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The Imperative for a More Unified, Proactive and Precautionary Approach to Hazardous Materials in the CAF

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JCSP 48

Exercise Solo Flight

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CANADIAN FORCES COLLEGE – COLLÈGE DES FORCES CANADIENNES

JCSP 48 – PCEMI 48
2021 – 2022

Exercise Solo Flight – Exercice Solo Flight

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HAZARDOUS REACTIONS: THE IMPERATIVE FOR A MORE UNIFIED, PROACTIVE AND PRECAUTIONARY APPROACH TO HAZMAT IN THE CAF

INTRODUCTION

> *No person shall use a hazardous substance in a workplace if a non-hazardous substance or one that is less hazardous can be used instead*
>
> - Consolidated Federal Laws of Canada, Canada Occupational Health and Safety Regulations, SOR/86-304 subsection 10.16: Substitutions of Substances, 4 April 2022

Hazardous Materials (HAZMAT) are a major concern in workplaces worldwide. Almost 1/8th of the entire planet's population is exposed annually to chemicals in the workplace.[1] Furthermore, exposure to these hazardous materials results in up to half of all work-related deaths with occupational cancer as the new leading cause of death in Canada.[2] Over 200 different chemical substances have been identified as cancer-causing, with exposure to many others causing poisoning, disabilities or debilitating, chronic diseases.[3] These toxic effects of various HAZMAT affect a wide range of human systems, including the neurological, endocrine, respiratory, and immune systems.[4]

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[1] Canadian Centre for Occupational Health and Safety and Dr. Thomas Tenkate, 'Chemical Hazards Assessment and Prioritization', CCOHS Podcasts, accessed 20 April 2022, https://www.ccohs.ca/products/podcasts/Episode189_ChemicalHazardsAssessmentPrioritization_Transcript_English.html.
[2] Canadian Centre for Occupational Health and Safety and Tenkate; Canadian Centre for Occupational Health and Safety Canada, 'CCOHS: Health and Safety Report - Past Issues', 22 April 2022, https://www.ccohs.ca/newsletters/hsreport/issues/2013/08/ezine.html.
[3] Canadian Centre for Occupational Health and Safety and Tenkate, 'Chemical Hazards Assessment and Prioritization'.
[4] *Ibid.*

Not only are HAZMAT a concern for Canadian society in general, but they are also a substantial concern for the Department of National Defence (DND) affecting personnel, infrastructure, the environment and creating significant liability. In National Defence, the "use of HAZMAT is inherent in almost every activity or operation performed or undertaken…".[5] Within DND, over 6000 different HAZMAT are used, and it is estimated that at least 25% of its full-time employees come into frequent contact with hazardous chemical products, and all of its employees may have some contact with these compounds.[6]

Not only is human exposure and impact a significant concern, but HAZMAT can also be very detrimental to the sustainability of DND's Real Property (RP). This is especially pertinent as DND has the largest portfolio of federal RP, comprising some $28 billion of assets spread over 2.2 million hectares of land between approximately 21,000 buildings and 12,000 residential houses.[7] Furthermore, DND's environmental impact on this portfolio has been exorbitant with a 10-year average of 1058 identified federal contaminated sites and an overall cost of assessment, remediation and monitoring in excess of $699 million for the last decade alone.[8] Finally, following years of contamination, the liability of this contamination has resulted in at least two substantial

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[5] Department of National Defence Canada, *Hazardous Materials Management Framework* (Ottawa: Canada Communication Group, 2016), 4.
[6] Office of the Auditor General Canada and Peter Kasurak, 'Report of the Auditor General of Canada - Chapter 13 - National Defence - Hazardous Materials: Managing Risks to Employees and the Environment' (Ottawa: Office of the Auditor General, September 1999), 5.
[7] Department of National Defence Canada, *Defence Real Property Portfolio Strategy*, V10 ed. (Ottawa: Canada Communication Group, n.d.), 6.
[8] Treasury Board Secretariat Canada, 'Federal Contaminated Sites Inventory', accessed 30 April 2022, https://www.tbs-sct.gc.ca/fcsi-rscf/ls-de-eng.aspx?qid=751964.

legal claims against the Crown for contamination of groundwater affecting nearby communities near Canadian Forces Bases (CFB) North Bay and Valcartier.[9]

Overall, as this paper will illustrate, the DND has and continues to fail to apply the precautionary principle when it comes to the selection of HAZMAT, resulting in an increased risk of occupational disease, an unsustainable infrastructure portfolio, significant environmental contamination and massive liabilities. This paper will first cover the definition, life-cycle and principles associated with HAZMAT. Following this, it will analyze how the CAF has handled HAZMAT in the past, including multiple audits and proposed action plans. Subsequently, the paper will highlight the progress made on many previously identified deficiencies and highlight current gaps in HAZMAT management including a lack of a national governing body, multiple "stovepipes" of excellence, and some examples of emerging chemicals that could be substituted or eliminated. Finally, this article will propose how the CAF should handle HAZMAT in the future, formally establishing an effective Functional Authority (FA), expanding and reviving a national advisory body to proactively assess and limit potentially nefarious chemicals on a class basis and expanding assessments of HAZMAT to include the vital aspects of HAZMAT within the real property portfolio.

[9] Justice Bernard Godbout, 'Spieser v. Attorney General of Canada et al. - Contamination of Groundwater by TCE in Shannon, Quebec', Pub. L. No. 200- 09- 007773–127 (2021), https://actioncollectiveshannon.ca/smartlets/do.aspx?interviewID=home&workspace=claims-shannon&lang=en; The Corporation of the City of North Bay and Her Majesty the Queen in Right of Ontario, Ontario Superior Court of Justice, North Bay, Court File No. CV-19-108.

To understand how these nefarious effects manifest within DND, it is important to understand the definition, life cycle and principles associated with HAZMAT. Within National Defence, HAZMAT is defined as "any material that, if handled improperly, can endanger human health and well-being or the environment or equipment.".[10] When considering the implications of HAZMAT in DND, one must consider the full life cycle including initial selection, procurement, handling, use, storage, transportation and disposal.[11] This holistic approach is necessary, as it ensures that all aspects of HAZMAT are considered. For example, an assessment of beryllium focused only on its usage as a high-performance semi-conductor in communications equipment fails to account for its serious acute toxicity, chronic toxicity and carcinogenic characteristics often associated with its disposal[12].

When it comes to the life-cycle management of HAZMAT and its associated effects, three key principles emerge: Hierarchy of controls, the Precautionary Principle and Regrettable Substitution.

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[10] Department of National Defence Canada, 'DAOD 4003-1, Hazardous Materials Management', policies, 13 November 2013, 2, https://www.canada.ca/en/department-national-defence/corporate/policies-standards/defence-administrative-orders-directives/4000-series/4003/4003-1-hazardous-materials-management.html. It should be noted that the various policies governing HAZMAT in DND adopt differing caveats when it comes to HAZMAT, with some from the Assistant Deputy Minister (Material) (ADM(Mat)), specifically excluding ammunition, explosives, nuclear material, halons, heavy metals, dust, asbestos, living organisms, mould, biological toxins and warfare agents. For the purposes of this paper, the term HAZMAT will use the standard aforementioned definition but will include halons, heavy metals, dust and asbestos due to their impact on infrastructure from the necessity of engineering controls and their roles in contaminating the environment..

[11] *Ibid.*, 4.

[12] Department of National Defence Canada, *CANFORGEN 093/11 ADMMAT 03/11 201545Z MAY 11 - Hazardous Materials Reference Application (HMRA)* (Ottawa: Canada Communication Group, n.d.), 2, accessed 20 October 2021; Department of National Defence Canada, *CF H Svcs Gp Instruction 4440-01 - Chemical Hazards Surveillance Program*, CF H Svcs Gp Instruction 4440–01 (Ottawa: Canada Communication Group, 2004), 46.

The first principle, rooted in occupational safety is that of the hierarchy of controls, as per Figure 1, below. This concept deals with the effectiveness of controls in reducing risk to workers, with elimination and substitution being the most effective at controlling hazards.[13] This reinforces the common understanding that the elimination of HAZMAT before entering the supply chain, is more effective, from a health and safety and financial perspective, than seeking to mitigate its impacts through engineering or administrative controls once the HAZMAT has entered the workplace. An excellent example of this would be aiming to keep workplace drinking-water lead levels As Low As Reasonably Achievable (ALARA), and under the Health Canada threshold of 0.005mg/L. It ensures better water quality and is far more cost-effective to identify and substitute a $130 older faucet with a high lead casting content (the source of the lead) than it is to install a $5000 activated carbon filtration system, that will require periodic filter changes, connection to a building maintenance system (to monitor filter life), and periodic testing to ensure the efficacy of filtration.[14]

[13] National Institute for Occupational Safety and Health (NIOSH) US CDC, 'Hierarchy of Controls | NIOSH | CDC', 27 October 2021, https://www.cdc.gov/niosh/topics/hierarchy/default.html. It should be noted that substitution and elimination are also usually the most difficult to implement in an existing process.

[14] Department of National Defence Canada, *D FHP Guidance on the Application of the New Lead (Pb) Drinking Water Guidelines*, CF H Svcs Gp Instruction 6695–08 (Ottawa: Canada Communication Group, 2019), 4, cmp-cpm.mil.ca/en/health/policies-direction/policies/6695-08.page.

