeated efforts to obtain information to complete site-specific hazard and consequence modeling as part of the risk assessment, Cytec Canada did not provide any site-specific information about potential hazards and risks at their manufacturing and research facility. Without access to the information required to complete a risk assessment, reasonable conservative assumptions were incorporated as an alternative approach.

The results of the screening level analysis indicate that the offsite risks for the considered release scenarios are within the "acceptable as is" or low-risk ranking categories, using a matrix method approach to estimate the offsite risks to the public. The release scenarios considered within this analysis are limited to release scenarios for representative worst-case hazardous materials that may be on-site at Cytec Canada. The results indicate that the levels of risk associated with Cytec Canada are acceptable concerning the existing and proposed residential land uses at 9304 McLeod Road.

1.0 System Description

The proposed residential development site is located at 9304 McLeod Road. The site is approximately 23 hectares, located at the intersection of McLeod Road and Beechwood Road, on the southeast corner. The surrounding area is a mix of industrial, agricultural, and residential (including a subdivision to the east of the property) land uses. At its closest point, the proposed development site property line is approximately 850 m from the property line of the Cytec Canada operation.

2.0 Methodology

In completing a screening level risk assessment, the matrix method may be used as an indicator of the safety performance of a facility. Risk matrices are a well-known semi-quantitative risk assessment approach that allows for a ranking of risks. As a tiered approach to assessing risks, if unacceptable or undesirable risks at a facility are identified at the screening level, it may indicate the need for a full quantitative assessment of risks. In the absence of certainty in completing the risk assessment and to ensure that the modeling uncertainties do not result in risk control and management decisions with unacceptable levels of risk to the public, conservative assumptions are made throughout the modeling and analysis process. The matrix inputs and methodology for the screening level RA follow engineering best practices, following the definitions and format suggested by CRAIM (2017).

The hazard identification phase of the analysis includes the selection of accidental release scenarios with both scenario frequency and consequence estimates. The selection of release scenarios is based on a review of the site conditions and operations and typically includes a range of scenarios from the worst possible case to more realistic scenarios. Each scenario represents a range of potential or possible release conditions and the selection of which scenarios to include as part of a risk assessment is a balance between reducing uncertainties in the analysis and selecting a finite number of scenarios to model. Alternate worst-case scenarios and other release scenarios included in a risk assessment may be selected based on the likelihood of occurrence (events that are reasonably expected to occur or more likely to occur than the worst-case scenarios) and release scenarios that are expected to have the longest offsite impact distances.

A screening level risk ranking was completed following the steps outlined below:

1. Hazard Modelling
    a. Identify the hazardous materials
    b. Identify the hazards associated with each material
    c. Identify a list of appropriate hazardous release scenarios
    d. Consequence modeling to identify and estimate the impact distances where possible
2. Risk Assessment
    a. Estimating the likelihood or probability of the identified scenarios
    b. Estimating the risk
    c. Evaluating the risk

In addition to general engineering principles and best practices, the following organizations and programs were referenced either directly or indirectly in the preparation of this memo:

