Gagetown Harmful Chemical Study Commission
Public Law 2025, chapter 763, section 2
Friday, October 2, 2026 at 12 p.m.
Maine State House, Room 437 (VLA) and via Zoom
Streaming: https://legislature.maine.gov/Audio/#437

Meeting Agenda

1. **Introductions**
   Chairs, Senator Craig Hickman and Representative Sam Zager

2. **Presentation: Maine Bureau of Veterans' Services**
   Director David Richmond

3. **Presentation: Effects of exposure to harmful chemicals**
   Commission members Thomas Schwartz, Ph.D., and Dr. Sampath Gunukula, Ph.D.

4. **Public Comment**
   Chairs, Senator Craig Hickman and Representative Sam Zager

5. **Discussion: Goals of the 2026 Gagetown Harmful Chemical Study Commission**
   Commission members

6. **Next steps**
   Chairs, Senator Craig Hickman and Representative Sam Zager

Future Meetings

All meetings will be held in SH Room 437 (VLA).

- Friday, October 16, 2026 at 12 p.m.
- Friday, October 30, 2026 at 12 p.m.

Gagetown Study Commission: Exposure to Chemicals - Background

October 2, 2026

Profs. Thomas J. Schwartz & Sampath Gunukula
University of Maine, Department of Chemical & Biomedical Engineering

Any opinions, findings, and conclusions or recommendations expressed in this material are solely those of the authors (TJS and SRG) and do not necessarily reflect the views of the University of Maine or the University of Maine System.

1

Introduction & Background

- **The Problem:**
  - On seven days over two years (3 in 1966 and 4 in 1967), Agents Orange & Purple were tested at CFB Gagetown.
  - Additionally, from 1956 to present day other herbicides were and are used for foliage control.
  - Maine National Guard troops have trained at CFB Gagetown intermittently since 1971, some of whom have experienced illness and other health issues.
  - *To what extent are these health issues related to the use of unregistered and registered herbicides at CFB Gagetown?*
- **2023 Gagetown Study Commission Recommendation:**
  - Add two experts in "Chemical Engineering, Environmental Science, or Human Health as they relate to exposure to hazardous chemicals" to "provide insight into the study methods, [data collection & analysis] and report conclusions."[1]
- **Scope of this presentation:**
  - Provide background information on the relevant chemistry and potential routes of exposure.
  - Help identify questions about existing materials and potential avenues for more information.
  - "Translate," as needed, any technical information.
  - *We are not toxicologists or environmental scientists and cannot provide any medical opinions. The analysis here is based on only on literacy in chemistry, engineering, and broad science, not deep expertise in toxicology.*

2

Herbicide Chemistry

2,4-D

The "Rainbow" herbicides:

Mixtures of 2,4-D (dichlorophenoxyacetic acid)
and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid)
in different ratios and with some other chemicals

2,4,5-T

- *Agents Orange and Purple are only 2,4-D & 2,4,5-T*
- *Agent White contains 2,4-D and picloram (next slide)*

- **Background information:**
  1. 2,4-D is one of the most common herbicides and is still used today in commercial lawn weed killers.[2]
  2. 2,4,5-T is no longer used (as of 1985, currently banned by the Rotterdam Convention).[3] Why? Impurities…
  3. Especially during early production, 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD, a.k.a. "Dioxin") is a significant impurity. TCDD is highly carcinogenic and environmentally persistent.[4]
     - 2,4-D and 2,4,5-T are both IARC-recognized possible carcinogens. EPA does not recognize 2,4-D as possibly carcinogenic.[4]
  4. TCDD contamination is one reason 2,4,5-T is no longer used

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Herbicide Chemistry

Other Herbicides at Gagetown:

Timeline: 1956-1964 – various mixtures of 2,4-D and 2,4,5-T
1965-1975 – Tordon 101 (2,4-D and picloram)
1975-1983 – Tordon 10k (picloram)
1983-2000 – 2,4-D and others (varied)
Post-2001 – Glyphosate formulations

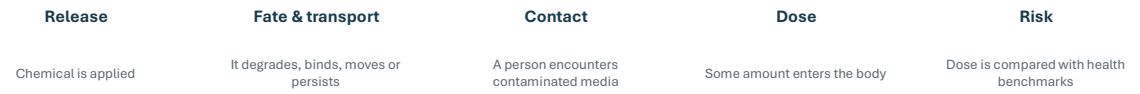
These were investigated by the 2004 Fact-Finders' Report and concluded they posed minimal risk because they were all approved pesticides in Canada at the time.

- Notably, 2,4,5-T manufactured before 1964 would likely have some amount of TCDD contaminant
- A recent report (2026) in *Nature Medicine* suggests there may be a link between picloram and colorectal cancer[5] *(This needs further study)*

4

Assessing Chemical Hazards

Chemical Exposure Happens in Multiple Steps:



Note that exposure does not necessarily translate to health impacts – this depends on dose, which can come from many sources

5

What Happens After Spraying?

The Fact-Finders' Report:

Identifies greatest potential concern for spray workers and individuals entering treated areas immediately after spraying or within 24 hours.

- Longer-term exposure of military trainees to **persistent residues, including TCDD, was also evaluated**.
- Verify how historical soil concentrations of herbicides and associated contaminants were reconstructed and how these assumptions affected the calculated dose and risk.

Fate and Transport of TCDD Generally:

This has been assessed partly by the US National Academies of Science, Engineering, and Medicine.[6,7] They produce a helpful infographic…

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Focus on aerial spray w.r.t. Gagetown

Focus on post-application fate and transport w.r.t. Gagetown

Fate and Transport of Tactical Herbicides During and Following Spraying

Runoff is also possible, but likely very dilute by the time it reaches the ocean (NASEM states this also)

Figure from Reference 6

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Questions Raised by the Commission

Question 1 – Toxicity and SDS Information

Safety Data Sheets (SDS – formerly known as MSDS) sometimes contain toxicology data, e.g. LD50, LC50, etc.

These are for pure compounds and at time of exposure

Mixtures can change toxicology – for example, alcohol (ethanol) changes how your body processes regular medicines. Things degrade over time.

So, we can review SDS that provide useful hazard information, but may not represent historical formulations, environmental transformation, or reconstructed exposure conditions

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Questions Raised by the Commission

Question 2 – Amounts of exposure during training – Geographic proximity

This will be hard (but not necessarily impossible) to assess. The Fact-Finders' Report indicated no significant contamination in soil or fish, and the ATSDR assessment requested by Senator Collins' office in 2012 determined the methods in this report are consistent with the approach that ATSDR would use.[8] The major challenge here is estimating exposure at the time National Guard troops were present.

Transport of these species makes this challenging to assess, but transport is in principle understood. A specialist consultant could help. *A new study could improve understanding of current TCDD distribution at the site, but even that will not establish concentrations and locations at the time of training*.

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Questions Raised by the Commission

Question 3 – Exposure based on time and distance

Yi and Ohrr (*Cancer*, 2014)[9] describe the impact of Agent Orange exposure on cancer incidence many years after exposure. There is a "lag time" described in that paper, but it refers to the lag time between exposure and developing cancer. This paper does not directly address the risk associated with exposure to a site (days, months, years) after spraying occurs. The meta-analysis by Xu *et al*. (*Sci. Rep.,* 2016)[10] only addresses external exposure levels, not temporal issues.

The National Academies of Science, Engineering, and Medicine published a report in 2011[7] describing the fate and transport of TCDD in Vietnam following Agent Orange spraying and conclude that TCDD is likely to remain in the soil and can be transported in water. But, it is difficult to estimate the time-dependent quantities and locations of TCDD or other chemicals from herbicides. **We also know from the Fact-Finders' Report that some amount of TCDD was present at Gagetown in at least some locations at least 40 years after spraying.**

There is disagreement in the academic literature on the correct modeling approach to use in assessing exposure. In particular, the EOI metric used by Yi and Ohrr had been called into question in 2009 by Ginevan, Ross, and Watkins (*J. Exposure Sci. & Environ. Epidem.*, 2009).[11] This does not invalidate Yi and Ohrr's conclusions; it just indicates that the question of how to quantify and model exposure is not yet well resolved in the literature.

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Bibliography

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lack of quantitative measurements of exposome traits in cancer cohorts, which consequently makes it challenging to establish clear associations with cancer risk. Emerging studies have identified exposome-induced changes in CpG site-specific DNA methylation levels[9], providing a new avenue for investigation. As DNA methylation data is frequently available in cancer cohorts, exposome-related methylation changes could serve as a valuable proxy for direct exposome measurements. This approach may enhance our ability to pinpoint specific exposome risk factors and improve our understanding of their role in EOCRC development.

In this study we aimed to explore the exposome traits that may contribute to the development of EOCRC compared to LOCRC, herein defined as CRC diagnosed in people 70 years and older. To this end, we constructed methylation risk scores (MRSs) for lifestyle and environmental factors using DNA methylation data from The Cancer Genome Atlas (TCGA) as the discovery cohort and conducted a replication meta-analysis across nine independent cohorts. The resulting MRSs were then compared between EOCRC and LOCRC. The relationship between pesticide use intensity and EOCRC incidence in the USA was further investigated using population-based data.

Results

Cohort description

For the discovery phase of this study, we utilized colon adenocarcinoma (COAD) samples obtained from TCGA[10]. The subsequent replication phase was carried out through a meta-analysis, incorporating data from studies on colon cancer (GSE131013, GSE42752, E-MTAB-7036 and GSE199057)[11–14], rectal cancer (TCGA-READ and GSE39958)[15] and colorectal cancer (GSE101764, GSE77954 and E-MTAB-3027)[16–18]. Patients were classified as EOCRC (<50 years) or LOCRC (≥70 years). This resulted in a discovery dataset containing 31 EOCRC and 100 LOCRC patients, whereas the replication cohort incorporated 83 EOCRC and 272 LOCRC patients. Population characteristics are presented in Table 1, with a detailed discovery cohort characterization in Supplementary Table 1.

Exposome-related DNA methylation marker sets

The exposome's association with EOCRC versus LOCRC was evaluated using 29 lifestyle and environmental factors, which we define here as the exposome, acknowledging its broader scope. The analyzed traits encompassed 11 lifestyle factors: the Alternative Healthy Eating Index (AHEI), alcohol consumption, birthweight, body mass index (BMI) (continuous variable in kg m^{-2}), cannabis use, coffee consumption, education level, Mediterranean Diet Score (MDS), obesity (defined as ≥30 kg m^{-2}), smoking habits and smoking inference model (smoking-Maas). Furthermore, we examined four air pollution particles: nitrogen dioxide (NO_2), polychlorinated biphenyls (PCBs) and particulate matter (PM) < 2.5 µm in diameter ($PM_{2.5}$) and between 2.5 µm and 10 µm ($PM_{2.5–10}$). In addition, we included 14 pesticides encompassing 2,4-dichlorophenoxyacetic acid (2,4-D), atrazine, acetochlor, chlordane, dicamba, malathion, dichlorodiphenyltrichloroethane (DDT), heptachlor, lindane, glyphosate, mesotrione, metolachlor, picloram and toxaphene. For the marker selection, we selected for each trait significantly associated CpG sites (CpGs) from extensive epigenome-wide association studies (EWAS), employing various significance thresholds, namely genome-wide (GW: $P < 1.2 \times 10^{-7}$), $P < 1.0 \times 10^{-5}$ and false discovery rates (FDR) of <0.01, <0.05 and <0.1. Smoking-Maas represents the CpGs included in a previously developed smoking inference model and their published coefficients[19]; no additional selection threshold was applied in the current study.

Exposome-related MRSs

Using available EWAS summary statistics across the five marker selection thresholds, we identified 63 exposome CpG sets across 29 exposome traits and computed 63 weighted MRSs from DNA methylation beta-values adjusted for Horvath epigenetic age[20]. Although termed 'risk scores,' these MRS serve as proxies for exposome exposure, enabling the assessment of exposure prevalence in early- versus late-onset tumors rather than estimation of individual cancer risk. The number of CpGs and their weights can be found in Supplementary Tables 2 and 3.

The limited availability of exposome data in tumor samples hinders the evaluation of its impact on EOCRC and restricts direct validation of the constructed MRSs against measured exposures. To address this, we performed a comprehensive validation of the constructed MRSs across several datasets, with all detailed results summarized in Supplementary Table 5.

Validation was performed by reconstructing the MRS in a dataset with available exposure measurements and assessing concordance between MRS values and the corresponding recorded exposure. By leveraging TCGA data, we observed a higher alcohol MRS in liver cancer

Table 1 | Study population characteristics

Study	N total	Females, N (%)	Age, years (mean (s.d.))	Cancer type
Discovery dataset:				
TCGA-COAD				Colon
Early-onset	31	18 (58)	43 (5)	
Late-onset	100	43 (43)	78 (5)	
Replication datasets:				
TCGA-READ				Rectal
Early-onset	14	6 (43)	44 (6)	
Late-onset	30	21 (70)	76 (6)	
GSE39958				Rectal
Early-onset	12	3 (25)	45 (7)	
Late-onset	9	2 (22)	74 (5)	
GSE42752				Colon
Early-onset	4	3 (75)	46 (3)	
Late-onset	7	5 (71)	76 (4)	
GSE77954				Colorectal
Early-onset	3	3 (100)	48 (1)	
Late-onset	10	3 (30)	77 (6)	
GSE101764				Colorectal
Early-onset	13	3 (23)	38 (8)	
Late-onset	37	13 (35)	76 (5)	
GSE131013[a]				Colon
Early-onset	2	0 (0)	46 (4)	
Late-onset	58	13 (22)	76 (5)	
E-MTAB-7036				Colon
Early-onset	18	14 (78)	41 (7)	
Late-onset	102	57 (56)	79 (5)	
E-MTAB-3027				Colorectal
Early-onset	3	0 (0)	75 (5)	
Late-onset	10	4 (10)	41 (7)	
GSE199057				Colon
Early-onset	14	7 (50)	44 (6)	
Late-onset	9	3 (33)	74 (2)	

Early-onset cases are defined as participants younger than 50 years, whereas late-onset cases comprise participants diagnosed at age 70 years and older. Dataset GSE77954 encompasses primary (n = 7) and metastatic samples (n = 6). The early-onset category in GSE131013 and E-MTAB-3027 comprises solely male participants, whereas GSE77954 includes only female participants. Consequently, adjustment for sex was not feasible in these datasets. DNA methylation data was generated using the Illumina Infinium HumanMethylation450 BeadChip, except for GSE199057, which used the EPIC BeadChip array.