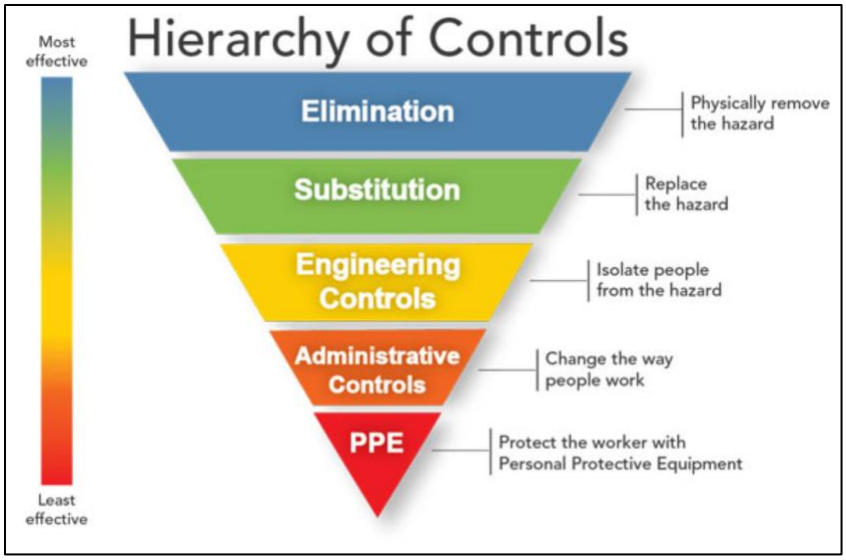

Figure 1: Hierarchy of Controls

Source: US Centre for Disease Control and Prevention – National Institute of Occupational Health and Safety, *Hierarchy of Controls*.

While substitution has been established as one of the most effective means to control a hazardous material, if not done carefully, can bring with it as many or more problems as the original HAZMAT presented. This leads to the concept of the Precautionary Principle. The United Nations Educational, Scientific and Cultural Organization defines the Precautionary Principle as follows: "When human activities may lead to morally unacceptable harm that is scientifically plausible but uncertain, actions shall be taken to avoid or diminish that harm.".[15] Furthermore, they identify the conditions where this principle applies as follows:

[15] Jens Erik Fenstad and Koïchiro Matsuura, 'The Precautionary Principle; 2005', *United Nations Educational, Scientific and Cultural Organization - World Commission on the Ethics of Scientific Knowledge and Technology*, March 2005, 13. It should be noted that this was the working definition among a large group of stakeholders due to wide variance in definitions.

> The precautionary principle applies where scientific evidence is insufficient, inconclusive or uncertain and preliminary scientific evaluation indicates that there are reasonable grounds for concern that the potentially dangerous effects on the environment, human, animal or plant health may be inconsistent with the high level of protection chosen.[16]

To fully appreciate the challenges of applying the Precautionary Principle, it is important to understand the significant knowledge gaps that exist when it comes to chemical substances in the world. The Chemical Abstracts Service (CAS) identifies that there are over 72 million recognized chemical compounds.[17] Of these, over 19 million are produced commercially.[18] Of these, some 62,000 chemicals, already in commerce when the Toxic Substances Control Act (TSCA) was passed in 1976, were, for all intents and purposes, exempted from this law.[19] Add to this, that the US Environmental Protection Agency (EPA) has only completed Hazard Characterizations for 1,272 chemicals.[20] So in reality, most of the compounds in commercial use 56 years ago are still in use today and have been exempted from legislation to clearly identify their hazards and restrict their usage, and 99.998% of all chemicals in existence have not undergone the comprehensive US EPA Hazard Characterization.

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[16] *Ibid.*, 12.
[17] US Navy United States and Sutto, Thomas E., *Naval Research Laboratory Industrial Chemical Analysis and Respiratory Filter Standards Development*, NRL/MR/6360--17-9750 (Washington, DC, 2017), 1; David H Blakey et al., 'A Screening Tool to Prioritize Public Health Risk Associated with Accidental or Deliberate Release of Chemicals into the Atmosphere', *BMC Public Health* 13 (21 March 2013): 2, https://doi.org/10.1186/1471-2458-13-253. The CAS assigns Registry Numbers to every distinct organic and inorganic substance through its CAS Chemical Catalogues File (CHEMCATS).
[18] *Ibid.*, 2.
[19] Charles W. Schmidt, 'TSCA 2.0: A New Era in Chemical Risk Management', *Environmental Health Perspectives* 124, no. 10 (October 2016): 183, https://doi.org/10.1289/ehp.124-A182. The TSCA aimed to protect the public and environment from potentially dangerous industrial chemicals.
[20] Environmental Protection Agency US, 'Introduction to ChemView', Overviews and Factsheets, 19 November 2013, https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/introduction-chemview.

When addressing the Canadian side of regulation, done through the Canadian Environmental Protection Agencies (CEPA) Toxic Substances List, there are only 163 listings, and interpreting the list can be challenging. For example, the list includes 20 subsets of petroleum and refinery gases, Cobalt and soluble cobalt compounds and plastic manufactured items.[21] It can be difficult to know if one is purchasing petroleum if it originated through a catalytic hydrodesulfurized naphtha separator, if one is purchasing equipment if the component ordered contain soluble or insoluble cobalt or how to interpret the listing that all plastic manufactured items as toxic.[22] This technically complex listing of compounds and dearth of complete hazard characterizations means that it is very challenging to know which compounds have the potential to cause harm and to select alternatives intended to cause less harm.

This leads to the last concept, which is referred to as Regrettable Substitution, which occurs "when a toxic chemical is replaced by another chemical that later proved unsuitable because it, too, turned out to be a Persistent, Bioaccumulative and Toxic (PBT) compound".[23] This can often occur when the hazard characterization of one compound in use is determined and found to be detrimental, an alternative is selected where the data on hazard characterization is not yet complete. Later on, post-evaluation,

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[21] Environment and Climate Change Canada, 'CEPA: Toxic Substances List: Schedule 1', list of regulations, 11 February 2010, https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/substances-list/toxic/schedule-1.html.
[22] *Ibid*.
[23] National Research Council US et al., *A Framework to Guide Selection of Chemical Alternatives* (National Academies Press, 2014), https://books.google.ca/books?hl=en&lr=&id=Ao1qBgAAQBAJ&oi=fnd&pg=PT24&dq=DOI:+10.17226/18872&ots=hEBX9vsPjL&sig=Cmhtd69eSO47tIo2gbylQDWKyss&redir_esc=y#v=onepage&q=regrettable&f=false.

this substitute turns out to be significantly detrimental, in some cases more so than the original compound. In effect, it is trading the known harm of one compound for the uncertainty of another. One of the best-known examples is where BisPhenol-A (BPA), once its significant negative health effects were realized, was swapped with BisPhenol-S. This substitute, while significantly less studied, and hence less regulated, is now thought to be even more harmful to children's health than BPA.[24] Unfortunately, this example is not unique, and regrettable substitutions appear to be commonplace in our society.[25]

DISCUSSION

How has the DND managed HAZMAT in the past

Inspections and Audits

Since as early as 1997, DND Sustainable Development Strategy has identified HAZMAT management as one its five key issues.[26] National Defence has undergone four separate audits of HAZMAT in the last three decades, two done internally (by the Chief Review Services (CRS) in 1996 and 2012 and two done externally (by the Office of the Auditor General (OAG) of Canada in 1999 and a follow up in 2001).[27] When DND's HAZMAT management was first assessed by the OAG in 1999, the report was very

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[24] School of Public Health Harvard University, 'Harmful Chemicals Removed from Products Often Replaced with Something as Bad or Worse', News, 25 January 2017, https://www.hsph.harvard.edu/news/hsph-in-the-news/harmful-chemicals-removed-from-products-often-replaced-with-something-as-bad-or-worse/. BPA is a compound often associated with clear plastic such as is used in water bottles and associated with endocrine disruption.

[25] Laura D. Scherer et al., 'The Psychology of "Regrettable Substitutions": Examining Consumer Judgements of Bisphenol A and Its Alternatives', *Health, Risk & Society* 16, no. 7–8 (2014): 649–66, https://doi.org/10.1080/13698575.2014.969687.

[26] Canada and Kasurak, 'Report of the Auditor General of Canada - Chapter 13 - National Defence - Hazardous Materials...', 26; Department of National Defence Canada, *Audit of Hazardous Materials Management* (Ottawa: Canada Communication Group, 2012), 8.

[27] Canada, *Hazardous Materials Management Framework*, 6. The 2012 CRS internal audit and OAG external audits excluded HAZMAT related to Real Property such as asbestos and halocarbons.

critical of the department. The report cited "widespread, frequent and recurring instances of non-compliance with the legal and policy requirements"[28] and "…information on hazardous materials that are used is not readily available…".[29] Furthermore, DND's performance concerning hazardous materials injuries compared to other federal departments and civilian industry was abysmal, as per Figure 2, below. Initially, DND's rate was more than 4 times higher than other federal departments and higher than many other dangerous occupations, such as construction and transportation. This is even more troubling when the 2012 CRS report identified that "information on health and safety incidents related to HAZMAT is not readily available."[30], which implies that actual numbers may be even higher than those officially reported.

[28] Canada and Kasurak, 'Report of the Auditor General of Canada - Chapter 13 - National Defence - Hazardous Materials...', 36. Unfortunately, the internal CRS report of 1996 is no longer accessible. In the OAG audit, 1400 cases of non-compliance were identified.
[29] *Ibid.*, 36.
[30] Canada, *Audit of Hazardous Materials Management*, 5.