- ACGIH American Conference of Industrial Hygienists (2001). Phosphoric acid. Documentation of TLVs and BEIs. ACGHIH, Cincinnati, OH, USA.
- AIHA American Industrial Hygiene Association (2006). Emergency Response Planning Guidelines. AIHA, Falls Church, VA, USA.
- Berkowitz, J. et al. (1981). Occupational and environmental hazards associated with the formulation and use of white phosphorus-felt and red phosphorus-butyl rubber screening smokes, US Army Medical Research and Development Command, Fort Detrick, MD, USA.
- Bremer, Jan (2013) "Modelling accidental releases of phosphorus in air" – Internal report for the RIVM - Centrum Veiligheid, National Institute for Public Health and the Environment, Netherlands
- Canadian Society for Chemical Engineering (CSChE) 2004 Risk Assessment – Recommended Practices for Municipalities and Industry.
- Canadian Society for Chemical Engineering (CSChE) Conference Presentation – Quantitative Risk Assessment – Creating QRA Scenarios to Support Recommended Practices for Municipalities and Industry
- Centre for Chemical Process Safety (2019) in Chemical Hazard Engineering Fundamentals
- City of Thorold response to Access to Information Request M.2024.08 for i) Any and all records related to E Emergency Management Planning for Cytec (Solvay) and, ii) Any other documents related to the Cytec (Solvay) facility located on Garner Road in Niagara Falls
- Conseil pour la Reduction des Accidents Industriels Majeurs (CRAIM) (2017). Risk Management Guide for Major Technological Accidents
- DNV Technical Documentation (2022) to support PHAST Version 8.7.66.0
- Environment and Climate Change Canada (ECCC) in the Technical Guidelines for the Environmental Emergency Regulations, 2019
- Katz, S. et al. (1981). Physical and Chemical Characterization of Military Smokes, Part III-White Phosphorus-Felt Smokes, Final Report. US Army Medical Research and Development Command, Fort Detrick, MD, USA.
- Major Industrial Accidents Reduction Council (MIARC) 2007 Risk Management Guide for Major Industrial Accidents Intended for Municipalities and Industry
- Organisation for Economic Co-operation and Development (OECD) 2003 OECD Guiding Principles for Chemical Accident Prevention, Preparedness and Response
- SLR Consulting (2022). Compatibility/Mitigation Study-Air Quality, Noise and Vibration: 9304 McLeod Road, Niagara Falls, ON
- Spanggord, R. et al. (1983). Environmental Fate of White Phosphorus/FELT and Red Phosphorus/Butyl Rubber Military Screening smokes: Phase I – Literature review. SRI Project LSU-4937-1, SRI International, Menlo Park, CA, USA.
- United States Environmental Protection Agency (US EPA) in the 2009 Risk Management Program Guidance for Offsite Consequence Analysis
- United States Environmental Protection Agency (US EPA) in the 2022 article Criteria for selecting alternative release scenarios
- United States National Oceanic and Atmospheric Administration (NOAA) Office of Response and Restoration Acute Exposure Guideline Levels (AEGLs)
- Villalba, G. et al. (2008). "Global Phosphorus Flows in the Industrial Economy From a Production Perspective", Journal of Industrial Ecology.

2.0 Summary of Hazard Modelling

Despite repeated requests for information to complete the hazard identification and selection of accidental release scenarios, no information was provided by Cytec Canada. Information was requested directly from Cytec on Nov 6, 2023, with a request that they respond on December 6, 2023. No response was received. A request for information (FOI) request was made to the MECP in 2022 and a decision for partial access to records was issued on Dec 14, 2023. The decision was appealed by Cytec and no information was received. Without this information, an alternative approach to consequence modeling was used to conservatively estimate the longest offsite impact distances that may be expected from an accidental release at the Cytec Canada site.

A request for information to the City of Thorold under the Municipal Freedom of Information and Protection of Privacy Act (the "Act") was granted (access in full). The City of Thorold provided the following: i) Any and all records related to Emergency Management Planning for Cytec (Solvay), and ii) Any other documents related to the Cytec (Solvay) facility located on Garner Road in Niagara Falls. The information provided did not contain any details or information (directly or indirectly) related to the chemicals stored on-site at the Cytec facility.

The City of Niagara Falls confirmed directly that there are no pending or active industrial developments in the area, indicating that proposed expansion or changes at the Cytec facility are not expected within the timeline of the proposed residential development.

3.1 Identifying the hazardous materials

The compatibility study completed by SLR Consulting (2022) identified Cytec Canada as the only industry within the potential area of influence (concerning D-6 Guidelines). It is reasonable to assume that a wide range of hazardous chemicals associated with the manufacture and production of phosphine and its derivatives may be present at any time on the Cytec manufacturing site. In practice, it is common, as a protective measure, to focus hazard analysis and consequence modeling on the most dangerous substances, which in this case would be the potential release or loss of containment of phosphine and phosphorus. While there may be other hazardous materials on the site, focusing on the release of phosphine and phosphorus is considered reasonable to estimate the potential for offsite impacts.