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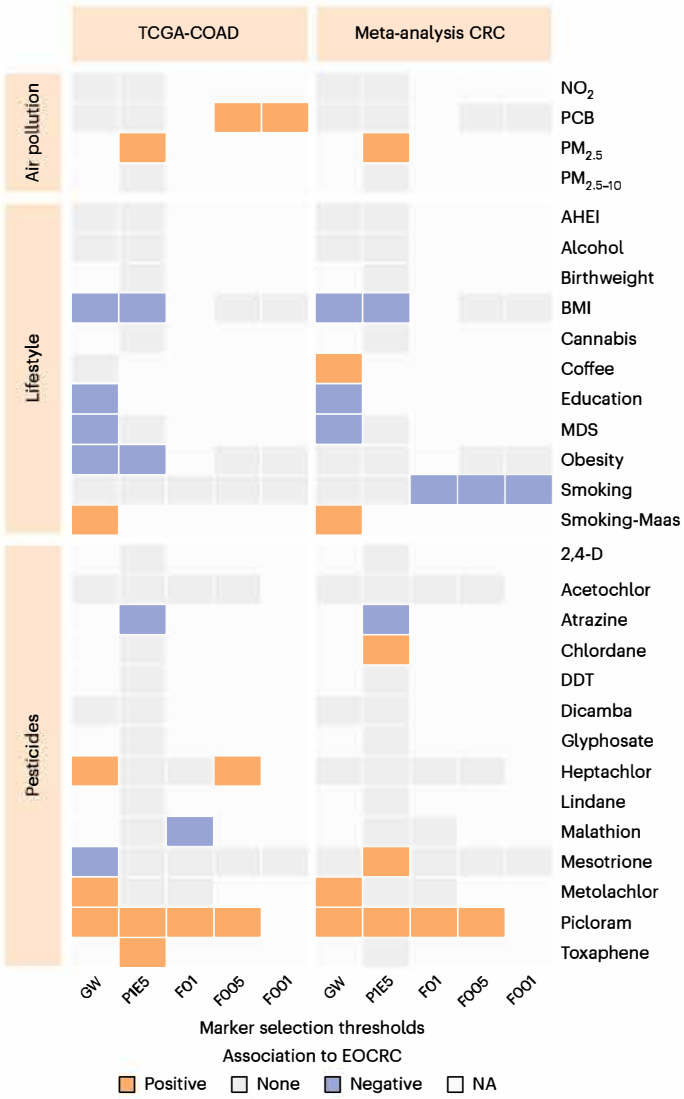


Fig. 1 | Exposome-related methylation risk scores show differences between early- and late-onset CRC patients. Summary overview of the association between the 63 exposome-related MRSs across 29 exposome traits (*y* axis) and five selection thresholds (*x* axis, as applied in the original EWAS), comparing early-onset (age <50 years) to late-onset (age ≥70 years, reference) cancer using sex-adjusted logistic regression. The discovery phase (left panel) was conducted in TCGA-COAD (31 early-onset versus 100 late-onset colon cancer). The replication phase (right panel) shows meta-analysis results from nine cohorts (E-MTAB-3027, E-MTAB-7036, GSE199057, GSE131013, GSE42752, TCGA-READ, GSE39958, GSE101764 and GSE77954), including 83 EOCRC and 272 LOCRC patients. The selection thresholds (*x* axis) indicate the significance threshold in the original EWAS used for CpG selection, namely $P < 1.2 \times 10^{-7}$ (GW), $P < 1.0 \times 10^{-5}$ (P1E5) and FDRs of <0.1 (F01), <0.05 (F005) and <00.1 (F001). The presence of CpGs across the five selection thresholds varies, with unavailable data indicated in white (NA), and nonsignificant findings in light gray.

patients with alcoholic liver disease (ALD), and a separation of current and former smokers from never smokers with the smoking-Maas across several cancer types (Supplementary Table 4 and Extended Data Fig. 1). We further validated the use of MRSs as proxies for cannabis dependence, higher $PM_{2.5}$ median exposure, and smokers (smoking-Maas) using publicly available datasets, including noncancer participants (Extended Data Fig. 1 and Supplementary Table 5).

Beyond the exposome traits included in our study, we examined additional traits using EWAS and publicly available datasets with DNA methylation and measured exposome data, including allergic asthma, major depressive disorder (MDD), polygenic risk scores (PRS) for depression, as well as prenatal exposures, including birthweight, gestational age, maternal education, maternal BMI and arsenic exposure. The constructed MRSs for these traits showed concordance with directly measured exposures, further strengthening the validity of MRSs as a proxy for exposure (Supplementary Table 5 and Extended Data Figs. 2–3).

Exposome-related methylation risk scores in EOCRC versus LOCRC

To elucidate the exposome's impact on early-onset colon and rectal cancer cases, we compared the 63 MRSs between early-onset and late-onset (reference group) patients using multivariate logistic regression models. Due to sex disparities in CRC incidence[21], we adjusted the regressions for sex when feasible. Figure 1 summarizes the results for all 29 exposome traits, analyzed across the five selection thresholds used in the original EWAS studies. In the discovery dataset, positive associations were observed for MRSs related to PCB, $PM_{2.5}$, smoking-Maas, heptachlor, metolachlor, picloram and toxaphene. In contrast, negative associations were found for MRSs corresponding to BMI, education level, MDS, obesity, atrazine, malathion and mesotrione (Fig. 1 and Supplementary Table 6). We highlight the results for four lifestyle factors previously linked to colon and rectal cancers, including the MDS[22] (Fig. 2a) and education level[23] (Fig. 2b), which are considered protective factors, as well as smoking habits[24] (Fig. 2c) and obesity status[25] (Fig. 2d), which are recognized as risk factors. To examine the directionality of our findings, the heatmaps in the left panels of Fig. 2 show the methylation level distributions across CpGs featured in each of the four MRSs, along with their direction in the original EWAS and after sorting by the derived MRSs. The heatmaps show that increased MRS correlates with higher beta-values in CpGs with positive associations in the EWAS and with lower beta-values in CpGs with negative associations (see Extended Data Fig. 4 for a more detailed explanation). These results suggest that an elevated MRS reflects greater exposure levels in the original EWAS. Specifically, for patients with early-onset colon cancer, this suggests a lower MDS ($P = 7.9 \times 10^{-3}$; adjusted P ($P_{adj.}$) $= 3.3 \times 10^{-2}$) (Fig. 2a), lower education levels ($P = 4.0 \times 10^{-3}$; $P_{adj.} = 2.2 \times 10^{-2}$) (Fig. 2b), increased smoking (smoking-Maas) exposure ($P = 1.1 \times 10^{-3}$; $P_{adj.} = 8.9 \times 10^{-3}$) (Fig. 2c), and lower obesity rates ($P = 8.4 \times 10^{-4}$; $P_{adj.} = 7.5 \times 10^{-3}$) (Fig. 2d) in comparison to those with late-onset, as illustrated in the middle panels of Fig. 2. The association of lower obesity rates with early-onset cases was verified utilizing physical metrics from TCGA-COAD. Colon cancer patients with a BMI over 30 kg m^{-2}, as measured in the clinic, were categorized as obese, resulting in 4 out of 24 early-onset and 18 out of 72 later-onset patients being marked as obese. This provides a relative risk (RR) of 0.67 (95% confidence interval (CI): 0.26–1.76) for obesity in early-onset colon cancer patients within the TCGA-COAD cohort (Extended Data Fig. 5), supporting the MRS results for obesity.

Extending our investigation, we conducted a meta-analysis across the nine replication datasets (Figs. 1 and 2 and Supplementary Table 7). This analysis corroborated the initial findings, notably the associations of a lower MDS ($P = 1.5 \times 10^{-2}$; $P_{adj.} = 4.6 \times 10^{-2}$), lower educational levels ($P = 2.11 \times 10^{-5}$; $P_{adj.} = 3.59 \times 10^{-4}$) and higher smoking exposure ($P = 1.02 \times 10^{-5}$; $P_{adj.} = 8.6 \times 10^{-4}$) in EOCRC (Fig. 2, right panel). To ensure platform consistency, the meta-analysis was repeated using eight datasets generated with the 450K array, excluding the EPIC-based cohort GSE199057. This strengthened the association for lower MDS ($P = 3.06 \times 10^{-3}$; $P_{adj.} = 1.3 \times 10^{-2}$), whereas educational level and smoking-Maas remained significant (Supplementary Table 8). Finally, despite the considerably reduced sample size, an exploratory tissue-specific meta-analysis of rectal-only (TCGA-READ and GSE39958) or colon-only cancer datasets (GSE131013, GSE42752, E-MTAB-7036 and GSE199057) showed a consistent trend in colon for education and smoking (Extended Data Fig. 6 and Supplementary Table 9).

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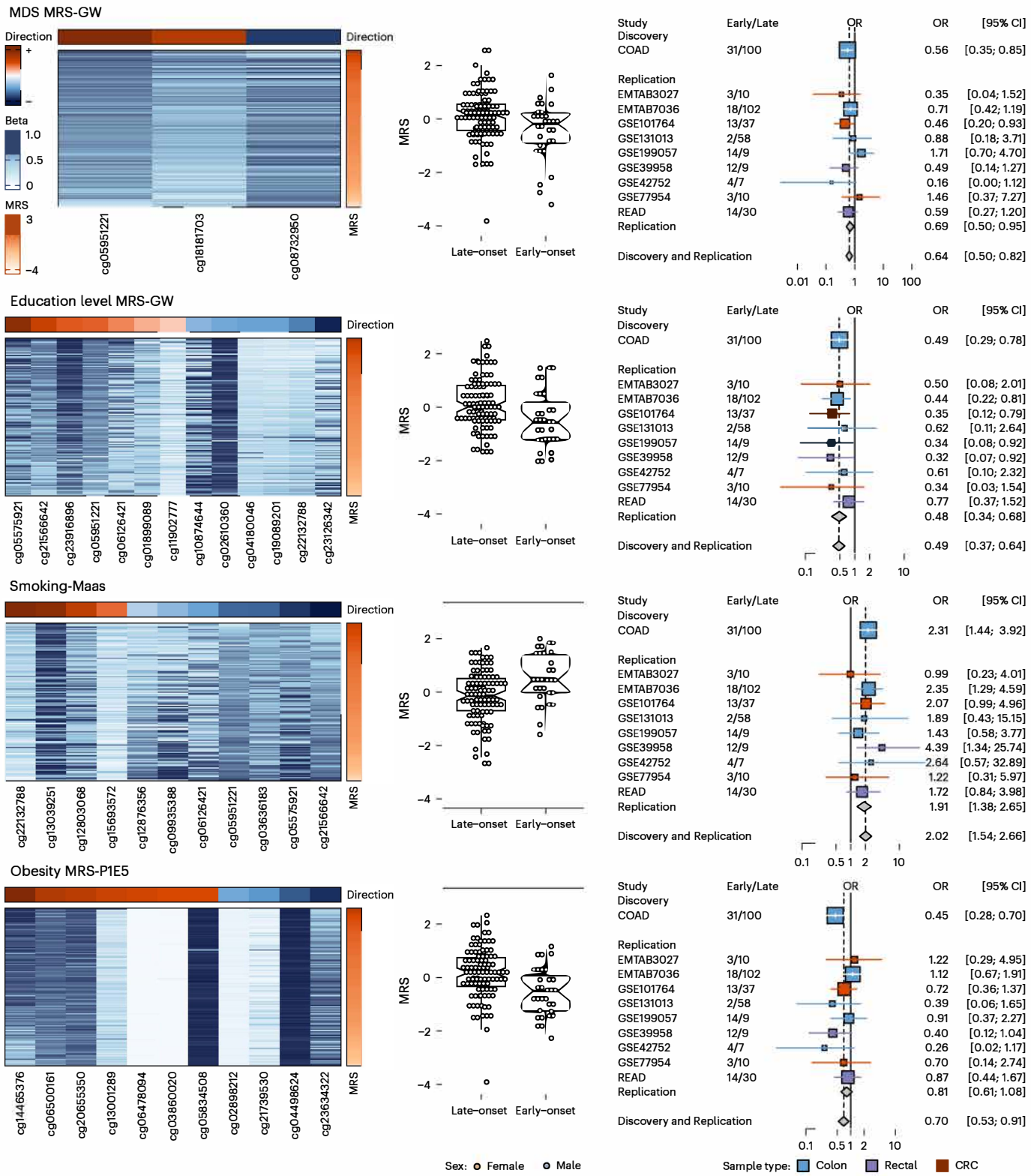


Fig. 2 | Lifestyle factors in EOCRC versus LOCRC tumors. a–d, Lifestyle-related MRS differed between EOCRC and LOCRC, including non-Mediterranean dietary patterns MRS-GW (marker threshold $P < 1.2 \times 10^{-7}$) (**a**), lower education levels MRS-GW (**b**), higher smoking exposure (smoking-Maas) (**c**) and lower obesity rates MRS-P1E5 (marker threshold $P < 1.0 \times 10^{-5}$) (**d**) in patients with EOCRC. The heatmaps (left) display epigenetic age-adjusted DNA methylation beta-values in TCGA-COAD, ordered by MRS; the top color bar indicates CpG effect direction in the original EWAS (red: positive; blue: negative). The boxplots (middle) show MRS distribution in patients with EOCRC ($N = 31$) and LOCRC ($N = 100$) in TCGA-COAD, stratified by sex (orange: female; purple: male). The forest plots (right) present sex-adjusted logistic regression results for each replication dataset, their meta-analysis (Replication), and combined with TCGA-COAD (Discovery and Replication), for colon (blue), rectal (purple) and CRC (red). Squares: ORs; horizontal lines: 95% CIs. Boxplots show median (center line), interquartile range (IQR) (box) and whiskers (1.5× IQR) and outliers.