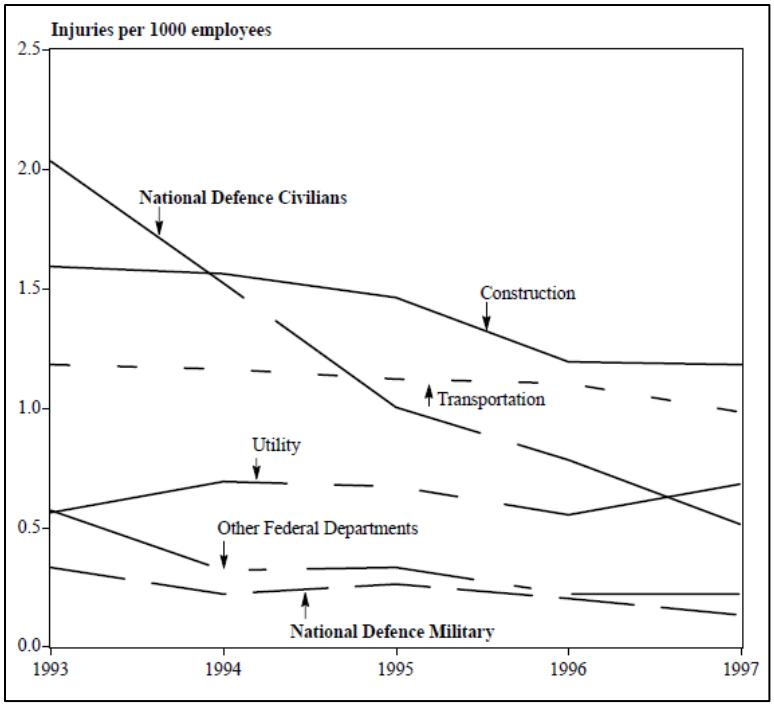

Figure 2: Hazardous Material Injuries of DND and other industries performing similar tasks

Source: Office of the Auditor General of Canada, *National Defence: Hazardous Materials: Managing Risks to Employees and the Environment*, 12.

These audits, both internal and external, have consistently identified ineffective FA governance, decentralized procurement with gaps in controls for life cycle management, and limited implementation of HAZMAT digital information management systems.

From these audits, one of the most pronounced challenges for DND has been establishing effective FA governance. This deficiency was explicitly cited in all three available audits, with the most recent 2012 internal audit explicitly stating that “most

notably, the shared FA governance structure for the program has been ineffective".[31] Within DND, HAZMAT responsibilities are shared between five separate Level one (L1) organizations: Assistant Deputy Minister (Infrastructure and Environment) (ADM(IE), for issues relating to real property, environment, sustainable development and life-cycle management of HAZMAT), Assistant Deputy Minister (Materiel) (ADM(Mat), for material acquisition and support), Vice Chief of the Defence Staff (VCDS) – Director General Safety (D Safe G, on issues relating to occupational health and safety), Strategic Joint Staff (SJS, on issues relating to Transportation of Dangerous Goods (TDG)) and Military Personnel Command (MPC) – Director Force Health Protection (DFHP, on issues relating to military occupational health).[32] While this segregation of duties can facilitate accountability and management of certain areas, it makes national coordination of policy implementation and holistic life-cycle management of HAZMAT very challenging.

Consider the example of a communications detachment purchasing, through ADM(Mat), a Travelling Wave Sonar Tube that contains a beryllium alloy for its semi-conductor properties. When these assets reach their end of life, they must be disposed of, usually by DND supply depots, due to the presence of controlled goods. This has the potential to introduce Beryllium dust (an acutely and chronic toxin with incredibly low

[31] Canada and Kasurak, 'Report of the Auditor General of Canada - Chapter 13 - National Defence - Hazardous Materials...', 36; Office of the Auditor General Canada, 'Report of the Auditor General of Canada - Chapter 12 - Follow-up of Recommendations in Previous Reports' (Ottawa: Office of the Auditor General, 2001), 63; Canada, *Audit of Hazardous Materials Management*, 24.
[32] Canada, *Hazardous Materials Management Framework*, 11.

allowable exposure levels)[33] to the surrounding work areas, and as such, D Safe G and DFHP will need to be involved to do job hazard analysis, air sampling and wipe tests of the surrounding areas. As this component was already introduced into the system, by the hierarchy of controls, elimination and substitution are no longer viable, and as such ADM(IE) must be involved with installing an engineering control, such as an isolated and dedicated Local Exhaust Ventilation (LEV) system. Furthermore, the shredded scraps of these components are no longer controlled goods, but are now HAZMAT, and must be transported to a final disposal site according to the regulations prescribed by SJS for the transportation of dangerous goods and disposed of in a manner prescribed by the Director-General Environment (DGE). In this way, it is evident how the decisions of one sub-organization to purchase an item containing HAZMAT, without full consideration of the holistic life-cycle impacts on other organizations has created a financial and human resources demand on the four other L1 organizations. Furthermore, without one centrally-assigned L1 functional area for HAZMAT, there are no mechanisms in place for one L1 to restrict the activities of the other, at various stages of the HAZMAT lifecycle.

Further to this example, consider that the Defence Administrative Orders and Directives (DAOD) 1000 series, which clearly articulates functional area responsibilities and accountabilities to each L1, clearly articulates 22 different functional areas, from diving safety, information security to fire-safety and respiratory protection; however,

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[33] Department of National Defence Canada, *CF H Svcs Gp Instruction 4440-21 - Medical Surveillance of Beryllium Workers*, CF H Svcs Gp Instruction 4440–21 (Ottawa: Canada Communication Group, 2017), 3. This example was based off of a real-life situation recently resolved in 7 Canadian Forces Supply Depot, Edmonton.

HAZMAT is not defined as one of these functional authorities.[34] Likewise, a clear HAZMAT functional area responsibility is not assigned within the separate DAODs for each L1.[35] This represents a substantial deficiency in the policy framework for DND, as these policies form the fundamental basis for all other management programs in the DND, and without this policy coverage, L1s lack the authority to provide national-level direction that impacts other L1s in the management of HAZMAT. Furthermore, the substantial overlap between the various policy instruments, means that personnel responsible for HAZMAT management throughout DND/CAF "are expected to know and meet the requirements for each of the policy instruments issued by the various organizations."[36]

The ambiguous and overlapping functional areas and policies for HAZMAT are one of the most notable deficiencies identified; however, the decentralized nature of HAZMAT selection control poses a major challenge to the implementation of national policy and direction in this area. This concept originates directly within the overarching

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[34] Department of National Defence Canada, 'DAOD 1000-8, Policy Framework for Safety and Security Management', policies, 11 January 2017, 4, https://www.canada.ca/en/department-national-defence/corporate/policies-standards/defence-administrative-orders-directives/1000-series/1000/1000-8-policy-framework-safety-security-management.html.

[35] Department of National Defence Canada, 'DAOD 1000-4, Policy Framework for Materiel and Asset Management', policies, 10 January 2017, https://www.canada.ca/en/department-national-defence/corporate/policies-standards/defence-administrative-orders-directives/1000-series/1000/1000-4-policy-framework-materiel-asset-management.html; Canada, 'DAOD 1000-8 Policy Framework for Safety...'; Department of National Defence Canada, 'DAOD 1000-11, Policy Framework for Infrastructure and Environment Management', policies, 12 January 2017, https://www.canada.ca/en/department-national-defence/corporate/policies-standards/defence-administrative-orders-directives/1000-series/1000/1000-11-policy-framework-infrastructure-environment-management.html; Department of National Defence Canada, 'DAOD 2007-0, Safety', policies, 13 November 2013, https://www.canada.ca/en/department-national-defence/corporate/policies-standards/defence-administrative-orders-directives/2000-series/2007/2007-0-safety.html; Canada, 'DAOD 1000-11, Policy Framework for Infrastructure and Environment Management'; Canada, 'DAOD 4003-1, Hazardous Materials Management'.