3.2 Identify the hazards associated with each material

Phosphorus (P_4) and Phosphine (PH_3)

Phosphorus and phosphine ignite spontaneously in air and are classified as pyrophoric compounds. In an accidental release or loss of containment scenario, the primary hazard is due to toxicity from the atmospheric dispersion of phosphorus pentoxide (P_4O_{10}), the main reaction product from both phosphine and phosphorus combustion. While phosphoric acid (H_3PO_4) is formed when phosphorus pentoxide reacts with water and this hydrolyzation is expected to occur with atmospheric moisture in the environment, it is reasonable to focus on P_4O_{10} as the primary hazard of concern for the public at the subject property on McLeod Road. A review of the literature and chemical processes during combustion indicates that a simplified model of complete combustion focusing on the concentration of P_4O_{10} is a conservative approach, overestimating the actual P_4O_{10} concentration.

Environment and Climate Change Canada suggests using the AEGL-2 endpoint for substances regulated under CEPA E2 regulations (phosphorus and phosphine) because it is defined as a limit below which sensitive individuals are protected. A similarly protective endpoint, ERPG-2, is available for phosphoric acid, and phosphorus pentoxide (there are no published AEGL-2 endpoints for these substances). A summary of the available and relevant endpoints for phosphorus, phosphine, phosphoric acid, and phosphorus pentoxide is provided in Table 1 below.

Table 1:

Substance Name	AEGL-2	ERPG-2
Phosphorus CAS# 7723-14-0	11 mg/m^3	None
Phosphine CAS# 7803-51-2	2.8 mg/m^3	0.71 mg/m^3
Phosphoric acid CAS# 13598-36-2		10 mg/m^3
Phosphorus Pentoxide CAS#1314-56-3		10 mg/m^3

Both phosphorus and phosphine will form either phosphorus pentoxide or, eventually, phosphoric acid in ambient environmental conditions in the event of an accidental release. Qualitatively, research confirms that both phosphorus pentoxide and phosphoric acid are expected to have the same or similar health effects on mucosal tissues in the event of inhalation by humans. The ERPG-2 values for both substances, the increased complexity, and limitations on commercial software to model the formation of H_3PO_4, and most significantly, the time frame for acute toxicity and exposure in the event of an accidental release indicate that P_4O_{10} is the primary hazard. It is the most stable combustion product and the main product of combustion for both phosphine and phosphorus. The primary hazard and compound of interest will be exposure to P_4O_{10} through atmospheric dispersion.

3.3 Hazardous release scenarios

The hazard release scenarios consider both the characteristics of the hazardous materials and the conditions under which they are stored to characterize the release rates, fluid properties, and dispersion of phosphorus pentoxide into the atmosphere. Phosphorus is generally transported at a slight overpressure and stored as a liquid in heated containers where it is isolated from air by keeping it covered with liquid and ventilated with nitrogen gas. In the absence of site-specific information from Cytec, a review of accident reports in the scientific literature was completed to determine appropriate hazardous release scenarios. In the case of the Cytec facility two scenarios were initially considered:

i) a large continuous release of liquid or solid phosphine from a storage tank; and,

ii) a continuous release of phosphine from a small hole release from valves or piping connections on a pressurized storage tank.

Phosphine and its derivatives are routinely transported off-site from the facility, but these quantities are expected to be much lower in comparison to the much larger storage tank release used for the first scenario. For the second release scenario, a pressurized release can be expected to be ignited upon release by an auto-ignition system typically used as a mitigative measure to minimize the risk of explosive or flammable mixtures with air in the event of an accidental release. The combined heat released and momentum from a pressurized and ignited release in this scenario is expected to increase the buoyancy of the resulting plume and disperse the phosphorus pentoxide cloud high into the atmosphere, minimizing ground-level impacts. In the absence of any site-specific information from Cytec and based on the expected behavior of the plume from a pressurized phosphine storage tank, greater hazard distances are expected to result from the first scenario pool fire, thus further analysis of the second scenario was not warranted. In the second, smaller continuous release scenario, the momentum and heat from the ignited plume would result in an elevated plume that would have negligible, if any, acute or short-term ground-level deposition or toxicity. As a result, the next steps of consequence modelling and risk assessment focused on the lower frequency but greater consequence large release scenario.