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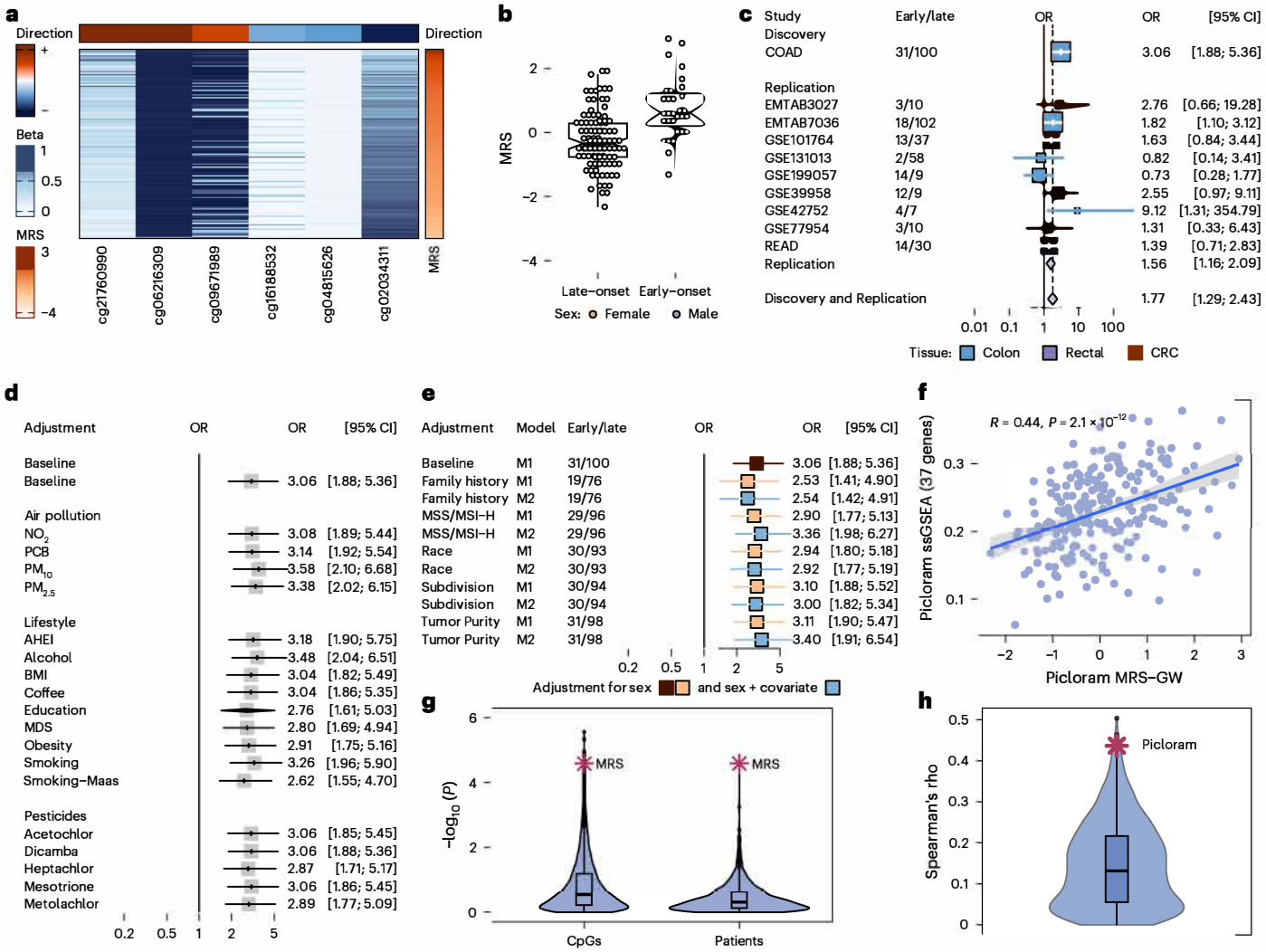


Fig. 3 | A higher picloram MRS is associated with EOCRC. The figure shows the distribution and validation of the picloram MRS employing the genome-wide CpG selection threshold (MRS-GW). **a**, Heatmap of epigenetic age-adjusted DNA methylation beta-values in TCGA-COAD, ordered by MRS; the top color bar indicates CpG effect direction in the original EWAS. **b**, Boxplot showing MRS-GW distribution in early- ($N = 31$) and late- ($N = 100$) onset TCGA-COAD patients, stratified by sex (orange, female; purple, male). **c**, Forest plot showing sex-adjusted logistic regression results in replication cohorts, their meta-analysis (Replication), and combined discovery and replication, including colon (blue), rectal (purple) and colorectal (red) cancer. **d**,**e**, The associations were further adjusted for other MRSs (31 EOCRC versus 100 LOCRC) (**d**) and tumor purity, subdivision (left/right), first-degree family with cancer diagnosis (yes/no), race (White/non-White) and MSI status (**e**). The baseline model (red) includes sex adjustment only; subset analyses show sex-adjusted (M1, orange) and fully adjusted models (M2, blue square). **f**, Spearman correlation between the 37-gene picloram-specific ssGSEA and the picloram MRS in TCGA-COAD ($P = 2.127845 \times 10^{-12}$); solid line: linear fit with the shaded area indicating the 95% CI. **g**,**h**, The violin plot shows the permutation results, confirming the robustness of CpG selection, patient categorization (**g**) and ssGSEA association (**h**). In the forest plots, squares represent ORs, and lines 95% CIs. Boxplots show median (center line), IQR (box), whiskers (1.5× IQR) and outliers.

Picloram-related MRSs

Our results highlight a new association between the MRSs for the herbicide picloram and EOCRC, in comparison to LOCRC cases, in both the discovery and meta-analysis (Fig. 1). We observed that a higher exposure level, as indicated by the original EWAS direction, is associated with an elevated MRS (Fig. 3a). This association highlights increased exposure to picloram among patients with early-onset colon cancer ($P = 2.59 \times 10^{-5}$; $P_{adj.} = 4.41 \times 10^{-4}$) (Fig. 3b)—a finding consistently supported by our meta-analysis using all replication cohorts ($P = 3.07 \times 10^{-3}$; $P_{adj.} = 1.51 \times 10^{-2}$; odds ratio (OR): 1.56 [95% CI: 1.16–2.09]) (Fig. 3c) as well as in the meta-analysis using only 450K array samples ($P = 7.17 \times 10^{-4}$; $P_{adj.} = 4.06 \times 10^{-3}$; OR: 1.71 [95% CI: 1.25–2.33]).

The model presented was initially adjusted only for sex to facilitate external validation in independent datasets lacking measurements for additional variables. To evaluate the robustness of the association between picloram MRS-GW and age at onset, we applied additional adjustments in TCGA-COAD patients. First, we accounted for the influence of other MRSs included in the GW marker selection threshold (Fig. 3d). We observed only minor variations across most adjustments, and none resulted in the loss of the significant association between picloram MRS-GW and age at onset (Fig. 3d). Second, we explored the distribution of the picloram MRS-GW between male and female participants ($P = 0.0024$) and between microsatellite stable (MSS) and instable (MSI) tumors ($P = 0.01$), tumor purity high (≥0.7) versus low (<0.7) ($P = 5.3 \times 10^{-15}$), and across the consensus molecular subtypes (Extended Data Fig. 7). The observed significant differences highlight the need for further adjustment when testing the association between picloram MRS-GW and age at onset. As not all variables were available for every patient, Fig. 3e presents Model 1 (adjusted only for sex) alongside Model 2, which incorporates each additional adjustment.

This approach ensures consistency by analyzing the same subset of patients to account for sample size differences. Notably, no substantial changes in the association between picloram MRS-GW and age at onset were observed after adjustments.

Picloram-induced gene expression alterations are associated with picloram MRS-GW

A high picloram MRS-GW score showed robust associations with EOCRC patients; however, validating whether the picloram MRS reflects actual picloram exposure is not feasible, as data on picloram-related DNA methylation effects are, to our knowledge, unavailable. Alternatively, we validated the pesticide MRSs using changes in gene expression induced by pesticides. Our rationale was that if the gene expression changes induced by pesticide exposure are reflected in the respective MRS, this would support that the MRS represents the molecular effects of pesticide exposure. To this end, we analyzed RNA-seq data (GSE262419) from induced pluripotent stem cell (iPSC)-derived cardiomyocytes exposed to a wide range of chemicals ($N = 67$) including several pesticides overlapping with those in our study. To identify gene expression alterations for each pesticide, we performed differential gene expression analysis (DGEA) using pesticide exposure as a continuous variable (0.2 µM, 1 µM and 10 µM). Differentially expressed genes ($P < 0.005$) were then used to generate single-sample gene set enrichment analysis (ssGSEA) scores in TCGA-COAD. The Spearman correlation between each pesticide's ssGSEA score and its corresponding MRS was tested, identifying notable correlations for dicamba (six genes: $R = -0.15$; $P = 0.025$), heptachlor (148 genes: $R = -0.15$; $P = 0.017$) and picloram (37 genes: $R = 0.44$; $P = 2 \times 10^{-12}$) (Fig. 3f), whereas non-significant trends were obtained for acetochlor (16 genes: $R = -0.015$; $P = 0.81$), atrazine (90 genes; $R = -0.07$; $P = 0.28$), lindane (38 genes: $R = 0.002$, $P = 0.98$) and metolachlor (51 genes; $R = 0.049$, $P = 0.46$). The observed correlations between picloram and dicamba-specific MRSs and ssGSEA scores suggest that these MRSs capture molecular footprints of exposure, supporting their potential as proxies for true pesticide exposure.

Robustness testing for picloram CpGs, patient categorization and the ssGSEA score

To assess robustness, we performed permutation tests to ensure that the observed associations stem from biological relationships rather than artifacts of CpG selection, patient classification or gene selection. CpGs in the picloram MRS-GW ranked 13th in significance among 10,000 permutations (Fig. 3g). Furthermore, patient classification permutation identified age-based classification as the second most significant, based on picloram MRS-GW, among 1,000 permutations (Fig. 3g). CpG site permutations for MDS, education levels, smoking-Maas and obesity are described in Extended Data Fig. 8a and onset categorization permutations in Extended Data Fig. 8b. Finally, permutation testing ranked the picloram-specific ssGSEA score 6th among 1,000 permutations (Fig. 3h), whereas dicamba and heptachlor ranked 71st and 300th, respectively. These results confirm the robustness of CpGs in picloram MRS-GW, patient categorization, and the genes included in the picloram and dicamba ssGSEA scores.

Molecular differences between high and low picloram MRS-GW

Given the robust association between the picloram MRS-GW and younger age at diagnosis, we investigated its relationship with tumor mutations and gene expression. Comparing tumors in the lowest and highest picloram MRS-GW terciles, we identified 75 differentially mutated genes ($P < 0.05$) in the full dataset, including 42 mutated only in the high exposure (Extended Data Fig. 9). Due to known differences between MSS and MSI, we performed a stratified analysis (Supplementary Table 10). In MSS tumors (Fig. 4a), eight genes were mutated differentially, with one gene restricted to high picloram exposure and five genes restricted to low exposure. Finally, in MSI tumors, 25 genes were mutated differentially (Fig. 4c), including 11 genes unique to low exposure and 10 genes unique to high exposure. The mutation distribution of the identified genes is presented in Fig. 4a–d.

DGEA adjusted for age, sex, MSI status, tumor purity and tumor location (left/right) identified 25 differentially expressed genes ($P_{adj.} < 0.05$, $|\log_2$fold-change (FC)$| > 1.2$), including 16 downregulated genes in low picloram exposure (Fig. 4c and Supplementary Table 11). MSS-stratified analysis identified four differentially expressed genes, whereas MSI-stratified analysis identified 244 genes (Supplementary Table 11). The subsequent GSEA using all samples revealed nine enriched pathways ($P_{adj.} < 0.05$, |normalized enrichment score (NES)| > 1), including upregulation of the Wnt/β-catenin signaling in low picloram exposure, consistent with *APC* mutations and downregulation of immune response-related pathways, such as complement and *IL6-JAK-STAT3* signaling.

Young tumors associated with picloram exposure

Current CRC classification into early- or late-onset relies on age at diagnosis; however, variability in the interval between tumor initiation and diagnosis makes age at diagnosis an unreliable indicator of the tumor's actual age[26]. We therefore evaluated single-base substitution signature 1 (SBS1), a mitotic division-related mutational signature, as a proxy for tumor age. SBS1 reflects the cumulative number of mitotic divisions and captures the replicative history of cells across premalignant and malignant stages[27,28]. We used the SBS1 score from the Catalogue of Somatic Mutations in Cancer, deconvolved by the Pan-Cancer Analysis of Whole Genomes consortium using established methods with high accuracy (≥0.827)[28], and no samples were excluded based on accuracy (Extended Data Fig. 10a). TCGA-COAD patients with DNA methylation and mutational signatures data were included, excluding MSI tumors due to distinct mutational mechanisms (Extended Data Fig. 10b)[29,30]. SBS1 distribution across age groups early-, intermediate- (IOCRC: aged 50–69 years) and late- ($N = 173$) onset is detailed in Extended Data Fig. 10c.