[36] Canada, *Hazardous Materials Management Framework*, 5.

policy for HAZMAT which states that "…HAZMAT procurement shall be decentralized and delegated…".[37] The most recent CRS Audit specifically cited that "There are inadequate controls over the local level selection and procurement of HAZMAT to prevent the usage of high-risk substances that can threaten the health and safety of HAZMAT users and pose risks to the environment.".[38] When delving deeper into this subject, it is important to note how the authorities for HAZMAT life cycle management are separated. DAOD 4003-1 – Hazardous Materials Management and the Supply Administration Manual specifically defines the HAZMAT control authority as "an individual acting on the authority of the Commanding Officer (CO) to approve the introduction or continued use of a HAZMAT".[39]. However, with there being some 372 Regular Force Units in DND, each with their own CO, this means that there may be an equivalent number of HAZMAT control authorities.[40] Further complicating coordination efforts is the fact that the majority of unit-level HAZMAT representatives are assigned this as a secondary duty, and it becomes almost untenable to achieve consistency and national-level coordination.[41]

Not only is having the control authority at the unit level almost impossible to ensure consistency of HAZMAT selection but this approach is also contradicted within

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[37] *Ibid.*, 4.
[38] Canada, *Audit of Hazardous Materials Management*, 16.
[39] Department of National Defence Canada, *Supply Administration Manual*, A-LM-007-100/AG-001 (Ottawa: Canada Communication Group, 2021), 976; Canada, 'DAOD 4003-1, Hazardous Materials Management', 2.
[40] Department of National Defence Canada, 'Defence Detailed Department Listings', accessed 30 April 2022, http://dhrim04.desc.mil.ca/engraph/custom/ORG_ECS_POS/ndpos003a_e.asp. This number also does not include all Reserve Force units for which data was not available.
[41] Canada, *Audit of Hazardous Materials Management*, 10.

other policy instruments within DND. One of DND's key HAZMAT directives, ED - 4003-9 – Hazardous Materials Managements Plans, specifically governs the creation of Hazardous Material Management Plans (HMMP) which direct, when it comes to product selection, that "the [base/wing] HMMP should identify who is responsible to evaluate, approve or restrict the current or proposed use of HAZMAT at the facility."[42] This is further clarified in Royal Canadian Air Force (RCAF) doctrine which states that the Wing Hazardous Materials Officer (WHMO) will "act as a procurement and control authority for HAZMAT products…".[43] This directly contradicts DAOD 4003-1 which assigned the HAZMAT Control authority at the unit level, vice the Wing/Base level. This issue is further exacerbated by the fact that the most recent CRS audit of 2012 found that "HMMPs have not been leveraged as a practical governance instrument".[44] So even if the HMMP were aligned with the DAOD, it is not used to reinforce the HAZMAT control authority nor has not been effective in improving control of the initial selection of less hazardous materials.

According to D Safe G's policy, when it comes to the initial selection of HAZMAT, this is a process done between the HAZMAT control authority, the worker

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[42] Department of National Defence Canada, *Environmental Directive ED 4003-9 - Hazardous Materials Management Plans* (Ottawa: Canada Communication Group, n.d.), 11 The responsibility for the production of the HMMP has been allocated to the Level 3 (L3) or Base/Wing level, with the Commander "responsible for developing and implementing a Wing Hazardous Materials Management Programme…".. .

[43] A4 AE HAZMAT, *1 Canadian Air Division Order - 12-201 - Hazardous Materials Management* (Winnipeg: 1 Canadian AIr Division Headquarters, 2014), 3.

[44] Canada, *Audit of Hazardous Materials Management*, 13. The audit also cited that "…standards were reported to be outdated." and "HAZMAT officers at some locations reported that HMMPs were developed to fulfill a requirement, but have not been implemented" with significant discrepancies between described procedures and actual processes..

and the technical authority (usually the Life Cycle Maintenance Manager (LCMM)).[45] This further complicates the area of product selection by having the responsibility split between three individuals, with no clear mechanism on how to resolve conflicts between them and competing values.

Not only have ineffective governance and lack of initial selection control wreaked havoc on HAZMAT management in DND, the lack of an integrated, widely used HAZMAT management system meant that even accessing the right Safety Data Sheets (SDS) or knowing what holdings one had were a serious challenge. The 1999 OAG report cited that "forty-five percent of personnel in our sample lacked training in interpreting information in the Workplace Hazardous Materials Information System (WHMIS)"[46] and "…that inventory lists were not available at all locations where hazardous materials were stored. Where they were available, they were often out-of-date and did not accurately reflect the current inventory of hazardous materials".[47] This lack of info, both to the user, to ensure that adequate controls and protective measures were in place, and to management, to provide oversight and alignment with national direction, was a serious hindrance to efforts to improve HAZMAT management in DND. It can also make the elimination of certain HAZMAT much more difficult when records are so

[45] Department of National Defence Canada, *General Safety Program - Hazardous Materials Safety and Management Manual*, A-GG-040-004/AG-001 (Ottawa: Canada Communication Group, 2004), 87. The values of the three individuals are usually: performance (usually of primary value to the user), long-term costs and maintenance (of interest to the LCMM) and minimizing health and environmental impact (for the HAZMAT control authority).
[46] Canada and Kasurak, 'Report of the Auditor General of Canada - Chapter 13 - National Defence - Hazardous Materials...', 18. WHMIS has since been replaced by the Global Harmonized System (GHS).
[47] *Ibid.*, 18.

incomplete that they either cannot be relied upon or do not identify existing holdings of HAZMAT one wishes to eliminate.

From these aforementioned observations, it is evident why consistently implementing national HAZMAT policy remains such an elusive goal for DND, with hundreds of HAZMAT control authorities, doing this role in the limited spare time they have from their primary duties, struggling through overlapping and conflicting policies from different L1s, and competing, without formal authority, with the user and technical authority for the initial product selection, selecting among millions of potential compounds to choose from, with limited data to support effective decision making.

Asbestos

When it comes to a missed opportunity to apply the Precautionary Principle in DND, one of the most illustrative examples deals with the use of asbestos in real property. As expanded upon in Annex B, asbestos exposure and its associated diseases (lung cancer, asbestosis and mesothelioma) now represent the majority of compensated claims for occupational cancer deaths.[48] As a result of DND's reactive posture to asbestos, it is now widespread throughout its entire portfolio, and will likely be a scourge of occupational disease for decades to come, due to insufficient funding to fund the exorbitantly expensive abatement that is required. Asbestos is but one of several

[48] Canada, 'CCOHS: Health and Safety Report - Past Issues'. Occupational Cancer is now the leading cause of workplace-related death in Canada.

HAZMAT compounds, reactively dealt with, that threaten the health of our personnel and the long-term sustainability of DND's infrastructure portfolio.

How is the DND currently managing HAZMAT

Governance and Policy

In the 26 years since DND's first internal audit, considerable progress has been made in managing HAZMAT within DND. The initial HAZMAT incident rate fell by almost 70% and is now reduced below levels in comparable industries.[49] The department voluntarily participated in the Accelerated Reduction / Elimination of Toxics program, the Strategic Options Process, and the Chemical Management Plan Challenge which aimed at eliminating the use of specific high-risk HAZMAT.[50] In 2004, DND started its Chemical Hazards Surveillance Program.[51] The publication of CANFORGEN 093-11 in May 2011 made the use of the Hazardous Materials Reference Application (HMRA) mandatory for the tracking of HAZMAT, which helped to resolve previous issues of inventory management and provided ready access to SDS.[52] WHMIS training requirements, although cited as inconsistent between bases, were being met in 2012.[53] Additionally, following the 2012 internal CRS Audit, a detailed 5-page Management

[49] Canada and Kasurak, 'Report of the Auditor General of Canada - Chapter 13 - National Defence - Hazardous Materials...', 11. Most of these programs focus on removing compounds from inventory once their hazards are fully characterized and deals less with emerging chemicals.
[50] Canada and Kasurak, 35; Canada, *Audit of Hazardous Materials Management*, 16.
[51] Canada, *CF H Svcs Gp Instruction 4440-01 - Chemical Hazards Surveillance Program*, 4. This program aims to address "the identification, evaluation and management of health risks associated with chemical compounds in all settings…" including health surveillance and monitoring for adverse effects from exposure, determining relevant exposure limits and recommending mitigation measures.
[52] Canada, *CANFORGEN 093/11...*
[53] Canada, *Audit of Hazardous Materials Management*, 14.

Action Plan (MAP) was developed, with explicit timeframes and objectives, to focus DND's efforts on improvement.

In 2015, despite ADM(Mat) originally being recommended to take the role of FA, ADM(IE) was assigned the FA for HAZMAT and assumed responsibility for improving governance frameworks and HAZMAT management processes, as per Figure 3 below.[54] In addition to this, a significant amount of new HAZMAT policies emerged, including a directive on the production of Hazardous Material Management Plans (ED-4003-9) in 2003, a Concept of Operations for HAZMAT management in 2004, L1 formation wide Hazardous Material Management directives in 2014 and a Hazardous Materials Management Framework in 2016.[55] These have been substantial improvements, showing a serious commitment by DND to improve their management of HAZMAT.

[54] Canada, *Hazardous Materials Management Framework*, 6. The assignment of ADM(IE) as functional authority for HAZMAT was not followed up with the requisite changes in policy to fully grant it authority, such as changing the DAOD 1000 series.
[55] Canada, *Environmental Directive ED 4003-9 - Hazardous Materials Management Plans*; Department of National Defence Canada, *Materiel Acquisition and Support (MA&S) - Concept of Operations - Hazardous Material Management* (Ottawa: Canada Communication Group, 2004); A4 AE HAZMAT, *1 Canadian Air Division Order - 12-201 - HAZMAT Management*; Canada, *Hazardous Materials Management Framework*.