In the large release scenario, a pool fire is expected to form, limited in size by a protective berm or dike typically used as a mitigative measure to limit the size of a spill in the event of an accidental release. In the event of a pool fire, the size of the pool, volume, and outflow rate are determined from site-specific details of the storage tank. In the absence of any site-specific information from Cytec, the following specifications for a pool fire from spontaneously igniting phosphorus were used to define the release scenario:

i) As a conservative assumption, an area-specific burn rate was evaluated based on published calculation methods in the literature. This approach results in a burn rate that is three times the average burn rate of the value recommended in the literature for most hazardous liquid and solid substances when oxygen is not a limiting factor.

ii) The mass release rate or spill rate was conservatively determined based on a release of 200 tonnes. This corresponds to a conservative assumption of a release over 3 hours from an atmospheric storage tank with a capacity of approximately four rail tank cars.

iii) The pool size is limited by the size of the protective berm surrounding the storage tank. A range of pool diameters from 3m to 15 m was considered to accommodate a variety of possible release scenarios, in the absence of site-specific information about the actual size of the berm surrounding the phosphorus tank(s) at Cytec.

3.4 Consequence Modelling

Consequence modeling and analysis of release scenarios are used to provide hazard extents using recommended guidelines for toxic endpoint criteria to determine downwind distances to specific concentrations.

The widely recognized and commercially available consequence modeling software PHAST (Process Hazard Analysis Software Tool) developed by Det Norske Veritas (DNV) was used to determine the consequence endpoints. PHAST was originally developed for the Dutch Government to carry out risk studies to assess

major hazard facilities covered by the Seveso Directive. PHAST includes built-in source characterization and dispersion modeling tools to calculate exposure distances for a variety of materials, release scenarios, averaging periods, and meteorological conditions.

Dispersion modeling is used to evaluate the ground-level concentrations downwind from the release site. In addition to the release scenario, the dispersion is also dependent on the meteorological conditions and dispersion model chosen. The dispersion model in PHAST is the UDM or Unified Dispersion Model also allows for detailed source term specification (hole size, duration, material, temperature and pressure, atmospheric conditions), pool formation, evaporation, and outcomes of fire, explosion, and toxicity.
As a conservative assumption, a range of wind speeds, humidities and ambient temperatures were used in the dispersion modeling. In the consequence modelling, wind directions were presumed to be equally likely in all directions from the release site, as an additional conservative assumption. The ambient temperatures of 15°C and 5°C and relative humidities ranging from 20 to 80 percent humidity correspond with conditions in the Niagara region over summer and winter conditions. A range of meteorological Pasquill stability classes and wind speeds were modeled to represent a range of atmospheric conditions that may be experienced and that are expected to provide worst-case dispersion conditions.

The maximum downwind concentrations at ground level at various distances from the release site are summarized below for the range of pool sizes and meteorological conditions:

a) At 100 m downwind, the maximum concentration was 22 mg/m^3 for a 7m diameter pool fire, unstable meteorological conditions (atmospheric stability class B), and 2 m/s windspeeds (corresponding to summer, late spring, and early fall conditions)

b) At 1000 m downwind, the maximum concentration was 1.2 mg/m^3 for a 7m diameter pool fire, stable meteorological conditions (atmospheric stability class F), and 2 m/s windspeeds (corresponding to cool, clear winter conditions)

c) At 10,000 m downwind, the maximum concentration was 0.49 mg/m^3 for a 7m diameter pool fire, stable meteorological conditions (atmospheric stability class F), and 2 m/s windspeeds (corresponding to cool, clear winter conditions)

From the results of the consequence analysis, there are no exceedances for P_4O_{10} expected at the subject site on McLeod Road, located 850m from the Cytec property line at its closest point, for the release scenario modeled. The only exceedance to the ERPG-2 guidelines for P_4O_{10} occurs at 100 m under stable atmospheric conditions, corresponding to the expected reduced depth and width of the combustion plume. Although lower atmospheric stability conditions correspond with increased turbulent dilution close to the source, this condition still did not result in an exceedance of the consequence endpoints.