Picloram MRS-GW was associated significantly with early-onset versus late-onset cases ($N = 25$ versus 72; OR: 2.99 [95% CI: 1.70–5.85]; $P = 4.27 \times 10^{-4}$). Next, we employed an SBS1 score threshold, identifying 72 young (SBS1 < 60) and 101 old tumors (SBS1 ≥ 60). The new patient categorization underscored a significant association with picloram MRS-GW (OR: 1.84 [95% CI: 1.31–2.66]; $P = 6.57 \times 10^{-4}$) (Extended Data Fig. 10d). The chronological age distribution for these SBS1-defined groups is shown in Extended Data Fig. 10e. This association remained significant using a non-age-adjusted MRS-GW when adjusting for sex ($P = 4.15 \times 10^{-4}$) and further for age at diagnosis ($P = 5.98 \times 10^{-3}$), confirming independence from chronological age. The SBS1 score was associated strongly with tumor mutation burden (TMB; $R = 0.66$, $P < 2.2 \times 10^{-16}$). Consequently, adjusting the original model ($P = 6.57 \times 10^{-4}$) for TMB attenuated the association ($P = 3.23 \times 10^{-2}$). To further investigate whether TMB could serve as a marker for tumor age, we performed linear regression models adjusted for sex, showing a stronger association between the picloram MRS-GW and SBS1 score ($P = 2.11 \times 10^{-5}$) than TMB ($P = 0.0148$), suggesting that although TMB and SBS1 are highly correlated, SBS1 captures the age-specific signal more effectively.

County-level pesticide uses and EOCRC incidence across the USA

Using MRSs as proxies, we identified associations between age at onset and several pesticides. We examined pesticide use intensity and EOCRC incidence rates (IR) across overlapping counties in California, Connecticut, Georgia, Iowa, New Mexico, Utah and Washington in the USA. Pesticide use estimates (1992–2012) were extracted from the Pesticide National Synthesis Project, and the age-adjusted EOCRC IR from the Surveillance, Epidemiology and End Results (SEER) for eight registries (SEER8). Among 225 pesticides with sufficient data (≥10 years and ≥50

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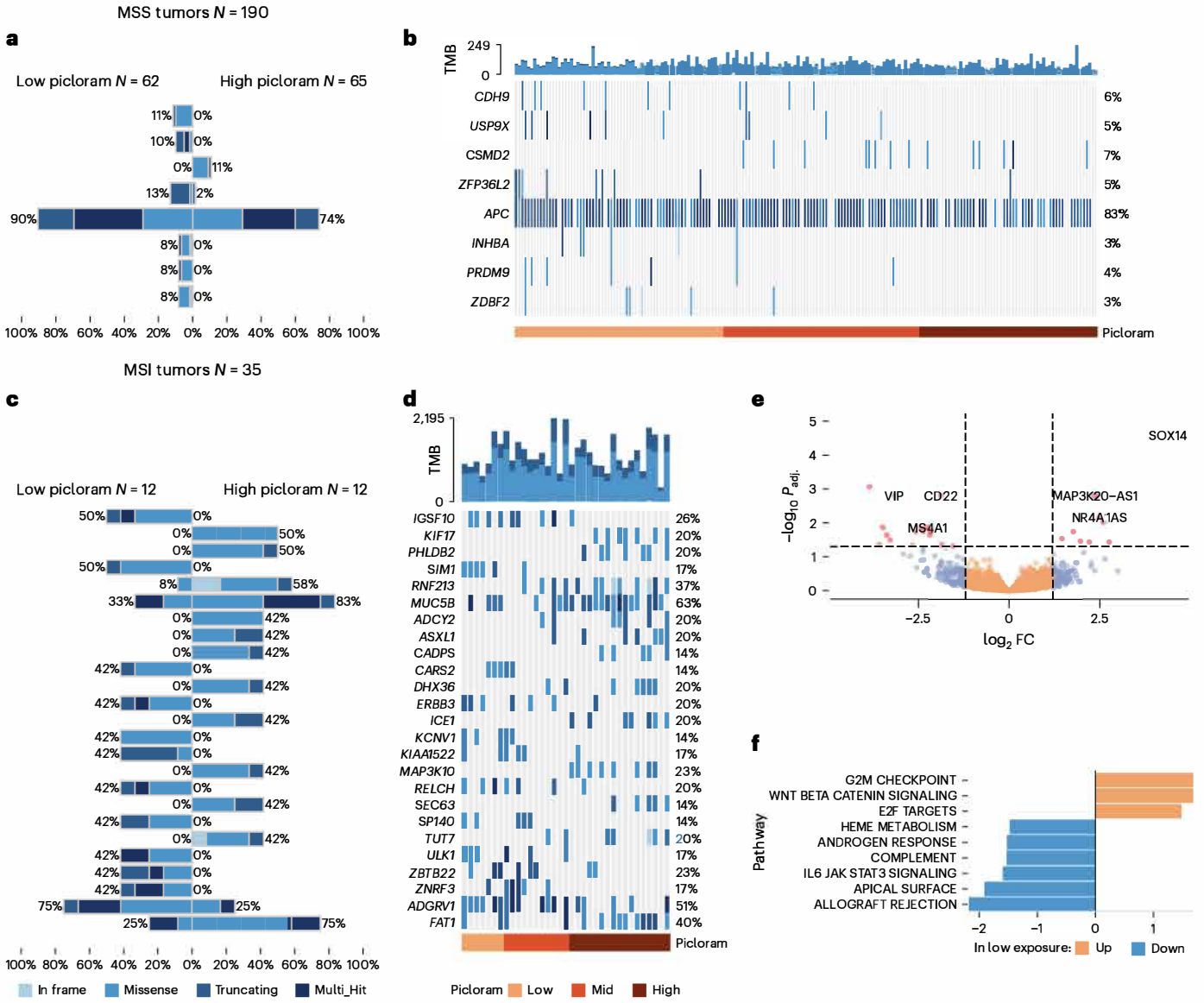


Fig. 4 | Molecular differences between high and low picloram MRS-GW. **a**,**b**, Tumors were divided into terciles of the picloram MRS-GW, and tumors in the first and third terciles were compared using Fisher's exacttest to identify differentially mutated ($P < 0.05$) genes. Differentially mutated genes in MSS tumors are shown with the percentage of tumors with a gene mutation in the first or third tercile (**a**) and their distribution across all MSS tumors, sorted on the picloram MRS (**b**). **c**,**d**, Similarly, the differentially mutated genes in MSI tumors are shown with the percentage of tumors having the gene mutated in the first or third tercile (**c**) and their distribution across all MSI tumors (**d**). **e**, Comparison of gene expression between tumors in the first and third tercile of the picloram MRS-GW using negative binomial generalized linear models. The analysis was adjusted for age, sex, MSI status, tumor purity and tumor location (left/right) and significance thresholds were set at an absolute $\log_2$FC > 1.2 and a $P_{adj.} < 0.05$, resulting in 25 differentially expressed genes with the top 6 genes highlighted. **f**, NESs for the significantly down- and upregulated pathways in low picloram exposure, using the differential expression results.

total observations), 62 were associated with EOCRC IR in linear mixed models adjusted for years of data collection and county-level random effects (Supplementary Table 12). After additional adjustment for seven county-level socioeconomic status (SES) indicators[31], including median household income, median house value, median rent, percent below 150% of the poverty line, education index[32], percent working class and percent unemployed, 27 pesticides remained significant (Fig. 5a and Supplementary Table 13).

As several pesticides were used within counties, we tested robustness by adjusting each of the 27 pesticides for the remaining 26 (Fig. 5b and Supplementary Table 13). Since merging the pesticide data can reduce the number of overlapping datapoints substantially, we first tested baseline models without pesticide adjustment to distinguish true attenuation from reduced data overlap. Reduced overlap led to frequent loss of significance, particularly for fenbuconazole (0.84), propargite (0.80) and flumioxazin (0.65) (Fig. 5b). Among the remaining 24 pesticides, glyphosate and picloram remained significant in 21 of 23 pairwise models, esfenvalerate and nicosulfuron in 15, and atrazine in 12, with others remaining significant in ten or fewer models.

Integrated pesticide- and SES-adjusted analyses of the five most robust pesticides showed limited consistency for atrazine and esfenvalerate, each significant in only one pesticide-adjusted model and moderate robustness for nicosulfuron, which remained significant in two models. Glyphosate showed stronger robustness, maintaining significance in three models, including two with all SES adjustments. Picloram demonstrated the most consistent association, remaining significant in all four pesticide-adjusted models and across most SES-adjusted models (Fig. 5c and Supplementary Table 14). Together with the MRS findings, these results highlight picloram as a potentially important environmental factor contributing to EOCRC risk.

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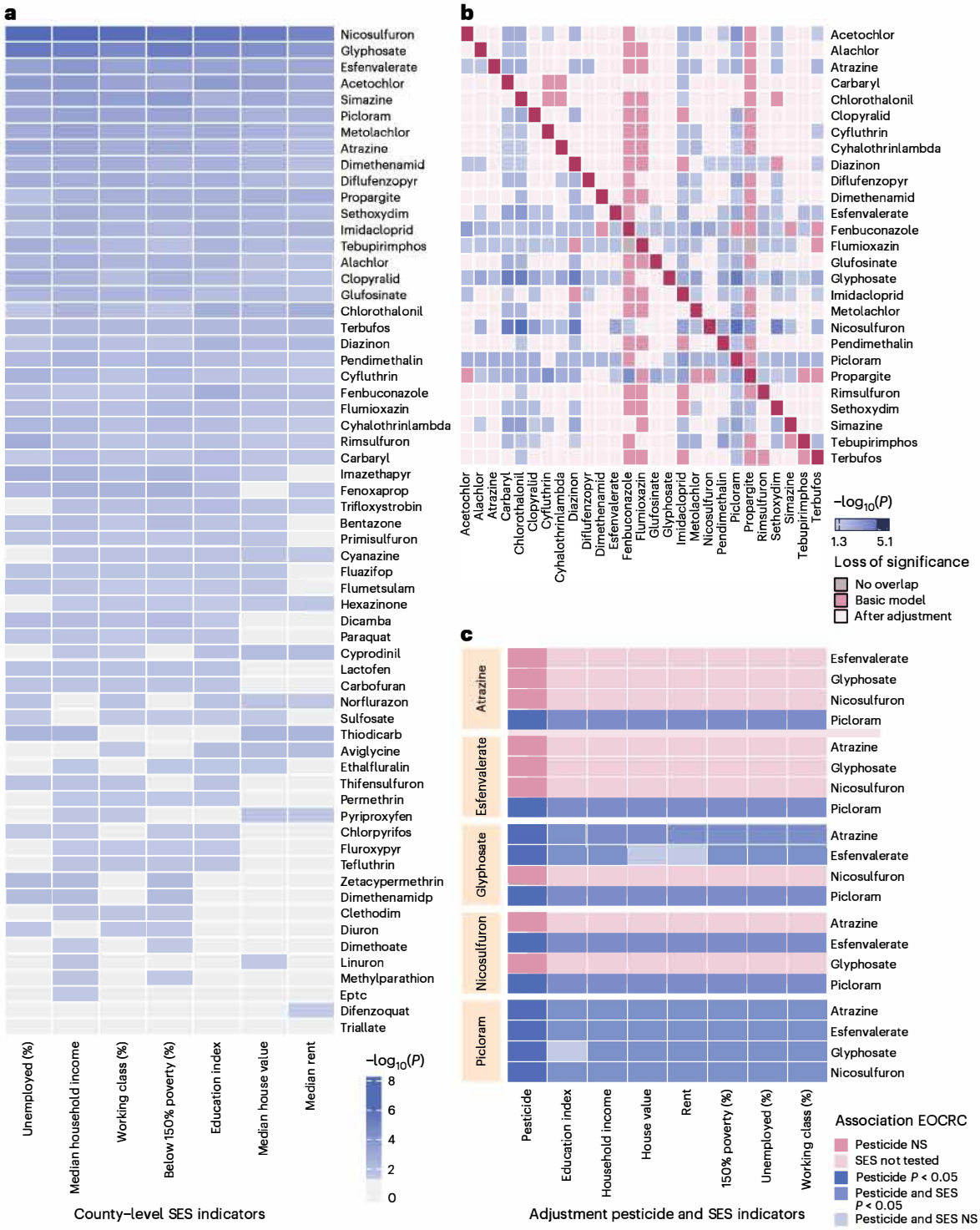


Fig. 5 | Pesticide use intensity is associated with EOCRC incidence. County-level pesticide use intensity estimates (1992–2012) were matched with EOCRC incidence rates. **a**, Heatmap showing associations between 62 pesticides (*y* axis) and EOCRC IRs, adjusted for seven SES indicators (*x* axis). **b**, The 27 pesticides (*y* axis) that remained significant were further adjusted for each of the other 26 pesticides (*x* axis). Pesticides that lost significance in the baseline model without pesticide adjustment are shown in dark pink, whereas those that were significant in the basic model but lost significance after pesticide adjustment are displayed in light pink. Cases with insufficient datapoints for testing are shown in gray. **c**, The five most robust pesticides were analyzed jointly, adjusting for the remaining pesticides and SES indicators. The left *y* axis represents the top five pesticides, including atrazine, esfenvalerate, glyphosate, nicosulfuron and picloram, whereas the right *y* axis reflects for each of them the four pesticides they are adjusted for. The *x* axis shows the adjustments for only the pesticide or the pesticide and each of the SES indicators. NS, nonsignificant.

Discussion

In this study, through the use of epigenetic markers, we explored the exposome traits that could be contributing specifically to EOCRC disease. A principal challenge in exposome research is the limited availability of direct exposure measurements, making it difficult to fully reconstruct a person's exposome profile. This research addresses the exposome impact, including environmental and lifestyle factors, on early-onset colon and rectal cancer cases through epigenetic fingerprints.

Despite the limitations in exposome data availability and the possibility of confounding bias, we validated the use of MRSs as a proxy for exposome exposure using datasets containing direct exposome measurements. In the context of alcohol consumption, we used the presence of ALD as a surrogate marker and showed that patients with ALD had higher alcohol MRS-GW scores compared to those without ALD. Regarding smoking exposure, our findings indicate that once the smoking-related methylation signature becomes embedded in tumor tissue it remains persistent and irreversible, even after prolonged (>15 years) smoking cessation. This highlights the lasting epigenetic imprint of smoking exposure on tumor DNA.