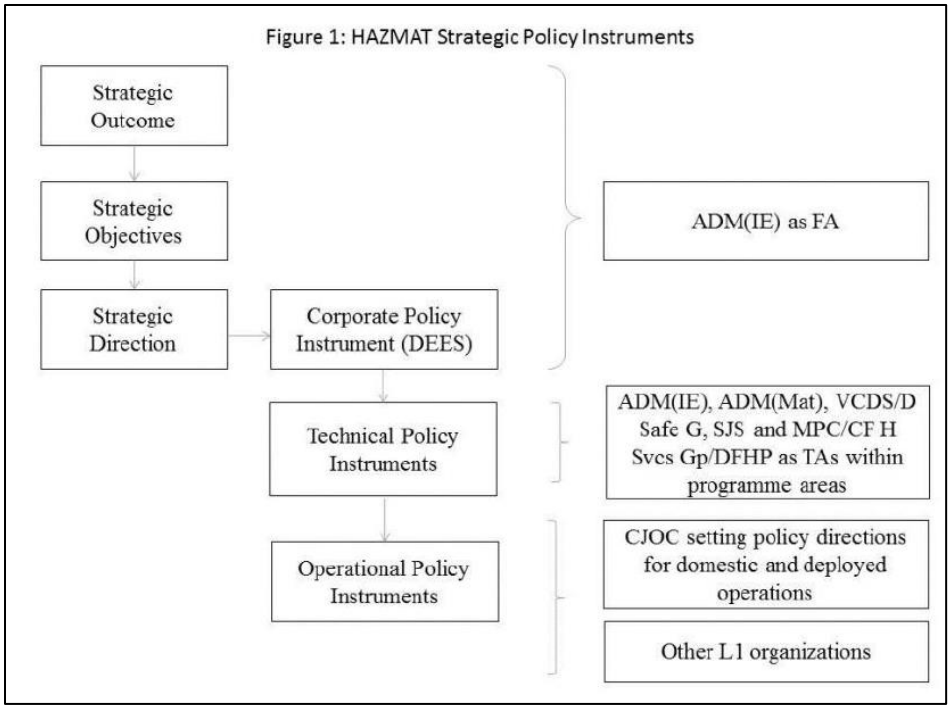

Figure 3: HAZMAT Strategic Policy Instruments

Source: Assistant Deputy Minister (Infrastructure and Environment), *Hazardous Materials Management Framework,* 8.

With all of these improvements, one might be tempted to conclude that DND has fully overcome its' HAZMAT management deficiencies and the department can shift its focus elsewhere to concentrate on other priorities. As tempting as this might be, it would be premature to conclude that DND's HAZMAT management issues are fully resolved. In the current context, DND's HAZMAT management practices still suffer from a lack of effective, coordinated functional area management, HAZMAT life-cycle management is 'stove-piped' and emerging chemical hazards are dealt with reactively with limited central coordination.

Despite ADM(IE) being designated the FA for HAZMAT management in 2015, the functional level responsibilities and authorities for the five different L1 organizations (ADM(IE), ADM(Mat), VCDS, CMP and SJS) remain relatively unchanged.[56] Many of these responsibilities have overlapping consequences, such as acquisition and disposal, with other sections, by such means as engineering controls and exposure monitoring. The cornerstone policy documents, the DAOD 1000 series, remain relatively unchanged, with HAZMAT still not listed as an explicit functional area, among the 22 that are.[57] Even DAOD 1000-11 – Policy Framework for Infrastructure and Environment Management, which outlines all functional areas for ADM(IE) and was issued in 2017 (two years after ADM(IE) was assigned FA for HAZMAT), does not have a single mention of HAZMAT or Hazardous Materials contained within.[58]

Furthermore, there are no established mechanisms to reconcile or resolve HAZMAT issues between the L1s. If, for example, ADM(Mat) starts acquiring refractory ceramic fibre (an emerging contaminant)-containing brake pads for their fleet of vehicles, it will have direct impacts on both human and financial resources within the remaining national L1s, without a mechanism for them to influence this HAZMAT selection. [59]

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[56] Canada, *Hazardous Materials Management Framework*, 4–5. The VCDS still remains responsible for the implementation of the DND Occupational Health and Safety Strategy, ADM(Mat) is still responsible for materiel acquisition, support, disposal and inventory management, SJS is still responsible for the transportation of dangerous goods, and MPC is still responsible for medical investigation and response to exposure to HAZMAT.
[57] Canada, 'DAOD 1000-8 Policy Framework for Safety...'
[58] Canada, 'DAOD 1000-11, Policy Framework for Infrastructure and Environment Management'.
[59] Canada, *CF H Svcs Gp Instruction 4440-01 - Chemical Hazards Surveillance Program*, 39. Refractory Ceramic Fibres are an emerging contaminant and likely regrettable substitution with similar characteristics

These inconsistencies in policy, an overlap of responsibilities and a lack of assigned authority for ADM(IE) to direct another L1, in effect, mean that the assigning of ADM(IE) as FA within the field of HAZMAT management was a paper-only solution to the identified problem. The original issue of a lack of centrally coordinated FA for HAZMAT management within DND remains extant, but for the purposes of future audits, the department can state that the previously identified deficiencies have been corrected.

As an extension of the lack of central coordinating FA, the L1s involved with HAZMAT management still remain solely focused on their relevant areas of expertise. This was specifically identified in the 2016 Hazardous Materials Management Framework which stated:

> In order to improve HAZMAT governance, there needs to be a transition from managing specific (so-called "stove-piped) aspects of HAZMAT in terms of environment, procurement, transportation, disposal, fire safety, and occupational health and safety – towards the integrated management of HAZMAT at the Formation, Base and Wing levels and updated within existing L1 Organization and Command governance structures for operations and activities.[60]

Not only was this cited in the overarching framework, but this is evident in how policy documents are produced. Director Land Equipment Program Staff (DLEPS) had formerly been given responsibility for product assessment, including determining

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to asbestos. Within this example, specific other L1 actions may include requiring ADM(IE) to install engineering controls (such as LEVs), D Safe G may be required to do substantial Job Hazard Analysis and DFHP may be required to monitor and survey workers for exposure.

[60] Canada, *Hazardous Materials Management Framework*, 9.

preferred, restricted and prohibited product lists.[61] Unfortunately, the majority of HAZMAT users and procurement staff are not even aware of these fields in HMRA and do not consider it during their selection and procurement decisions, highlighting a gap between HMRA training and those making recommendations on product selection and acquisition.[62]

Furthermore, the HAZMAT control authorities remain very decentralized and uncoordinated, primarily as a unit-level secondary duty. The hiring of Base and Wing HAZMAT Officers (B/WHMO) seemed like a step in the right direction towards centralized control; however, due to being outside of the direct chain of command for procurement, "the lack of direct authority over HAZMAT users, as well as the lack of a clear strategy for the HAZMAT management program, restricted their [WHMO] ability to promote enduring improvements to life-cycle activities.".[63] This resulted in most local HAZMAT management programs operating independently, detecting and reacting to issues of non-compliance, without clear overarching national objectives, and based on the initiatives of the WHMO.[64]

Not only have a lack of clear functional authorities and coordination between the L1 "stovepipes" hampered efforts at effective HAZMAT management, opportunities to leverage the most effective means of control (substitution and elimination) are being

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[61] Canada, *Audit of Hazardous Materials Management*, 20; Jenna McBride, Discussion on Director Land Equipment Procurement Staff's role in the production of HMRA products lists, Telephone, 3 May 2022. This responsibility had ceased 5 years previous without being re-instated with another L1.
[62] Canada, *Audit of Hazardous Materials Management*, 21. HMRA training is an an ADM(Mat) responsibility.
[63] *Ibid.*, 12.
[64] *Ibid.*, 12.

missed. Despite voluntary participation in several aforementioned programs which aimed to eliminate the use of specific high-risk HAZMAT, these efforts are often limited to one L1 and do not achieve the actual intended effect of substituting high-risk HAZMAT for lower risk HAZMAT. Consider the ADM(Mat) Preferred Products list.[65] From a starting point, despite having an SDS, many of the chemical ingredients may not have undergone a rigorous hazard characterization and suppliers can often mask their actual formulations under trade secrets, only giving up generic terms, like "fluorosurfactants", making them potential likely candidates for a regrettable substitution.[66]

Secondly, the current list, despite being very difficult to find and only availably by emailing certain ADM(Mat) personnel, is over five years out-of-date and only contains 25 preferred products (out of over 6000 HAZMAT products used in DND), belonging to 15 different groups, with half of them being reagents or compressed gases.[67] Furthermore, none of the products identified the rationale for why that product should be preferred over another and is not a regrettable substitution.[68] Furthermore, despite the wealth of experience in HAZMAT, the 1 Canadian Air Division HAZMAT officer had "never seen an approved list" and the Canadian Forces Health Services Group Senior Advisor for Toxicology had "not been consulted in the production of the preferred

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[65] McBride, Discussion on Director Land Equipment Procurement Staff's role in the production of HMRA products lists. The Preferred Products list was created to have the least number and lowest levels of controlled chemical ingredients as well as require the lowest levels of PPE to protect the worker.
[66] National Foam, 'Safety Data Sheet – NMS#210 Aer-O-Water®C6 3EM 3% Aqueous Film Forming Foam Concentrate (AFFF)', 2 November 2016, 1. This makes it very complex, as some fluorosurfactants, like PerFluoroOctanicAcid, (PFOA) are CEPA –Schedule 1 Toxic regulated substances, while others, like PerFluoroHexanoicAcid (PFHxA) are not.
[67] Department of National Defence Canada, 'HMRA Preferred Product List' (Ottawa: Director Land Equipment Procurement Staff, n.d.), accessed 29 April 2022.
[68] *Ibid*.

products list…".[69]. If these two individuals, arguably some of the most qualified to advise on emerging chemical hazards, have never seen or been consulted on the production of the preferred products list, which represents less than 0.5% of all HAZMAT used in DND, and is meagre on substantiation for why a product is "preferred", then one must question the value of this list and DND's overall attempts to reduce emerging harmful chemicals.