3.0 Risk Assessment

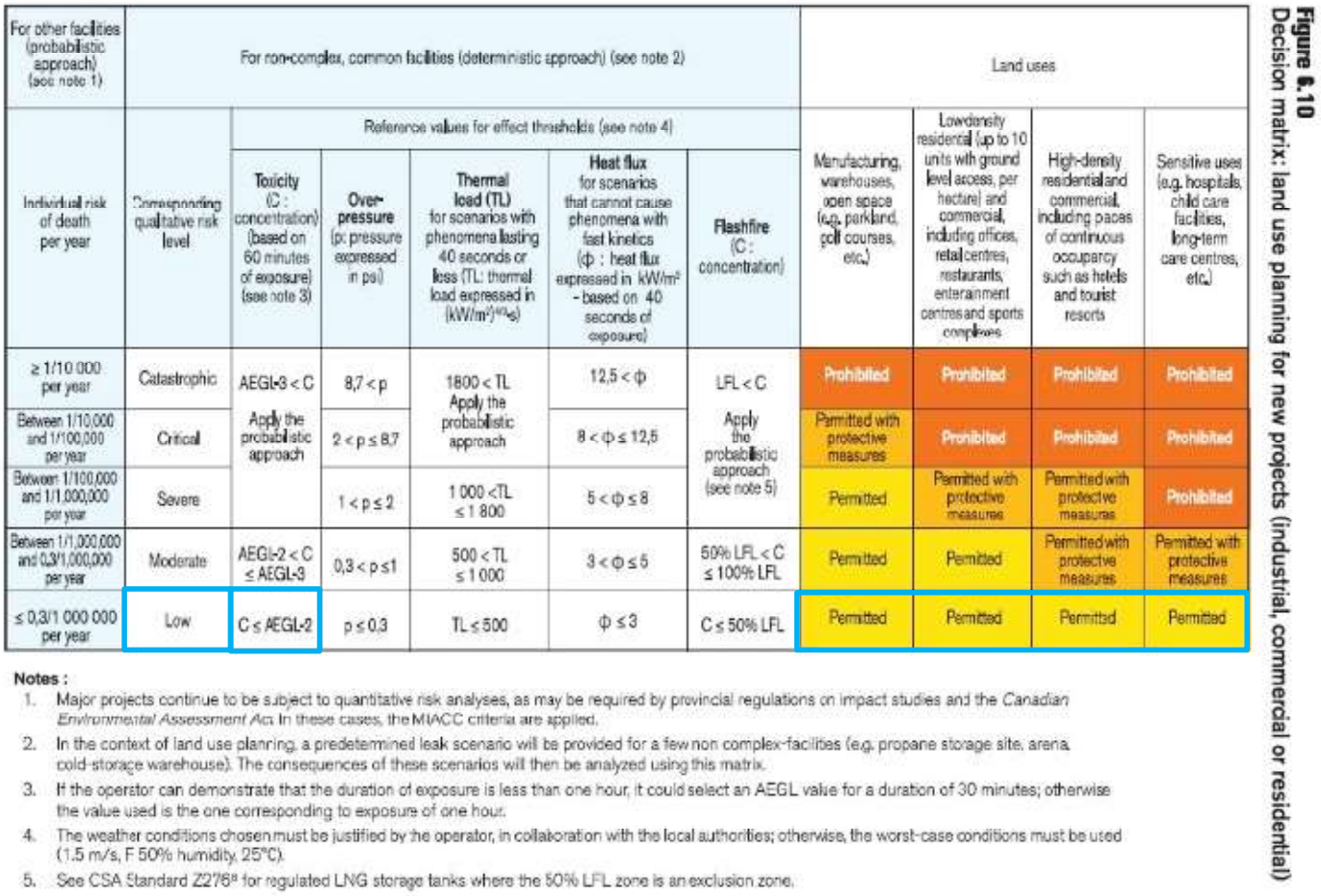
Risk may be defined as a measure of the probability and severity of harm to the public for a specific set of hazard events. Risk assessments should consider the probability of exposure as well as the likelihood of being adversely affected by exposure. In the matrix approach, each release scenario or hazardous event is categorized using broad groupings for frequency and consequence. The matrix is populated by estimating the consequences and frequencies of events and plotting the pairs on the matrix as risk levels which may be expressed as ranging from high to low or ranging from tolerable to intolerable, such as in the matrix by