Exposures across the lifespan may change, so the analyses incorporating both categorical and quantitative measurements are challenging and may raise concerns about potential spurious associations. Our results consistently link EOCRC to exposure to the herbicide picloram based on epigenetic fingerprints. Picloram's mechanism of action as an herbicide relies on its capacity to mimic the plant growth hormones auxins and to inhibit the enzymes that break down auxins, which leads to more persistent effects than the natural hormone. Therefore, picloram disrupts normal growth, causing abnormal stimulation and maturation of tissues, which triggers growth discontinuation, root deterioration and eventually plant death. Picloram was first registered as an herbicide in the USA in 1964, and the herbicide and its derivatives have generally shown to be of moderate-to-low acute toxicity in laboratory animals[33]. However, dietary exposure to residues of picloram is plausible as it has been found in grain and meat byproducts, and the effects of long-term use on human health have not been described so far. If the use of picloram in crops started in the mid and late twentieth century, then current patients with LOCRC were not exposed during their childhood, whereas cases of EOCRC were and have been for a longer part of their lives, which could explain our results. The association between pesticide exposure and EOCRC using population-based data further validates the association with picloram.

Distinct molecular aberrations are observed when comparing tumors in the first tertile of the picloram MRS to those in the third tertile. Specifically, we identified an upregulation of the Wnt/β-catenin signaling pathway and a higher prevalence of *APC* mutations (90%) in low picloram tumors compared to 74% in high picloram tumors. These findings suggest that picloram, along with other exposome factors, may influence tumor development by promoting alternative oncogenic pathways, diverging from the classical Fearon and Vogelstein model[34]. Nevertheless, given the scarcity of studies investigating picloram's impact, particularly on DNA methylation and health outcomes in humans, we emphasize the urgent need for longitudinal and experimental research. We believe that determining the reversibility of picloram-induced epigenetic changes in normal tissue and tumors, establishing a causal link between picloram exposure and colorectal carcinogenesis, and understanding its dose-dependent risk are critical next steps in disentangling the EOCRC epidemic.

Besides picloram, we also show evidence for associations between EOCRC and exposure to glyphosate, esfenvalerate, nicosulfuron and atrazine. In the USA, atrazine is one of the most widely used herbicides—as a selective herbicide to prevent weeds from germinating in corn production—whereas glyphosate is applied extensively in corn, soybeans and other crops as a broad-spectrum herbicide used to eliminate weeds that have already emerged, creating a complementary weed control strategy. Glyphosate is already categorized as 'probably carcinogenic to humans' by the International Agency for Research on Cancer (IARC), suggesting the validity of the obtained results[35]. Although atrazine has been banned in the European Union since 2004, the United States Environmental Protection Agency still approves its continued use[36]. New studies have identified several mechanisms for how atrazine could cause carcinogenesis in humans, for example, by damaging DNA integrity, the stability of the cell genome, DNA double-strand breaks and the activation of DNA damage checkpoints[37]. This resulted in the Monographs program for 2025–2029[38] to warrant a high-priority re-evaluation of the IACR classification as a result of the newly identified human cancer and mechanistic evidence. Furthermore, a recent update study in the Agricultural Health Study Cohort further suggested the link between atrazine use and several cancer types, including in patients <50 years of age[39].

Lower education levels were found for patients with EOCRC. Educational attainment is an important determinant of health and lifespan[40] and it is used frequently as a proxy for SES in health studies, revealing strong associations with the prevalence of noncommunicable diseases, including cancer[41]. Furthermore, findings from the International Public Opinion Survey on Cancer 2020[42] highlight that people without a university degree are less aware of modifiable cancer risk factors compared to those with higher educational attainment. These findings suggest that education level not only influences health outcomes but also plays a critical role in shaping awareness and the adoption of healthier lifestyle behaviors.

The patient's age at diagnosis is currently used as the tumor's age, possibly introducing bias in identifying early-onset patients. To address this, we assessed whether tumor age can be established by identifying molecular characteristics of aged tumors, such as mutational signatures[27,28]. Characteristic mutational signatures in cancer genomes arise from various mutational processes, including defects in DNA maintenance mechanisms and both external and internal exposures[28]. Mutations attributed to SBS1 are thought to occur during DNA replication in mitosis, suggesting that the rate of SBS1 mutations may serve as an indicator of the number of mitotic divisions a cell has undergone[27,28]. Furthermore, the number of SBS1-attributable mutations within a tumor is correlated with patient age at cancer diagnosis[27,28]. Here we demonstrated that using an SBS1 score threshold to distinguish between younger and older tumors is associated with picloram MRS. This finding suggests that the observed differences may be attributable to tumor biological age rather than the patient's chronological age.

We acknowledge the limitations of the current study. First, the number of EOCRC cases in the datasets is relatively small, specifically in the analysis of colon and rectal cancers separately. We emphasize the need for larger studies to capture the diversity of worldwide patients with EOCRC in terms of ethnicity, cultural and socioeconomic differences. Another limitation of this study is the restricted availability of pesticide exposure data, which began only in 1992, as well as the lack of data on tumor onset age, with only age at diagnosis available. Because of the substantial time lag between onset and diagnosis, these constraints prevent us from assessing accurately the latency period between picloram exposure and EOCRC development. This emphasizes the need for future in vivo studies to examine the causality and latency period of picloram in EOCRC.

The study also presents unprecedented strengths. First, the use of MRS as a proxy for exposome factors is a new approach that enables the exploration of traits that would otherwise be unfeasible due to limited data availability. Similarly, the lack of longitudinal follow-up measurements or reliance on self-reported data can be overcome, as MRSs integrate the cumulative impact of exposure over time. Nevertheless, prospective birth cohorts with long-term follow-up, quantitative exposure measurement, and biomarker and omics analyses throughout life can elucidate the etiology of EOCRC. In addition, given that early-life exposures may be key to CRC development, prospective birth cohorts are needed. Second, several independent cohorts were used, and permutation tests were implemented; the picloram MRS was associated consistently with EOCRC compared with LOCRC. Validation of the association between picloram use intensity and EOCRC in population-level data also further strengthens the evidence for picloram as a new risk factor. Third, the exposome, namely the totality of exposures including, among others, diet, lifestyle and environment, during early life and young adulthood, has changed considerably in the last decades. The categorization of the population into two cohorts

with extreme ages (<50 versus ≥70) and the exclusion of cases with intermediate age favor the identification of substantial generational changes in the exposome of the two cohorts, whereas those in between may show a gradual change in their exposure. This investigation has substantial relevance and broad potential impact, as it identifies research priorities for primary interventions through behavior modification and secondary prevention among people exposed to EOCRC risk factors, for current and future generations. Moreover, it might guide the development of health policies for environmental exposures and regulatory guidelines for agricultural products. Finally, the spotlight on the tumor age rather than on the patient is a new perspective for CRC research and epidemiology for both EOCRC and those diagnosed over the age of 50 years. This could be one of the potential explanations for why no differences in tumor biology between EOCRC and LOCRC have been found to date.

In conclusion, our findings not only provide exposome traits based on epigenetic fingerprints that could be contributing to the development of CRC, specifically in EOCRC, but also pave the way with a compelling rationale for addressing lifestyle and environmental exposures to mitigate EOCRC risk, highlighting the importance of both personal and policy-level interventions.

Online content

Any methods, additional references, Nature Portfolio reporting summaries, source data, extended data, supplementary information, acknowledgements, peer review information; details of author contributions and competing interests; and statements of data and code availability are available at https://doi.org/10.1038/s41591-026-04342-5.

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Methods

Study population

The discovery phase of our study utilized TCGA-COAD samples. To ensure the integrity of our analysis, patients with Lynch syndrome (TCGA-A6-6781, TCGA-CM-6674 and TCGA-D5-6927) were excluded. Our replication effort encompassed nine datasets, focusing on rectal (TCGA-READ and GSE39958)[15], colon (GSE131013, GSE42752, E-MTAB-7036 and GSE199057)[11–14], and colorectal (GSE101764, GSE77954 and E-MTAB-3027)[16–18] cancer studies. For the TCGA samples, we implemented exclusion criteria, removing cases annotated with 'Item in special subset,' 'History of unacceptable prior treatment related to a prior/other malignancy,' 'Case submitted is found to be a recurrence after submission,' 'Neoadjuvant therapy,' 'Synchronous malignancy,' and 'Pathology outside specification.' This led to the exclusion of ten patients from the COAD dataset and eight from the READ dataset. Furthermore, samples preserved in formalin-fixed paraffin-embedded form were excluded to maintain consistency in sample quality. Duplicate samples were identified and removed based on their plate number, further refining our cohorts for analysis. Participants were categorized based on age at diagnosis, including early-onset (aged <50 years), intermediate-onset (aged between 50 and 69 years), and late-onset (aged ≥70 years), following the literature for late-onset cut-off[43].

DNA methylation data processing

DNA methylation data was in all datasets obtained using the Illumina Infinium HumanMethylation450 BeadChip, except in GSE199057, in which the Illumina Infinium Human Methylation EPIC BeadChip array was used. TCGA methylation data was acquired from the Genomic Data Commons (GDC) Data Portal through the TCGABiolinks package v.2.25.0 (ref. 44). For the additional datasets, idat files or signal intensity files were downloaded from the Gene Expression Omnibus (GEO) database using the GEOquery package v.2.60.0 (ref. 45). We processed the tumor sample methylation data with the sesame package v.1.19.7 and v.1.24.0 (ref. 46) in R v.4.3.1. CpG sites showing more than 50% missing data were removed from each dataset. The remaining missing values underwent imputation using the impute package v.1.66.0 (ref. 47), followed by mean imputation for CpGs with imputed values of 0. DNA methylation beta-values were then converted to M-values using the lumi package v.2.44.0 (ref. 48). Next, we estimated the epigenetic age using the Horvath clock, following the R software tutorial[20], and adjusted the DNA methylation m-values for the estimated age to account for the influence of age on methylation. Finally, we converted the m-values back to beta-values for further analysis. The final dataset refinement involved excluding CpGs that were not present across all datasets, those associated with cross-reactive probes and CpGs identified as single-nucleotide polymorphisms[49].

Exposome-related traits marker selection

We conducted a detailed literature review to compile a list of exposome traits potentially influencing the risk of EOCRC, ensuring the inclusion of traits with available comprehensive EWAS. This process led to the identification of 29 key exposome traits[19,50–62]. The traits analyzed encompassed 11 lifestyle factors: the AHEI[50], alcohol consumption[51], birth weight[52], BMI (continuous variable in kg m^{-2})[53], cannabis use[62], coffee consumption[54], education level[55], MDS[50], obesity (defined as ≥30 kg m^{-2})[56], smoking habits[57] and smoking-Maas[19]. Furthermore, we examined four air pollution particles: NO_2 (ref. 58), PCBs[60] and $PM_{2.5}$ and $PM_{2.5-10}$ (ref. 59). In addition, we included 14 pesticides encompassing 2,4-D, atrazine, acetochlor, chlordane, dicamba, malathion, DDT, heptachlor, lindane, glyphosate, mesotrione, metolachlor, picloram and toxaphene[61]. CpG sites were chosen using stringent significance criteria: $P < 1.2 \times 10^{-7}$, $P < 1.0 \times 10^{-5}$ and FDR of <0.01, <0.05 and <0.1. We employed a tiered strategy for marker selection to balance sensitivity and specificity, facilitating a comprehensive assessment of the relationship between exposome exposures, DNA methylation levels and EOCRC. This approach includes a broad range of CpG sites explored using less stringent P value thresholds (for example, $P < 1.0 \times 10^{-5}$ and FDR < 0.1), increasing sensitivity to include CpG sites with potential biological relationships. This was instrumental in selecting both highly confident associations and those of potential biological relevance that may not meet the strictest statistical thresholds. In addition, we included CpG sites using more stringent criteria (for example, $P < 1.2 \times 10^{-7}$, FDR < 0.05 and FDR < 0.01), enhancing specificity and reducing the risk of including false positive CpG sites. This approach allowed for a nuanced exploration of the data, ensuring that both robust and biologically meaningful associated CpG sites were included in our analysis.

Exposome-related methylation risk scores in patients with EOCRC versus LOCRC

To assess the impact of these exposome traits on EOCRC risk, we computed individual MRS by applying effect sizes from relevant EWAS to methylation levels at each CpG site and summing these across all pertinent CpGs.

The performance of these MRSs as proxy measures was evaluated by reconstructing the scores in a dataset[63–72] with directly measured exposure data and assessing the level of agreement between the derived MRS values and the corresponding observed exposure levels. In addition to the exposome traits included in our study, the analysis was extended to a broader set of exposures to further validate the applicability of MRSs as a proxy, including allergic asthma[73], MDD[74], PRS for depression[75], birthweight[76,77], gestational age[76], maternal education[78], maternal BMI[79,80] and arsenic exposure[69].

After constructing the scores in the tumor cohorts, the scores were normalized to a mean of 0 and an s.d. of 1, using exclusively data from EOCRC and LOCRC patients. We examined the association between these MRSs across early- versus late-onset cases (reference group) by employing logistic regression analyses adjusted for sex, using the stats R package v.4.1.3. This analysis spanned the discovery dataset TCGA-COAD and extended to nine validation cohorts. Models were excluded from the subsequent meta-analysis if they issued fitting warnings or were unable to estimate the 95% CI. The collective data from the validation cohorts were subjected to a meta-analysis utilizing the metafor R package v.4.4-0 (ref. 81). The P values obtained were FDR[82]-corrected for the number of traits in each marker selection threshold, including 17 traits in GW, 26 in P1E5, 7 in F01, 8 in F005 and 5 in F001, using the p.adjust function in stats v.4.1.3. The results were then summarized visually in forest plots, offering a clear depiction of the associations between MRS and EOCRC versus late-onset cases.

Pesticide-induced gene expression alterations in iPSC-derived cardiomyocytes

The validity of the pesticide MRSs was assessed using gene expression alterations induced by pesticides in iPSC-derived cardiomyocytes. Raw gene expression counts per plate were extracted from GSE262419 (ref. 83). Each plate included raw read counts for 22,537 probes, which were aggregated at the gene-level to yield 19,703 unique genes. Low-expressed genes were then filtered out per pesticide by excluding those with a mean count of fewer than ten across pesticide-exposed samples and those that did not reach at least ten counts in at least two samples. We conducted DGEA (DESeq2 (v.1.44.0)) per pesticide by comparing the exposure doses as a continuous variable. Pesticide-specific gene sets were constructed using DEGs ($P < 0.005$). These gene sets were used as input to construct ssGSEA scores using the GSVA R package v.1.42.0 (ref. 84) in TCGA-COAD RNA-seq tumor samples. Genes with expression levels of at least ten in more than 50 samples and a variance greater than 0.01 across samples were retained for downstream analyses in TCGA-COAD. The obtained pesticide-specific ssGSEAs were tested for their Spearman correlation with their respective pesticide-specific MRS.