Overall, despite nearly three decades of progress against identified deficiencies in HAZMAT, DND still lacks an effective FA supported by clear policy and assigned authorities over other L1s. HAZMAT users and technical authorities still focus on their respective aspects of the HAZMAT life cycle while WHMOs struggle to coerce consistency with little to no authority and product lists are developed in isolation, based on limited outdated data, neglecting other functional experts and limited focus on emerging yet-to-be-regulated contaminants.

Other emerging contaminants

While DND missed the opportunity to proactively respond to asbestos before its prohibition in society, there are several emerging contaminants being used today by DND that offer significant potential for substitution or elimination using the Precautionary Principle. While the list is by no means exhaustive, (a suitable area of future research would be identifying further compounds for consideration), beryllium, hexavalent

[69] Janick Lalonde, 'RE: Notes from Today's Discussion', 29 April 2022; Eugene Pike, 'RE: DND HAZMAT Policies - A-LM-187-004/JS-001', 27 April 2022. The 1 Canadian Air Division HAZMAT officer is responsible for oversight of HAZMAT management on most Royal Canadian Air Force Wings.

chromium and isocyanates have a strong potential for elimination or substitution. This is due to their widespread usage in DND, their significant adverse health effects, their extremely low Threshold Limit Value (TLV) exposure levels, limited regulation and a number of potentially viable alternatives. For a detailed exploration of these emerging compounds, please refer to Annex C.

How should the DND handle HAZMAT in the future

Governance and Policy

As alluded to in the four previous audits of DND HAZMAT management, National Defence requires an effective FA. This must not simply be stated once in a framework document, but rather must be explicitly identified and supported through cornerstone policy documents (such as the DAOD 1000 series) that provide unambiguous authorities for this functional area. While still respecting the technical authorities of the respective L1s involved in HAZMAT, clear mechanisms must be established to holistically look at HAZMAT throughout its lifecycle, with a specific focus on initial selection as the most effective method to control exposure to this hazard in the workplace. The mechanisms must include broad representation from the different affected L1 groups to ensure that policies are not being developed in a "stove-piped" fashion, and factor into account the human and financial resource implications that each L1 must bear from the initial selection and procurement of materials through to disposal.

Greater centralization of HAZMAT control authorities must occur if coordinated national-level direction is to be implemented, and those charged with this control (such as the WHMO) must be empowered through explicit delegation of these authorities over

HAZMAT users and procurement personnel. Furthermore, DND's definition of HAZMAT must be expanded to include the hazardous materials inherent in the RP portfolio, such as asbestos, PolyChlorinatedBisphenols (PCBs), lead, mercury and ChloroFluoroCarbons (CFCs), as the impact of these compounds is a massive component of DND's existing liabilities and source of its contaminants to the local environment.

Hazardous Materials Advisory Committee

As the largest Federal Department, inherently dealing with HAZMAT in all activities, with the largest Real Property portfolio, and a burgeoning cost to maintain and remediate its vast holdings of federal contaminated sites and infrastructure contaminated with HAZMAT, DND cannot afford to wait for commercial chemical compounds to be regulated out of usage in society writ large before ceasing their usage within DND. Furthermore, previous reliance on a decentralized, local HAZMAT Control Authority, resulted in many local procurement personnel reporting that "selection was based primarily on product performance, cost and product availability" and "they lacked the technical knowledge that would be needed to assess products requisitioned and to suggest less hazardous alternatives" and that they were "unaware" of HMRA preferred, restricted and prohibited fields and "did not consider it in making initial selection and procurement decisions".[70] This is not how HAZMAT should be selected.

[70] Canada, *Audit of Hazardous Materials Management*, 17, 20.

The process of exercising precaution in the selection and acquisition of HAZMAT is fraught with pitfalls from the millions of available products, the dearth of data on their hazard characteristics, the unfortunate history of regrettable substitutions and the minimal training and guidance provided to those who must exercise the role of HAZMAT control authority. One counter-argument to this Precautionary Principle approach is that the reactive approach allows private industry to explore alternative options, and DND gets to only utilize the successful alternatives; however, as the federal department with the most personnel and largest portfolio, waiting for viable alternatives to become tried and true allows existing or emerging nefarious compounds, like asbestos and beryllium, to become widespread and difficult to remove.

In order to properly exercise the precautionary principle, an interdisciplinary committee must be established, at the national level, to bridge the different technical areas of the various L1s, and bring unique expertise (such as toxicology, industrial hygiene and environmental remediation) together to begin to evaluate chemicals on a class-based approach, vice individual registered chemicals. This approach will provide the necessary expertise to ensure that regrettable substitution is avoided and optimized, holistic HAZMAT decision-making occurs within DND.

CONCLUSION

HAZMAT is a substantial national concern, as the root cause of our country's leading cause of workplace-related death and many occupational diseases. HAZMAT is

inherent in all of DND's activities and affects all of our personnel, infrastructure and equipment. Despite significant progress in several fields, continued reactive and ineffective management of HAZMAT plagued the department. As emerging compounds of the past and present (such as asbestos and isocyanates) have highlighted, this reactive methodology only trends to a workforce crippled by occupational disease, an unsustainable infrastructure portfolio and a tarnished reputation from extensive litigation.

Substitution and elimination at the initial product selection stages of the life cycle remain the most effective methods within the hierarchy of controls, both in terms of cost and hazard reduction. However, for substitution and elimination to be effective, the Precautionary Principle must be carefully applied to ensure that a Regrettable Substitution does not occur. Due to the overwhelming numbers of chemical compounds, the limited hazard characterization, the technical complexity of the subject and excessive decentralization of HAZMAT control authorities, the current construct of HAZMAT control authorities have hindered their ability to apply the Precautionary Principle. This situation is further compounded by an ineffective FA concept, contradicted by an outdated and overlapping policy whereby L1s produce "stove-pipes" of excellence for their limited purview of the HAZMAT lifecycle. This has engendered a departmentally reactive approach to emerging chemical hazards, whereby the largest federal department lags the progress of industry and Canadian society, awaiting legislation as the impetus for internal change.

To break this cycle, HAZMAT must be established as a separate, deliberate FA, supported by a clear, delineating policy that will break down horizontal barriers between intradepartmental “stovepipes”. HAZMAT control authorities must be further centralized and empowered to influence initial selection decisions to support national objectives. The Precautionary Principle must be applied and regrettable substitutions avoided, with the re-establishment of a National Hazardous Materials Advisory Committee. It must be established with technical expertise and representation from the involved L1s and charged with the complex task of proactively eliminating or substituting both regulated and emerging chemical compounds that pose an unnecessary risk to the department. The scope of HAZMAT management must be formally broadened to include those HAZMAT inherent in RP, as they are responsible for the majority of occupational diseases, costs associated with remediation and liability. Finally, our progress against our established objectives must be formally and objectively assessed through internal and external audits of our progress. Only once these obstacles to success are overcome will DND truly become proactive and precautionary in our management of hazardous materials allowing us to keep our personnel safe, our infrastructure sustainable and our reputation intact.

Annex A: Recommendations
Annex B: The failure to apply the Precautionary Principle with asbestos
Annex C: Other emerging contaminants of concern

ANNEX A: RECOMMENDATIONS

The following recommendations are made to create a more proactive and precautionary model for HAZMAT management in the DND:

- The CDS/DM must formally establish a FA for HAZMAT within DND, including aligning cornerstone doctrine (such as the DAOD 1000 series) and granting authority to direct other L1s in aspects of HAZMAT life cycle management.
- DND must clarify, further centralize and empower the HAZMAT control authorities, to allow for effective implementation of national objectives pertaining to the selection and acquisition of less hazardous material, throughout its lifecycle
- DND must (re)-establish a National Hazardous Materials Advisory Committee, reporting to the assigned HAZMAT FA, with representation from subject matter experts on emerging contaminants and all L1s that affect HAZMAT management throughout its' lifecycle. This organization must be charged with applying the Precautionary Principle in the control of HAZMAT selection, focused on preventing Regrettable Substitutions and carefully scrutinizing emerging contaminants on a class-based basis. This organization will be responsible for the production, maintenance, dissemination and adherence to the national HMRA Approved, Preferred Products, Restricted and Prohibited HAZMAT lists.
- DND should either initiate a follow-on internal CRS audit or request an external OAG audit, of its HAZMAT management to objectively assess

progress towards assigned goals in the past decade. The scope of these audits should be expanded to include HAZMAT inherent in RP, such as asbestos, PCBs, lead, halocarbons, etc.

ANNEX B: THE IMPACT OF ASBESTOS IN DND

Asbestos is a naturally occurring compound, ubiquitous throughout most of the world. [71] The term asbestos is a broader term that refers to several different fibrous materials including actinolite, amosite, anthophyllite, chrysotile, crocidolite and tremolite.[72] Due to its inherent sound deadening and heat resistant properties, it was seemingly useful for insulation and fireproofing resulting in the various forms of this compound being widely mined, refined and utilized.[73] As early as 1879, mining operations commenced for asbestos, with Canada (mainly from Quebec) becoming the first global asbestos producer.[74] At its peak, the annual production of asbestos worldwide grew to some 2 million tonnes in 1998.[75] It is estimated that over half of all the asbestos ever used in the world originated from Quebec.[76]

Throughout this time period, DND (like the rest of Canadian society), continued to use asbestos in its equipment and its infrastructure. It was used extensively as brake and clutch pads, asbestos cement roof files, vermiculite insulation, heating line insulation and various forms of asbestos cement.[77] As the use of asbestos continued, physicians started identifying several health effects in asbestos workers, as per Table 1, below.