CRAIM (Figure 6.10 in their Risk Management Guide).

The risk associated with each release scenario is inherently dependent on the frequency at which the event or release scenario can be expected to occur. Approaches to estimating the frequency of occurrence vary in complexity, and the selection of an appropriate approach is dependent on the amount and quality of the data available. In many instances, the amount of time and level of effort to obtain detailed event frequencies for specific release scenarios is undermined by the degree of uncertainty associated with the specific quantitative frequency values. In a matrix approach, qualitative descriptions of the frequencies can be used to describe each release scenario, based on reasonable assumptions regarding the likelihood of occurrence. The likelihood of occurrence is an aggregate description of the likelihood of occurrence given the release scenario and the degree of conservatism built into the modeling.

In the large release scenario modeled, a large continuous release of liquid or solid phosphine from a storage tank was qualitatively assessed as a low-frequency or unlikely event. Smaller release events, such as leaks, may be expected to have a higher frequency. From the results of the consequence analysis for the release scenario modeled, under a wide range of input parameters, no significant offsite impacts at the subject property are expected. Based on the risk matrix from the CRAIM Guidelines, it would suggest that a wide range of land uses may be permitted at the subject property. Furthermore, the results indicate that there would be a negligible benefit, if any, to providing further detail in a detailed quantitative risk assessment and further analysis with the available information regarding the Cytec facility and its proximity to the subject site. As shown below in Table 2, with toxicity results well below AEGL-2 concentrations and a corresponding qualitative risk level assessed as “Low” for a large release scenario, there would be no restrictions on residential land uses at the subject site located at 9304 McLeod Road in Niagara Falls.

The results of the risk assessment were reviewed in context with respect to the Cytec facility and historical emergency planning operations concerning the surrounding area. Although information was not provided by Cytec directly, the City of Thorold provided a copy of the Emergency Response Contact Information letter sent to several of their residents by Cytec, indicating: i) the ongoing and continued commitment by Cytec (locally) and Solvay (corporate) to the safe operation of their chemical manufacturing facility in Niagara, and ii) within the City of Thorold, Welland and Niagara Falls, communications were attempted with residents located within 1.5 km of the likely release point at the facility. In addition, a review of correspondence between 800460 Ontario, the property owner at 9304 McLeod Rd, indicates that no such communication and request for contact information was ever made by Cytec to the property owners. Given this information, the conclusions from the qualitative risk assessment appear to be fully supported by the actions of Cytec with respect to their risk assessments and emergency planning operations related to the properties surrounding their facility in Niagara.