Robustness testing for picloram MRS-GW, CpG selection, patient categorization and ssGSEA genes

The robustness of the findings for picloram MRS-GW was further examined in patients from TCGA-COAD. Additional TCGA data was acquired from the GDC Data Portal through the TCGABiolinks package v.2.25.0 (ref. 44). First, the association between picloram MRS-GW and EOCRC versus LOCRC was further adjusted for the other MRS in the GW marker selection threshold. Second, we further adjusted the association between picloram MRS-GW and EOCRC versus LOCRC by patient-specific characteristics (race and family history) and tumor-specific factors (MSS, tumor location (left/right), and tumor purity). Third, we evaluated the robustness of the selected CpGs and patient categorization by conducting two permutation analyses, ensuring that the observed associations are not artifacts of the specific CpG selection or patient grouping but reflect underlying biological relationships. The first analysis involved assigning patients randomly to the MRSs. Specifically, we shuffled the patients with EOCRC and LOCRC in the TCGA-COAD dataset 1,000 times, creating alternative configurations of the dataset. For each rearranged dataset, we performed logistic regression analyses, adjusting for sex, to assess the stability of the association between MRSs and early-onset across these permutations. The second analysis targeted the specific assignment of CpGs to their corresponding effect sizes (weights). We temporarily removed the CpGs that were selected initially for each exposome trait to create a pool of potential CpGs. From this pool, we generated 10,000 new sets, each containing an equal number of CpGs as in the original analysis but selected randomly. These randomly chosen CpGs were then used to construct new MRSs for each trait. Subsequently, logistic regression analyses, adjusted for sex, were applied to these permutation-derived MRSs to test the significance of the associations under these randomized conditions. Finally, we explored the robustness of the genes included in the pesticide-specific ssGSEA by generating 1,000 random gene sets using the same number of genes as in each specific gene set and computed 1,000 ssGSEA scores. Next, we tested the Spearman correlation between each score and the picloram MRS-GW.

Molecular characterization between high and low picloram MRS

The possible associated molecular landscape of the picloram MRS-GW was explored by comparing the first and third terciles. First, we tested for mutational differences using maftools R package v.2.8.5 (ref. 85). Second, we conducted a DGEA using the DESeq2 R package v.1.44.0, adjusting for age, sex, MSI status, tumor purity and tumor location (left/right). Stratification analyses were performed separately for MSS and MSI tumors. The obtained results were adjusted for multiple testing using the Benjamini–Hochberg procedure for FDR[82]. DEGs were defined by an absolute $\log_2$ FC > 1.2 and an FDR-adjusted P value < 0.05. Finally, we performed GSEA using the fgsea R package v.1.20.0 (ref. 86). Genes were ranked based on the Wald statistic from DESeq2 output, and the Hallmark gene sets (n = 50) were obtained from the HALLMARK Molecular Signatures Database[87]. Significantly enriched pathways were defined as those with FDR-adjusted P values < 0.05 and absolute NES > 1.

Young versus older tumors using single-base substitution signature 1

Patients from the TCGA-COAD dataset were selected when presented with comprehensive profiles including DNA methylation data, mutational signatures (https://dcc.icgc.org/releases/PCAWG) and confirmed microsatellite stability. To ensure data integrity, we excluded extreme outlier patients, identified by SBS1 scores exceeding the mean SBS1 score by >3 s.d. The patients were categorized into early- (age <50 years), intermediate- (age 50–69 years), and late- (age ≥70 years) onset cases. Initially, we assessed the differential impact of picloram MRS-GW within this subset between the early- and late-onset groups. Subsequently, we aimed to enhance the specificity of our findings by integrating the concept of tumor age, as defined by the SBS1 score[28], into our analysis of early- and late-onset categories. In a new approach, we explored the efficacy of using tumor age—defined by an SBS1 score of 60 as a threshold—as an alternative to chronological age in distinguishing between young and old tumors. We selected an SBS1 score threshold of 60 because it corresponded to the first quartile in late-onset patients and the median in intermediate-onset patients. The third quartile in early-onset patients had an SBS1 score of 67.

To ensure that the results observed were not confounded by age at diagnosis, we constructed the picloram MRS-GW using non-age-adjusted DNA methylation levels. Subsequently, we tested its association with young versus old tumors while incorporating an additional adjustment for age at diagnosis. We then explored whether total TMB could serve as a stronger indicator of tumor age than the SBS1 score. TMB was calculated using nonsilent variants and normalized by dividing by 38, corresponding to the standard exome size using maftools R package v.2.8.5 (ref. 85). To evaluate these relationships, we performed linear regression models, assessing the association between picloram MRS-GW and either (1) the SBS1 score or (2) TMB, with both models adjusted for sex.

Pesticide use and EOCRC in the USA

The results obtained for pesticide MRSs were validated using population data from the USA. We assessed the association between pesticide use and EOCRC incidence across overlapping counties. Using data from the Pesticide National Synthesis Project between 1992 and 2012, we analyzed county-level pesticide use intensities by dividing the total estimated pesticide use by the county's area in square miles.

Age-adjusted IR for colon and rectum (Site and Morphology; Site recode ICD-O-3/WHO 2008: 'colon and rectum' without excluding specific tumors) were extracted from the SEER database using the SEER*Stat software (v.8.4.1)[88]. This comprehensive dataset allowed us to incorporate Research Plus Data spanning from 1975 to 2020 for eight registries (SEER8). We calculated age-adjusted EOCRC incidence rates (for people aged 25–49 years) at the county level annually, expressed as cases per 100,000 population. Counties with no cases for more than 50% of the years were excluded to mitigate the impact of sparse data on our analysis.

The pesticide data and EOCRC incidence data were overlapped at county level per year. To refine our analysis and reduce the influence of extreme values, we removed the top 5% measurements based on log-transformed pesticide use intensity. We used a linear mixed model to examine the relationship between pesticide use intensity and EOCRC incidence, adjusting for the years measured and including a random effect to account for variations across counties, using the lmerTest R package v.3.1-3 (ref. 89). For the pesticides significantly associated with EOCRC IR, we further adjusted the model for seven county-level socioeconomic factors: median household income, median house value, median rent, percentage below 150% of the poverty line, education index, percentage of the working class and percentage unemployed. The pesticides that remained associated significantly were further adjusted for the remaining pesticides. Due to limited overlapping datapoints, we curated datasets for each pesticide combination to maximize the number of observations. If the combination of data for one pesticide with other pesticides was not significant at ≥65%, the pesticide was removed from further analysis. Pesticides that remained significant in ≥50% of the pairwise adjustments were further adjusted for the other pesticides, combined with adjustments for SES, to examine the potential confounding effects of simultaneous pesticide use and SES.

Statistical analyses were performed in R v.4.1.3 (ref. 90).

Reporting summary

Further information on research design is available in the Nature Portfolio Reporting Summary linked to this article.

Data availability

All methylation and related clinical data used in this study are publicly available via the GDC Data portal (https://portal.gdc.cancer.gov/) for TCGA datasets, the Gene Expression Omnibus (https://www.ncbi.nlm.nih.gov/geo/) for GSE131013, GSE42752, GSE39958, GSE101764, GSE77954, GSE199057, GSE262419, GSE50660, GSE72680, GSE289816, GSE294810, GSE269103, GSE198904, GSE62924, GSE71678, GSE110828, GSE75248 and GSE224363 or the BioStudies database (https://www.ebi.ac.uk/biostudies/) for E-MTAB-7036 and E-MTAB-3027. Pesticide use data can be extracted from the National Water-Quality Assessment (NAWQA) project (https://water.usgs.gov/nawqa/pnsp/usage/maps/county-level/). Access to the Research Plus Data from the SEER cohort can be requested via https://seer.cancer.gov/data/access.html.

Code availability

The code used for the analysis in this study is publicly available via GitHub at https://github.com/CancerCompBioLab/EOCRCexposome (ref. 91). All the input files needed to replicate our findings and the results obtained during the study are also available from the GitHub repository.

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Author contributions

J.A.S., E.E. and S.C.E.M. conceived the study design. S.C.E.M., L.L., M.B.E., J.A.S. and O.B.I. analyzed the data. J.A.S., E.E., J.T., S.C.E.M. and I.B. interpreted the data and results. S.C.E.M., J.A.S. and I.B. drafted the paper, and S.C.E.M. drafted the figures. All authors critically reviewed the paper and the results and approved the final version.

Competing interests

I.B. reports accommodation and travel expenses from Amgen, Merck, Sanofi and Servier; and personal speaker honoraria from AstraZeneca and Amgen. E.E. has received personal honoraria from Agenus, Amgen, Bayer, Boehringer Ingelheim, Bristol Myers Squibb, Cure Teq AG, GlaxoSmithKline, Hoffman La Roche, Janssen, Johnson&Johnson, Lilly, Medscape, Merck Serono, MSD, Nordic Group BV, Novartis, Organon, Pfizer, Pierre Fabre, Repare Therapeutics Inc., RIN Institute Inc., Rottapharm Biotech, Sanofi, Seagen International GmbH, Servier and Takeda. J.T. reports personal financial interest in form of scientific consultancy role for Accent Therapeutics, Alentis Therapeutics, AstraZeneca, Boehringer Ingelheim, Bristol Myers Squibb, Carina Biotech, Cartography Biosciences, Chugai, Daiichi Sankyo, F. Hoffmann-La Roche, Genentech, Johnson & Johnson/Janssen, Larkspur Biosciences, Lilly, Marengo Therapeutics, Menarini, Merus, MSD, Novartis, One-carbon Therapeutics, Ono Pharma USA, Peptomyc, Pfizer, Pierre Fabre, Quantro Therapeutics, Scandion Oncology, Scorpion Therapeutics, Servier, Sotio Biotech, Syntelios AG, Taiho, Takeda Oncology, Theriva Biologics and Tolremo Therapeutics; and stocks from Alentis Therapeutics, Oniria Therapeutics, 1TRIALSP and Pangaea Oncology. The other authors declare no competing interests.

Additional information

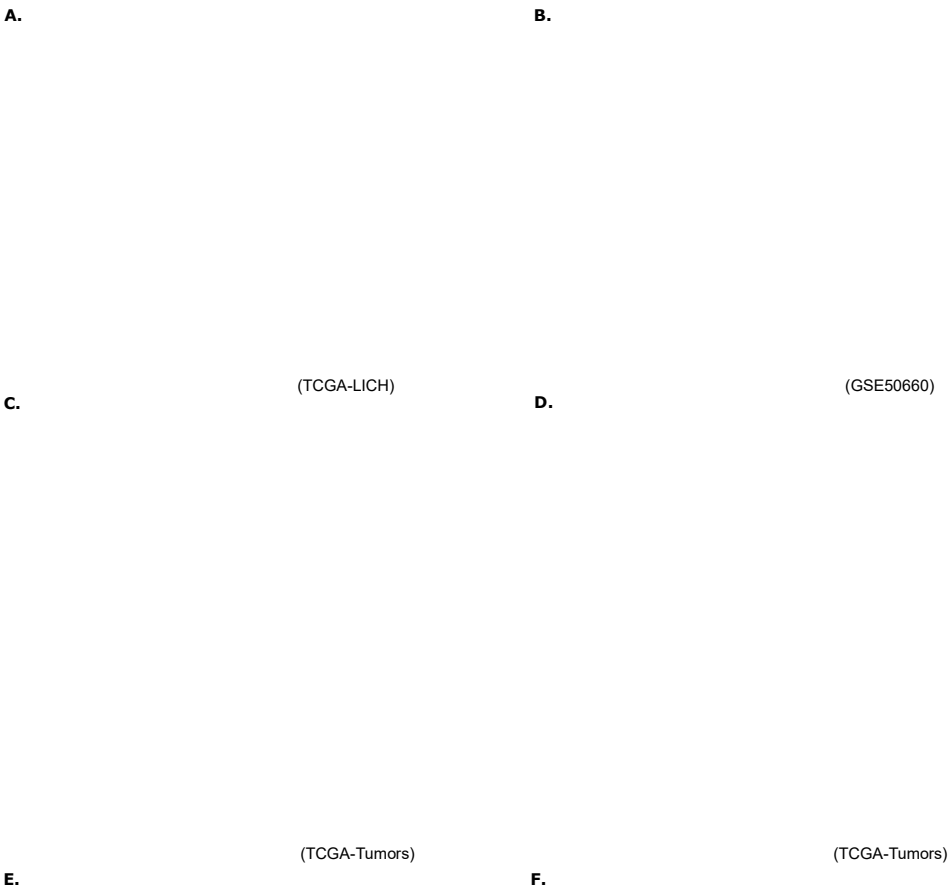
Extended data is available for this paper at https://doi.org/10.1038/s41591-026-04342-5.