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[71] Canada, *CF H Svcs Gp Instruction 4440-01 - Chemical Hazards Surveillance Program*, 39.
[72] Canada, *General Safety Program - Hazardous Materials Safety and Management Manual*, 477.
[73] Canada, *CF H Svcs Gp Instruction 4440-01 - Chemical Hazards Surveillance Program*, 39.
[74] Alec Farquhar, 'Celebrating the Asbestos Ban in Canada and Where to Go from Here', 4, https://www.ohcow.on.ca/edit/files/occ-covid/20_10_14___asbestos_ban_and_strategy_-_occ-tober.pdf.
[75] Fenstad and Matsuura, 'The Precautionary Principle...', 10.
[76] Farquhar, 'Celebrating the Asbestos Ban in Canada...', 4.
[77] Canada, *CF H Svcs Gp Instruction 4440-01 - Chemical Hazards Surveillance Program*, 39.

Table 1: Early warning and actions pertaining to asbestos

Date	Event
1898	UK Factory Inspector Lucy Deane warns of harmful and 'evil' effects of asbestos dust
1906	French factory report of 50 deaths in female asbestos textile workers and recommendation for controls
1907	Pulmonary fibrosis was identified in 10 men who had all died and who had worked in an asbestos carding room for up to 14 years
1911	'Reasonable grounds' for suspicion, from experiments on rats, that asbestos dust is harmful
1911/ 1917	UK Factory Department finds insufficient evidence to justify further actions
1928	Link established between asbestos exposure and pulmonary fibrosis
1930	UK 'Merewether Report' finds 66% of long-term workers in Rochdale factory with asbestosis
1931	UK Asbestos Regulations specify dust control in manufacturing only and compensation for asbestosis, but this is poorly implemented
1935-1949	Lung cancer cases reported in asbestos manufacturing workers
1955	Research by Richard Doll (UK) establishes high lung cancer risk in Rochdale asbestos workers
1959-1964	Mesothelioma cancer identifi ed in workers, neighborhood 'bystanders' and the public in South Africa, the United Kingdom, and the United States, amongst others
1998-1999	EU and France ban all forms of asbestos
2000-2001	WTO upholds EU/French bans against Canadian appeal
2018	Canada bans the import, sale and use of asbestos, as well as the manufacture, import, use and sale of products containing asbestos of all types

Source: United Nations Educational, Scientific and Cultural Organization,

The Precautionary Principle, 10-11.

Despite many of these initial warnings, asbestos was widely used for over 100 years, until the 1985s, when it was banned for use in construction materials (with limited

usage continuing on equipment for such items as brake pads).[78] Despite the European Union banning all forms of asbestos in 1999, Canada continued producing, using and exporting asbestos, until it was finally banned in 2018.[79]

Nowadays, science has firmly established that all forms of asbestos are Group 1 carcinogens (agents considered to be known human carcinogens), and are all able (even with a relatively short exposure) to cause fibrosis, pleural calcification, asbestos bodies (classic asbestosis) and mesothelioma (a condition which is usually fatal within one year).[80] These conditions also have very long latency periods from exposure to onset of symptoms, with 10-20 years for asbestosis, 20-25 years for lung cancer and 35-40 years for mesothelioma.[81] Unfortunately, occupational cancer is now the leading cause of work-related death in Canada, with lung cancer and mesothelioma (usually as the result of asbestos exposure) representing the majority of compensated claims for occupational cancer deaths.[82] Some of these current estimates are that somewhere between 107,000 to 222,000 people are now dying annually, with up to 4000 of them Canadians, from diseases related to asbestos exposure.[83] Furthermore, it is estimated that approximately 150,000 Canadian workers are still exposed to asbestos, with construction workers being

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[78] Department of National Defence Canada, *Department of National Defence - Canadian Forces - Asbestos Management Directive* (Ottawa: Canada Communication Group, 2007), 12.
[79] Fenstad and Matsuura, 'The Precautionary Principle...', 11; Public Works and Government Services Canada Canada, 'Canada Gazette, Part 2, Volume 152, Number 21: Prohibition of Asbestos and Products Containing Asbestos Regulations' (Government of Canada, Public Works and Government Services Canada, Integrated Services Branch, Canada Gazette, 17 October 2018), https://canadagazette.gc.ca/rp-pr/p2/2018/2018-10-17/html/sor-dors196-eng.html.
[80] Fenstad and Matsuura, 'The Precautionary Principle...', 10; Canada, *General Safety Program - Hazardous Materials Safety and Management Manual*, 477; Canada, *CF H Svcs Gp Instruction 4440-01 - Chemical Hazards Surveillance Program*, 40.
[81] Canada, *CF H Svcs Gp Instruction 4440-01 - Chemical Hazards Surveillance Program*, 41.
[82] Canada, 'CCOHS: Health and Safety Report - Past Issues'.
[83] Farquhar, 'Celebrating the Asbestos Ban in Canada...', 2.

the most affected group. [84] Not only does asbestos have a massive cost on human health and wellness is also has a massive negative cost on our economy, with an annual estimated cost to the Canadian economy of over $2.3 billion.[85]

Unfortunately, despite over 100 years of opportunities to adopt the Precautionary Principle, DND was reactive in its approach to asbestos, banning its usage once this was mandated within broader society. For items such as generic building insulation, there were many other viable alternatives that were substantially less hazardous, such as fibreglass.[86] Even today, DND still uses asbestos in many of their vehicle brake pads, despite there being less harmful viable alternatives.[87]

Although comprehensive data is sparse, due to ongoing collection efforts and very long latency times, the effect on DND's infrastructure portfolio is massive. DND's attempts to create Asbestos Management Plans for all 21,000 of its commercial buildings in its portfolio have resulted in some 20,254 data entries into the National Asbestos Inventory for National Defence, with a very large portion of the entries listing whether asbestos is present or an Asbestos management plan is in place as "Unknown" or "In Progress".[88] While the exact costs to abate all of DND's asbestos in its buildings are not

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[84] *Ibid.*, 6.
[85] *Ibid.*, 2.
[86] Canada, *CF H Svcs Gp Instruction 4440-01 - Chemical Hazards Surveillance Program*, 39.
[87] McBride, Discussion on Director Land Equipment Procurement Staff's role in the production of HMRA products lists. It should be mentioned that they are now mostly being phased out as a result of the 2018 ban on asbestos.
[88] Department of National Defence Canada, 'National Inventory of Asbestos in National Defence Buildings', navigation page, 2 October 2017, https://www.canada.ca/en/department-national-defence/services/national-asbestos-inventory.html. Due to the way the data set is accessible, only as a 538 page PDF, sorting and classification of the data, to extrapolate further data (such as percentages unknown or in progress), is not readily possible .

yet known, the costs for asbestos abatement are very expensive, and the procedures are rigorous, requiring an airtight workspace, kept under negative pressure, cleaned with HEPA vacuums and wetted with de-ionized water, with full protective clothing and respirators at all times.[89] Despite not having the exact costs for DND to fully deal with asbestos due to incomplete data, comparable data sets can be indicative. For example, a recent Dutch study estimated that had the Precautionary Principle been exercised (with the banning of asbestos) in 1965 (at a time when the linkage to mesothelioma was plausible but not proven), instead of 1993 (when these hazards were essentially proven and widely acknowledged), it would have saved the lives of 34,000 Dutch citizens and €19 billion in building remediation and compensation costs.[90] This is out of the estimated 53,600 total projected victims and €30 billion remediation costs forecast by the Dutch Ministry of Health from 1969 to 2030.[91]

As asbestos is now so widespread, contained within the majority of its 21,000 commercial and 12,000 residential buildings, ADM(IE) is unlikely to ever have sufficient funding to ever abate all of its asbestos. Asbestos is a very appropriate example of where the Precautionary Principle could have been applied in DND, many years before the public legislation, and prevented the severity of the situation DND finds itself in now. Unfortunately, this is not the only example. Lead, a long-known reproductive and developmental toxin, was widely used in paints, water piping, faucets and solder, and now many bases struggle to meet the recently revised Health Canada drinking water

[89] Canada, *Department of National Defence - Canadian Forces - Asbestos Management Directive - M*, 52.
[90] Fenstad and Matsuura, 'The Precautionary Principle...', 11.
[91] *Ibid.*, 11.

guidelines for lead with limited options for elimination.[92] Other examples could be expanded upon, such as CFCs, PCBs and mercury, to name a few. These must cause us to adopt a paradigm shift away from reaction to legislation to a more proactive approach, as these truly threaten the lives of our personnel and the long-term sustainability of our infrastructure portfolio.

[92] Canada, *D FHP Guidance on the Application of the New Lead (Pb) Drinking Water Guidelines*; Canada, *CF H Svcs Gp Instruction 4440-01 - Chemical Hazards Surveillance Program*, 44.