For other facilities (probabilistic approach) (see note 1)	For non-complex, common facilities (deterministic approach) (see note 2)						Land uses			
		Reference values for effect thresholds (see note 4)								
Individual risk of death per year	Corresponding qualitative risk level	Toxicity (C : concentration) (based on 60 minutes of exposure) (see note 3)	Over-pressure (p: pressure expressed in psi)	Thermal load (TL) for scenarios with phenomena lasting 40 seconds or less (TL: thermal load expressed in $(kW/m^2)^{4/3}s$)	Heat flux for scenarios that cannot cause phenomena with fast kinetics (Φ : heat flux expressed in kW/m^2 - based on 40 seconds of exposure)	Flashfire (C : concentration)	Manufacturing, warehouses, open space (e.g. parkland, golf courses, etc.)	Low-density residential (up to 10 units with ground level access, per hectare) and commercial, including offices, retail centres, restaurants, entertainment centres and sports complexes	High-density residential and commercial, including places of continuous occupancy such as hotels and tourist resorts	Sensitive uses (e.g. hospitals, child care facilities, long-term care centres, etc.)
≥ 1/10 000 per year	Catastrophic	AEGL-3 < C	8,7 < p	1800 < TL Apply the probabilistic approach	12,5 < Φ	LFL < C	Prohibited	Prohibited	Prohibited	Prohibited
Between 1/10,000 and 1/100,000 per year	Critical	Apply the probabilistic approach	2 < p ≤ 8,7		8 < Φ ≤ 12,5	Apply the probabilistic approach (see note 5)	Permitted with protective measures	Prohibited	Prohibited	Prohibited
Between 1/100,000 and 1/1,000,000 per year	Severe		1 < p ≤ 2	1 000 <TL ≤ 1 800	5 < Φ ≤ 8		Permitted	Permitted with protective measures	Permitted with protective measures	Prohibited
Between 1/1,000,000 and 0,3/1,000,000 per year	Moderate	AEGL-2 < C ≤ AEGL-3	0,3 < p ≤ 1	500 < TL ≤ 1 000	3 < Φ ≤ 5	50% LFL < C ≤ 100% LFL	Permitted	Permitted	Permitted with protective measures	Permitted with protective measures
≤ 0,3/1 000 000 per year	Low	C ≤ AEGL-2	p ≤ 0,3	TL ≤ 500	Φ ≤ 3	C ≤ 50% LFL	Permitted	Permitted	Permitted	Permitted

Notes :

1. Major projects continue to be subject to quantitative risk analyses, as may be required by provincial regulations on impact studies and the *Canadian Environmental Assessment Act*. In these cases, the MIACC criteria are applied.
2. In the context of land use planning, a predetermined leak scenario will be provided for a few non complex facilities (e.g. propane storage site, arena, cold storage warehouse). The consequences of these scenarios will then be analyzed using this matrix.
3. If the operator can demonstrate that the duration of exposure is less than one hour, it could select an AEGL value for a duration of 30 minutes; otherwise the value used is the one corresponding to exposure of one hour.
4. The weather conditions chosen must be justified by the operator, in collaboration with the local authorities; otherwise, the worst-case conditions must be used (1.5 m/s, F 50% humidity, 25°C).
5. See CSA Standard Z276[8] for regulated LNG storage tanks where the 50% LFL zone is an exclusion zone.

Figure 6.10
Decision matrix: land use planning for new projects (industrial, commercial or residential)

Chapter 6

Table 2: Risk Assessment Results Indicated on CRAIM Risk Matrix (CRAIM Guidelines) for the largest release scenario

4.0 Conclusions

The results of the consequence analysis indicate that offsite impacts due to toxic inhalation of phosphorus pentoxide (from the ignition of phosphorus) is not expected for a wide range of pool sizes and meteorological conditions. The offsite risks are expected to be well within the acceptable ranges of risks to the public, specifically for the planned residential development at the McLeod Rd site.

The results and conclusions presented in this letter report reflect the information available at the time of preparation and analysis and should be interpreted in the context of the quality and type of information available for this screening level risk assessment. A complete discussion of the sources of error and levels of uncertainty, including a complete sensitivity analysis is beyond the scope of this assessment. However, high uncertainty in the analysis does not automatically mean high risk. In this memo, typically conservative estimates of the relevant parameters are made to avoid the underestimation of risk in the absence of certainty regarding modeling scenarios and parameters. The findings in this memo are specific to this project and for the purposes described above. If there is a substantive change to the information relied upon in the preparation of this report, it is advised that the conclusions and recommendations in this report be reviewed in the context of any changes.

Should you have any questions or require further clarification or additional information, please do not hesitate to contact me.

Yours truly

Sarah Arulanandam

Sarah Arulanandam M.A.Sc., P.Eng.
SA Consulting