ANNEX C: OTHER EMERGING CONTAMINANTS OF CONCERNS

While there are hundreds of potential chemical compounds of concern, there are several that are now widely prevalent in DND equipment and infrastructure, where there is an opportunity to apply the Precautionary Principle. Three of these compounds, or classes of compounds, are briefly expanded upon below. It is acknowledged that this list is likely larger, and there are greater opportunities for DND to apply the Precautionary Principle. It is proposed that this task would be within the mandate of the National Hazardous Materials Advisory Committee to screen, identify and assess emerging contaminants, using a class-based approach, for their ability to be eliminated or properly substituted using the Precautionary Principle.[93]

Beryllium (Be)

Beryllium is a lightweight, high-strength material with good semiconducting properties.[94] As such, it is often found in many components used by the military such as aluminum alloys, turbine blades, aircraft brake pads and semi-conductors in communications equipment.[95] Exposure to beryllium dust often occurs during maintenance, disposal, cutting and grinding operations on equipment or components containing this compound.[96] Unfortunately, Be has also "been determined by the International Agency for Research in Cancer (IARC) to be a group 1 human carcinogen" (for lung cancer).[97] Be is also associated with Acute Beryllium Disease (clinically resembling pneumonia or bronchitis), Chronic Beryllium Disease (CBD, a fibrotic lung

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[93] Arlene Blum, 'Six Classes of Chemicals - Green Science Policy Institute', SixClasses.org, accessed 22 April 2022, https://www.sixclasses.org/.
[94] Canada, *CF H Svcs Gp Instruction 4440-01 - Chemical Hazards Surveillance Program*, 48.
[95] *Ibid.*, 48.
[96] *Ibid.*, 48.
[97] *Ibid.*, *CF H Svcs Gp Instruction 4440-21 - Medical Surveillance of Beryllium Workers*, 2.

disease caused by prolonged dust or fume inhalation) and Beryllium Sensitization (BeS, an immunological sensitivity to Be). [98] Be also has an incredibly low 8-hour Threshold Limit Value Time-Weighted Average (TLV-TWA) of 0.05 µg/m3 of air.[99] To put that in perspective, one gram of Be (about the size of half of a sugar cube), evenly spread into the air, would contaminate 20 million cubic meters (roughly the interior volume of a building with a 10m high roof, and a length of 1400m and a width of 1400m) of air to the TLV-TWA. There have been a number of sites within Canada where DND activities have created Be dust levels that exceed the 0.2 µg/100 cm^2 threshold levels causing significant concern, such as 7 Canadian Forces Supply Depot (7 CFSD), on CFB Edmonton and 1 Air Maintenance Squadron (1 AMS) on CFB Cold Lake.[100] Overall, there are some alternative compounds to Be that offer similar performance characteristics for both strength and semi-conduction and would be a good candidate for substitution with the Precautionary Principle.

Hexavalent Chromium (Cr^{+6} or CrVI)

Hexavalent Chromium is almost entirely a product of industrial activity and is often found in "corrosion control compounds, welding and electroplating".[101] Within DND, it can be released during the welding of stainless steels (such as welding certain components of the Leopard -2 Main Battle Tanks or refinishing of aircraft such as the

[98] Canada, *CF H Svcs Gp Instruction 4440-01 - Chemical Hazards Surveillance Program*, 46; Canada, *CF H Svcs Gp Instruction 4440-21 - Medical Surveillance of Beryllium Workers*, 3.
[99] Canada, *CF H Svcs Gp Instruction 4440-21 - Medical Surveillance of Beryllium Workers*, 3.
[100] MWO R.J. MacDonald and LCdr C.L. Mecham, 'Beryllium Sampling - 4 Wing (3229) 1 Air Maintenance Squadron Building 561 - Air Weapons Maintenance Shop', PMed (Cold Lake, AB: 22 Canadian Forces Health Services Centre, 28 April 2022), 5.
[101] Canada, *CF H Svcs Gp Instruction 4440-01 - Chemical Hazards Surveillance Program*, 48.

CP-140 Aurora).[102] It is classified as a Group 1 carcinogen by the IARC (for lung cancer) and has been linked to nasal septum perforation and occupational asthma (due to sensitization).[103] Similar to Beryllium, it has very low exposure thresholds, with a TLV-TWA of 0.2 μg /m^3 and a TLV-STEL (Short Term Exposure Limit) of 5 μg/m^3.[104]

This contaminant is of significant concern within DND, especially when it comes to the refinishing of aircraft or the welding of tank hulls. Ideally, refinishing and welding would take place inside an official purpose-built facility with the proper engineering controls in place, however, this has not always been possible due to lack of availability or infrastructure, either schedule-wise or in the geographic area.[105] As such, DND personnel would often schedule a "paint night" or "welding night", when the remainder of the personnel would leave the facility at the end of the workday, the ventilation would be shut off, doors opened, and refinishing or welding operations would occur, with the theory that the risk would be mitigated by allowing the hexavalent chromium dust to dissipate before the arrival of staff the next morning. The efficacy of these measures was analyzed through testing by DND Preventative Medicine technicians and outside consultants.

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[102] Canada, 41; Cara Stantec Consulting Ltd., Cara Dawson, and Pamela Sears, 'Final Report: Industrial Hygiene and Engineering Risk Evaluation of CP140 Aurora Aircraft Refinishing Process, 10 Hangar Periodic Maintenance Bay, 14 Wing Greenwood, Greenwood, NS', Industrial Hygiene and Engineering Risk Evaluation (Greenwood: Prepared for Defence Construction Canada, 28 March 2019), 3.
[103] Canada, *CF H Svcs Gp Instruction 4440-01 - Chemical Hazards Surveillance Program*, 41, 46, 48.
[104] Stantec Consulting Ltd., Dawson, and Sears, 'Final Report: Industrial Hygiene and Engineering Risk Evaluation of CP140 Aurora Aircraft Refinishing...', 74.
[105] Capt Kristin Johnston, 'Refinishing Operations in a Maintenance Hangar', 31 May 2018, 2, Refinishing Operations in a Maintenance Hangar.

In the example of refinishing operations for the CP-140 aircraft in Greenwood, it was found that the "concentrations of select analyzed chemicals of interest [methyl ethyl ketone, strontium chromate (as hexavalent chromium) and hexamethylene diisocyanate (HDI)] in the air were found to be elevated above their respective ACGIH [American Council of Governmental Industrial Hygienists] TLV-TWAs during the Refinishing Process"[106], " the limited use of paint resistant tarps in the vicinity of the aircraft was not sufficient to adequately prevent the accumulation of settled material on the surfaces of the hangar"[107] and "Strontium Chromate and Chromic Acid remain above baseline levels post-refinishing".[108] In reality, this means, that this highly carcinogenic chemical, with very low exposure thresholds, was breaching TLV-TWAs during maintenance, existing measures to limit dust (tarps) were ineffective and even post-cleaning, hexavalent chromium residues remained, which could eventually accumulate in the area. This is yet another compound, widely used in DND, where options should be thoroughly considered to determine if this HAZMAT can be eliminated or substituted using the Precautionary Principle.

Isocyanates

Isocyanates are another group of compounds widely used in DND. They are generally found in glues, plastic foams and insulation products. [109] Specific to DND, isocyanates are often found in polyurethane and urethane paints as toluene diisocyanate (TDI), diphenylmethane (MDI) and hexamethylene diisocyanate (HDI).[110] One of the

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[106] Stantec Consulting Ltd., Dawson, and Sears, 'Final Report: Industrial Hygiene and Engineering Risk Evaluation of CP140 Aurora Aircraft Refinishing...', 4.
[107] *Ibid.*, 5.
[108] Johnston, 'Refinishing Operations in a Maintenance Hangar', 3.
[109] Canada, *CF H Svcs Gp Instruction 4440-01 - Chemical Hazards Surveillance Program*, 26.
[110] *Ibid.*, 26.

most common applications within DND has been the application of the Chemical Agent Resistant Coating (CARC) which is an isocyanate-based coating that is often released during repair and refinishing that involves sanding or welding.[111] Isocyanates also have significant health effects. They are the most common cause of occupational asthma in Canada, they act as sensitizers (presenting as shortness of breath and coughing that appears shortly after re-exposure) and irritants and can have a "direct pharmacologic effect on the bronchial airways". [112] Similar to Be and CrIV, isocyanates also have very low permitted exposure levels, with the ACGIH TLV-TWA of 1 Part Per Billion (ppb) (inhalable fraction and vapour) and the ACGIH TLV-STEL of 5 ppb.[113] This compound is widespread throughout DND, with very low exposure levels and a significant risk of severe health effects to our personnel. Furthermore, this is a prime candidate for potential substitution using the Precautionary Principle, as the US Naval Research Laboratory - Strategic Environmental Research and Development Program (SERDP) has already successfully demonstrated and validated an isocyanate-free siloxane-based aircraft topcoat paint.[114] Furthermore, these potential substitutions met the MIL-PRF-85285 military specification and were successfully applied to active US Department of Defence assets (such as helicopters).[115]

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[111] *Ibid.*, 27.
[112] *Ibid.*, 24.
[113] Occupational Safety and Health Administration US Department of Labour, '2,6-TOLUENE-DIISOCYANATE (TDI) | Occupational Safety and Health Administration', accessed 5 May 2022, https://www.osha.gov/chemicaldata/735.
[114] Strategic Environmental Research and Development Program (SERDP) US Naval Research Laboratory and Dr. Erick Iezzi, 'Demonstration and Validation of Siloxane-Based Aircraft Topcoats That Are Isocyanate-Free and Provide a Reduced Environmental Impact', accessed 5 May 2022, https://www.serdp-estcp.org/News-and-Events/Blog/Demonstration-and-Validation-of-Siloxane-Based-Aircraft-Topcoats-that-are-Isocyanate-Free-and-Provide-a-Reduced-Environmental-Impact.
[115] US Naval Research Laboratory and Iezzi.

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