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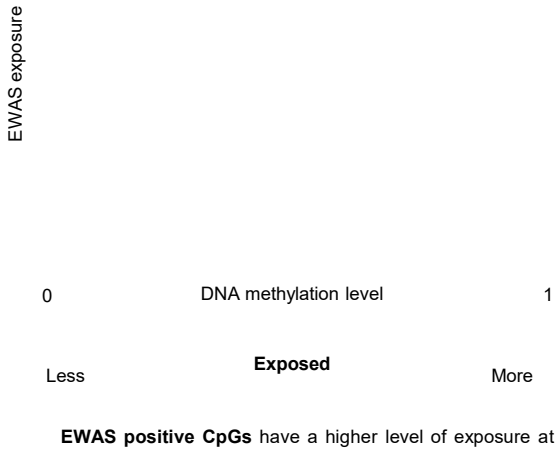
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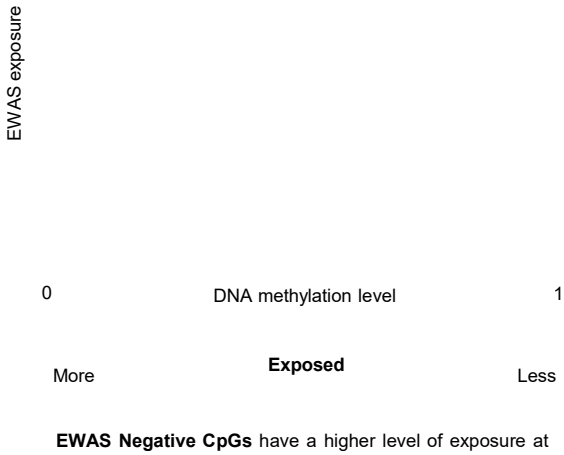
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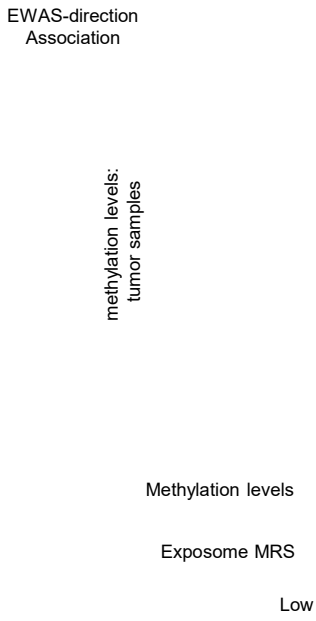
Epigenome Wide Association Study (EWAS)-direction association

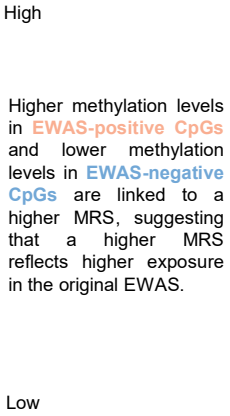


EWAS positive CpGs have a higher level of exposure at higher methylation levels



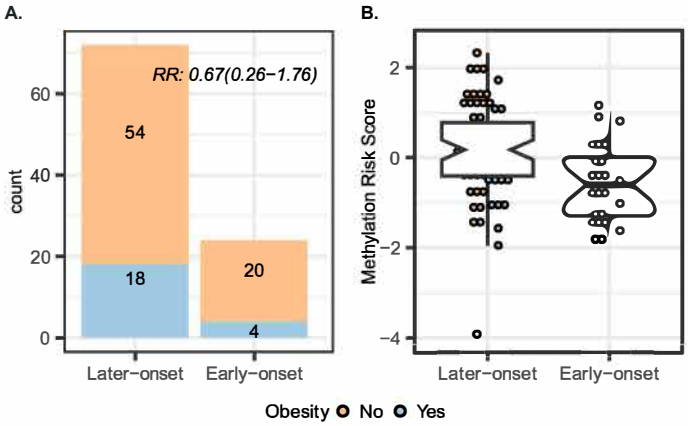
EWAS Negative CpGs have a higher level of exposure at lower methylation levels





Higher methylation levels in **EWAS-positive CpGs** and lower methylation levels in **EWAS-negative CpGs** are linked to a higher MRS, suggesting that a higher MRS reflects higher exposure in the original EWAS.

https://doi.org/10.1038/s41591-026-04342-5



Extended Data Fig. 5 | Late-onset colon cancer patients are more likely to be obese than early-onset patients. A subset of 96 patients within the TCGA-COAD cohort had physical metrics available. **A.** Among 24 early-onset patients, 4 were classified as obese (BMI > 30 kg/m^2), compared to 18 out of 72 late-onset patients. This provided a relative risk (RR) of 0.67 (95% confidence interval: 0.26-1.76) for obesity in early-onset colorectal cancer patients. **B.** The boxplots show the methylation risk score distribution among these 96 patients, including the median (center line), interquartile range (box), and whiskers extending to the most extreme values within 1.5×IQR; points beyond represent outliers. CI; Confidence Interval, RR; relative risk.


OAD
Air pollution
Lifestyle
Pesticides
NO2
PCB
PM2.5
AHEI
Alcohol
Birthweight
BMI
Cannabis
Coffee
Education
MDS
Obesity
Smoking
Acetochlor
Atrazine
Chlordane
DDT
Dicamba
Glyphosate
Heptachlor
Lindane
Malathion
Mesotrione
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Negative
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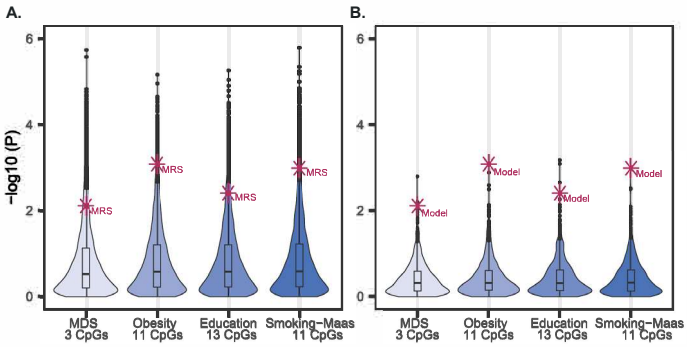
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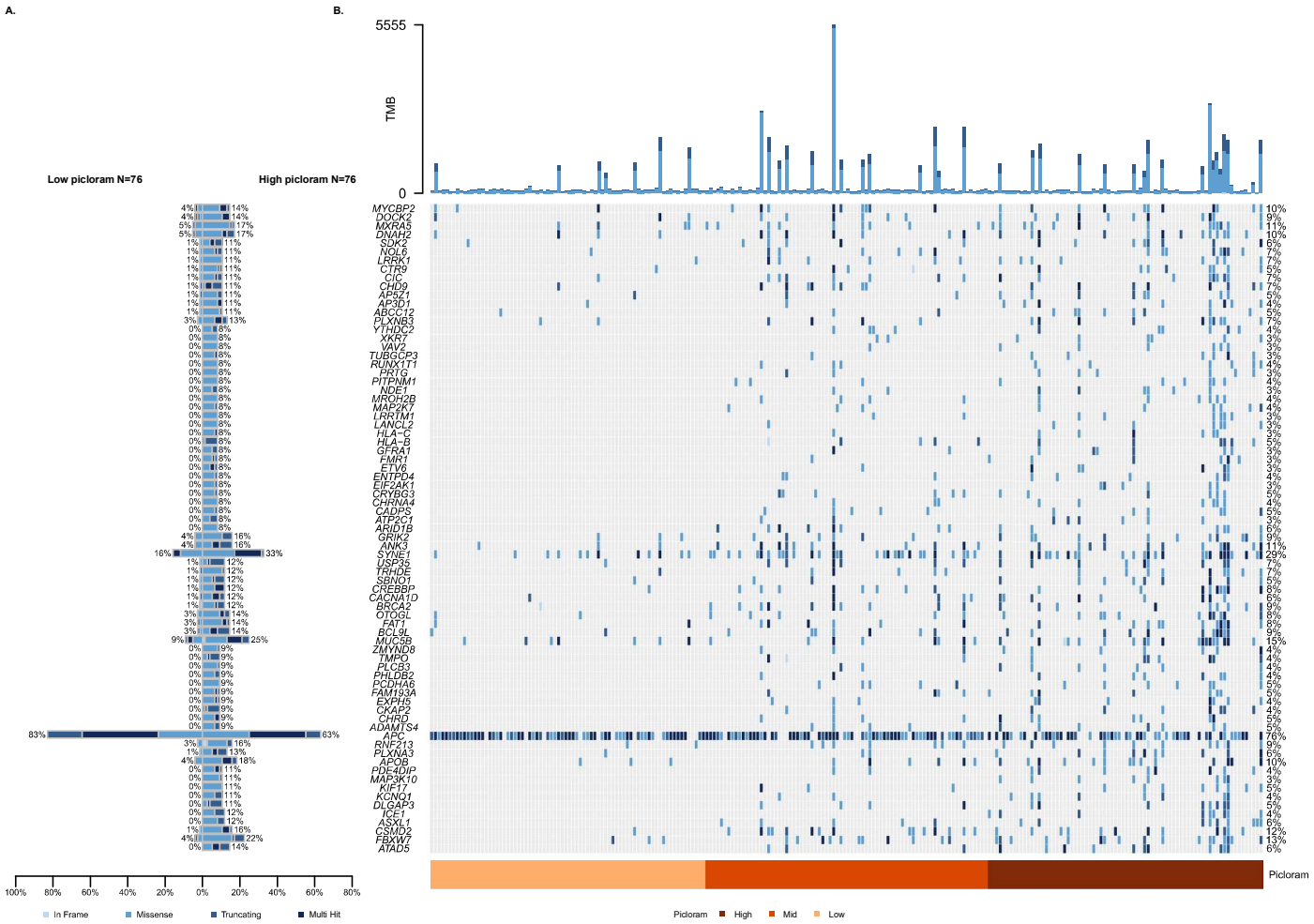
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https://doi.org/10.1038/s41591-026-04342-5



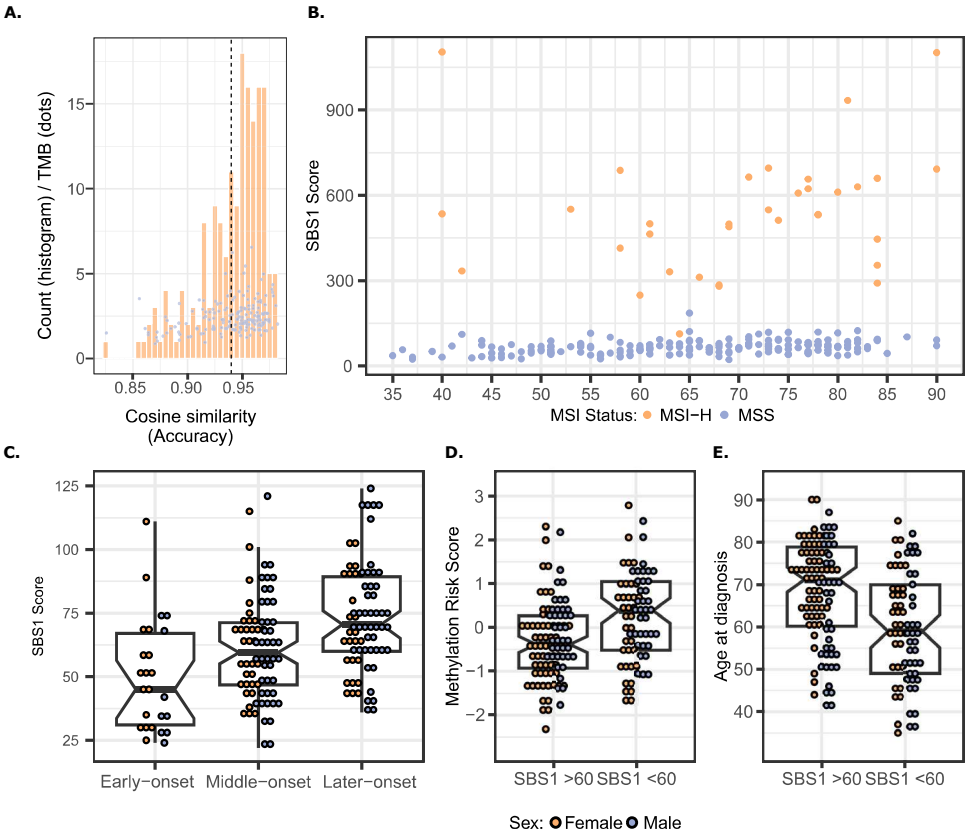
Extended Data Fig. 8 | Permutation results for CpG sites and patient categorization. The violin plots show the results from the permutation tests. **A.** The stability of the CpGs in each MRS was tested using 10,000 permutations. The red asterisks reflect the p-values obtained using the CpGs included in our MRSs. **B.** The patient categorization is tested using 1,000 permutations. The red asterisks reflect the p-values categorization using age at diagnosis for each MRS. Box plots show the median (center line), interquartile range (box), and whiskers extending to the most extreme values within 1.5×IQR; points beyond represent outliers.

https://doi.org/10.1038/s41591-026-04342-5



Extended Data Fig. 9 | Molecular differences between high and low Picloram MRS-GW in TCGA-COAD. Tumors were stratified into tertiles according to the picloram MRS-GW, and the lowest (N = 76) and highest (N = 76) tertiles were compared using Fisher's Exact Test to identify differentially mutated genes ($P < 0.05$). **A.** Percentage of tumors harboring mutations in each gene in the lowest and highest tertiles in TCGA-COAD. **B.** Distribution of mutations across all tumors, ordered by picloram MRS-GW.

https://doi.org/10.1038/s41591-026-04342-5



Extended Data Fig. 10 | Mutational signature accuracy and the relationship of SBS1 score distribution with age and picloram MRS-GW. A. The plot shows the distribution of cosine similarity (accuracy) across MSS tumor samples. The histogram (orange bars) shows the counts by cosine similarity score, while the overlaid points represent tumor mutation burden for each sample. The dashed vertical line indicates the mean cosine similarity threshold. **B.** The distribution of the single-base substitution signature 1 (SBS1) score shows the relation with chronological age in microsatellite stable (MSS) tumors (blue), while microsatellite instable-high (MSI-H) tumors (orange) show a distinct pattern that differs from MSS tumors and chronological age. **C.** The SBS1 score distribution in patient categorization based on age at diagnosis, including early- (aged <50; N = 25), intermediate- (aged 50 to 69 years; N = 76), and late-onset (aged ≥70 years; N = 72) cases. Next, patients were categorized based on the acquired mutations belonging to SBS1 as young tumors (< 60) and old tumors (≥ 60). The boxplot shows **D.** the picloram-MRS distribution and **E.** the chronological age distribution across the SBS1-based categorization. EOCRC; early-onset CRC, IOCRC; intermediate-onset, LOCRC; late-onset CRC, SBS1; single-base substitution signature 1.

nature portfolio

Corresponding author(s): Jose A. Seoane

Last updated by author(s): 2026/03/02

Reporting Summary

Nature Portfolio wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Portfolio policies, see our Editorial Policies and the Editorial Policy Checklist.

Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

n/a	Confirmed
☐	☒ The exact sample size (*n*) for each experimental group/condition, given as a discrete number and unit of measurement
☐	☒ A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☐	☒ The statistical test(s) used AND whether they are one- or two-sided *Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
☐	☒ A description of all covariates tested
☐	☒ A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
☐	☒ A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
☐	☒ For null hypothesis testing, the test statistic (e.g. *F*, *t*, *r*) with confidence intervals, effect sizes, degrees of freedom and *P* value noted *Give P values as exact values whenever suitable.*
☒	☐ For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☐	☒ For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☐	☒ Estimates of effect sizes (e.g. Cohen's *d*, Pearson's *r*), indicating how they were calculated

Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	TCGA-COAD and TCGA-READ data was acquired from the Genomic Data Commons (GDC) Data Portal through the TCGABiolinks package v2.25.0 and data from the Gene Expression Omnibus (GEO) database via the GEOquery package v2.60.0, incidence rates were obtained from the Surveillance, Epidemiology, and End Results (SEER) database using the SEER*Stat software (version 8.4.1)
Data analysis	Tumor sample methylation data was processed using the sesame package v1.19.7, missing values underwent imputation using the impute package v1.66.0, logistic regression analyses were conducted using the stats v4.1.3. R package, meta-analyses were utilized with the metafor R package v4.4-0, Linear mixed models and ANOVA analyses were executed with the lmerTest R package v3.1-3, all code is available in the github

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio guidelines for submitting code & software for further information.

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Policy information about availability of data

All manuscripts must include a data availability statement. This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our policy

All methylation and related clinical data used in this study are publicly available via the GDC Data portal (https://portal.gdc.cancer.gov/) for TCGA-COAD and TCGA-READ datasets or via the Gene Expression Omnibus (https://www.ncbi.nlm.nih.gov/geo/) for GSE131013, GSE42752, GSE39958, GSE101764, GSE199057 and GSE77954 or ArrrayExpress E-MTAB-7036 and E-MTAB-3027. Pesticide use data can be extracted from the National Water-Quality Assessment (NAWQA) project (https://water.usgs.gov/nawqa/pnsp/usage/maps/county-level/). Access to the Research Plus Data from The Surveillance, Epidemiology, and End Results (SEER) cohort can be requested via https://seer.cancer.gov/data/access.html. RNA-seq data associated with picloram exposure data is in GSE262419.

Research involving human participants, their data, or biological material

Policy information about studies with human participants or human data. See also policy information about sex, gender (identity/presentation), and sexual orientation and race, ethnicity and racism.

Reporting on sex and gender	We adjust our models for sex. This information is collected by the respective cohorts. We could not perform sex stratified analyses due to sample size.
Reporting on race, ethnicity, or other socially relevant groupings	Due to limited data availability, we have not included race or ethnicity as a covariate in our model, hence, we do not report this information.
Population characteristics	We included patients with colon or rectal cancer when diagnosed <50 years of age (early-onset) or aged 70 or later (later-onset). TCGA-COAD includes 31 early-onset and 100 later-onset colon cancer cases. The replication phase comprises the meta-analysis of GSE131013, GSE42752, GSE39958, GSE101764, GSE199057, GSE77954, E-MTAB-7036 and E-MTAB-3027, which combined includes 83 patients with early-onset and 272 with later-onset colon and rectal cancer.
Recruitment	We did not recruit any participants as we only used publicly available datasets.
Ethics oversight	We only used publicly available datasets.

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☒ Life sciences ☐ Behavioural & social sciences ☐ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/documents/nr-reporting-summary-flat.pdf

Life sciences study design

All studies must disclose on these points even when the disclosure is negative.

Sample size	We did not perform sample-size calculations. We included the available publicly available datasets that included methylation measured in tumor samples and had age information.
Data exclusions	Patients aged 50-69 were excluded from our main analysis to capture the suspected change in lifestyle. We excluded datasets if no age information was available.
Replication	We included patients in TCGA-COAD as discovery and included the meta-analysis of GSE131013, GSE199057, E-MTAB-7036, E-MTAB-3027, GSE42752, TCGA-READ, GSE39958, GSE101764, and GSE77954 as the independent replication of the obtained results.
Randomization	Patients were categorized based on age at diagnosis and included permutation analysis to very this categorization.
Blinding	blinding was not performed

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study
☒	☐ Antibodies
☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology and archaeology
☒	☐ Animals and other organisms
☒	☐ Clinical data
☒	☐ Dual use research of concern
☒	☐ Plants

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Plants

Seed stocks

Report on the source of all seed stocks or other plant material used. If applicable, state the seed stock centre and catalogue number. If plant specimens were collected from the field, describe the collection location, date and sampling procedures.

Novel plant genotypes

Describe the methods by which all novel plant genotypes were produced. This includes those generated by transgenic approaches, gene editing, chemical/radiation-based mutagenesis and hybridization. For transgenic lines, describe the transformation method, the number of independent lines analyzed and the generation upon which experiments were performed. For gene-edited lines, describe the editor used, the endogenous sequence targeted for editing, the targeting guide RNA sequence (if applicable) and how the editor was applied.

Authentication

Describe any authentication procedures for each seed stock used or novel genotype generated. Describe any experiments used to assess the effect of a mutation and, where applicable, how potential secondary effects (e.g. second site T-DNA insertions, mosiacism, off-target gene editing) were examined.

Gagetown Harmful Chemical Study Commission

Established by Public Law 2025, Chapter 763

Public Comment

The following pages include the written public comment received by the Commission on October 2, 2026.

WRITTEN SUBMISSION · GAGETOWN HARMFUL CHEMICAL STUDY COMMISSION · OCTOBER 2, 2026

The dates that the official framing omits

Kelly Porter Franklin · Nanaimo, British Columbia, Canada
Civilian · Resident at CFB Gagetown, 1958–1964 · Exposed to herbicide spraying during residence

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My name is Kelly Porter Franklin, a Canadian civilian. From my first birthday in November 1958 until 1964, I lived at CFB Gagetown, where my father was transferred — and where my parents and I were sprayed repeatedly with the same recipe of chemicals that made up Agent Orange, with a reprieve only in 1959 and 1962. I submit this statement in support of the Maine reservists and veterans who trained at Gagetown — because the Canadian and American governments have been telling us the same incomplete story, and the incompleteness serves neither of our peoples.

Maine National Guard members began training at CFB Gagetown in 1971. Spraying at Gagetown was never limited to seven days — it was a program that ran for decades, and Maine veterans trained there throughout it. Your own background materials carry, by its full title, the document that describes that broader period: *CFB Herbicide Spray Programs: 1952–2004 Fact-Finders' Report.* On January 11, 2006, Stephen Harper — twelve days before being elected Prime Minister of Canada — made a public commitment at Woodstock, New Brunswick, naming the Gagetown spray program as running **"from 1956 to 1984."** Maine Guard training began within that window, in 1971, and has never stopped. Neither has the contamination. The seven days your problem overview describes were a fragment of that program — not the whole of it.

THE DATES, PLAINLY

Harper's named spray period at Gagetown:	**1956–1984**
Maine Guard training begins at Gagetown:	**1971** — within Harper's window
Seven days (official U.S. framing):	**1966–1967**
Entirety of Maine Guard exposure:	Within the spray period

One further point. The evidentiary standard sometimes demanded of Gagetown veterans — proof of personal proximity to spraying — misunderstands the chemistry. Dioxin does not

expire when spraying stops. Its half-life in contaminated soil, as Dr. Wayne Dwernychuk documented, runs to a hundred years or more. A reservist training on Gagetown ground in 1978 contacted the same contaminated soil as anyone present in 1966. The relevant question is not whether someone was present *during* spraying. It is whether the ground they trained on was contaminated. Stephen Harper's own public commitment at Woodstock answers that: contamination at Gagetown existed from 1956 — without interruption — for the full duration of Maine Guard training. I ask this commission: do not permit the official framing to define your inquiry.

Kelly Porter Franklin
Nanaimo, British Columbia, Canada
tcddkelly@gmail.com

Harper commitment (1956–1984): Woodstock, N.B., 11 January 2006 · reported Radio-Canada, 12 January 2006, "Stephen Harper veut indemniser les victimes," ici.radio-canada.ca/nouvelle/290783/harper-agent · broadcast as *The Promise* · CBC Radio *The House* · 19 May 2007 · Maine Guard training start: Troy Jackson, President of the Maine Senate, testimony to Maine Legislature · Dioxin persistence: Dr. Wayne Dwernychuk; TCDD soil half-life 100 years or more

State of Maine
Gagetown's Harmful Chemical Use

3 Minute Statement

Since 2005 there has been 9 registered and non registered request calling on Canadas Federal Government to convene a Fully Independent Public Inquiry into CFB Gagetown's Harmful Chemical Use. The last of these request was presented in 2024. Two of those 9 request were presented on behalf of the Brats In The Battlefield, for which I am the Chair. 8 of those requests were replied to with the same Government response. And I quote, Given the extensive research and investigations National Defence has already conducted and testing of herbicide at CFB Gagetown, National Defence does not have any plans to conduct further inquiries at this time.

The exception to the 8 request I just mentioned is the 9th request where in the Federal Government states they are aware of the State of Maine's Commissioned Study into Gagetown's Harmful Chemical use and the potential health impacts associated with historical herbicide use at CFB Gagetown. The Government of Canada is aware of the Commission's findings and continues to monitor related research and developments. Any new evidence will be assessed in accordance with established scientific and policy processes.

I believe we must give serious consideration to the Government of Canada's established scientific and policy processes, especially when those scientific and policy processes employed by Gagetown's Fact Finding Project into the history of Gagetown's Harmful Chemical use has been deemed seriously flawed by reputable Scientist such as Dr. Meg Sears.

We must not loose sight of who the Government of Canada hired to conduct the scientific research into Gagetown's History of Harmful Chemical use.

They hired the Chemical Industry itself to conduct the Health Risk Assessment of Gagetown's Harmful Chemical use. At the time of Gagetown's Health Risk Assessment, Cantox Environmental was the company that conducting the study and the companies Senior Vice-President and Principal was Donald B. Davies, Ph.D., DABT

From 1980 to 1984, Mr. Davies worked for Health and Welfare Canada, at the Health Protection Branch Toxicological Evaluation Division,
From 1984 to 1991, Mr. Davies worked for Dow Chemical Canada Inc. as a Research Associate -Toxicologist. From 1991 to 2007. Mr. Davies worked for Cantox Environmental Inc. as their Senior Vice-President and Principal. Before the ink was dried on Gagetown's final report, Cantox had changed its name to Intrinsik Environmental Sciences Inc. with Mr. Davies at the helm.

Mr. Davies was the Vice-President and Principal for Cantox Environmental during Gagetown's Fact Finding Project and the Health Risk Assessment of Gagetown's Harmful Chemical History.

Canada's Federal Government then hired Dr. Leonard Ritter to Chair the Pier reviews for the studies conducted by Cantox Environmental on the History of Gagetown's Harmful Chemical Use.

Dr. Leonard Ritter also honed his skills at Health Canada and was one of the founders of Cantox Environmental. Need I say More?

The Health Risk Assessment of Gagetown's Harmful Chemical use was never ment to dig up the true history of Gagetown's Harmful Chemical Use, it was ment to cover it up.

My name is Eleanor Bilodeau. I am the surviving spouse of Sgt. Gerard F Bilodeau. Among his 22 years of service which included the US Army, 82nd Airborne, Maine and Kentucky National Guards and the Maine and Tennessee Army Reserves, He was sent to Gagetown NB base for summer guard duty under the 133rd Engineering Battalion of Portland, Maine. June and July of 1984 and May 1987.

In 2018 Gerard was diagnosed with Parkinson's disease. In 2019 he was diagnosed with Prostate Cancer and in 2020 he was diagnosed Lewy Body dementia. He died in August of 2020, 3 months after his dementia diagnosis.

I've heard the Gagetown horror stories from my husband, his describing of thrashing thru the woods with a machetti, clearing trees for making roads, wet grounds, setting up tents on those wet grounds, and staying in them. He also talked with Canadian soldiers who said there was still spraying going on especially the area they worked in. I also spoke to another man in his unit last year and he said also there was spraying from planes going on while they were there.

Once diagnosed with Parkinsons, my husband went right to the Gagetown trips where he believed was the cause. In 2019 he started the VA Claim process and died before completing it. He told me before he developed LBD that if he died, to keep going after the VA and keep the claim going. I had to start my own claim. For 6 years since his death I have tried over and over but without that being on the list of confirmed places you could be exposed, its not even considered. I could get no one to talk to me at VA face to face, only thru paperwork. My experience with a few VSO Reps ended up with me pursuing the case myself because I knew more than they did in the 6 years while doing this.

My question is: If he went there and it has the reputation it has and he died from 2 diseases associated with toxic chemicals in herbicides/pesticides, then why is it not considered presumptive ? Canadian soldiers were paid a lump sum each. That says to me, there is something there to hide.

We need to get an up to date thorough soils test done the right way to answer the questions once and for all.

Thank you for the opportunity to speak and thank you to all who are working on this issue.

Sincerely,

Eleanor Bilodeau
PO Box 68
Unity, ME 04988

Gagetown Harmful Chemical Study Commission

Established by Public Law 2025, Chapter 763

Table of Contents: Background Materials

Overview		
	Material	**Source**
1.	Overview of Problem: Harmful Chemical Exposure at Base Gagetown	*Provided by the Office of Policy and Legal Analysis*
2.	Gagetown Harmful Chemical Study Commission Report (January 2024)	*Provided by the Office of Policy and Legal Analysis*
3.	Substance Profile: "2,3,7,8-Tetrachlorodibenzo-p-dioxin"	*Report on Carcinogens, Fifteenth Edition (December 2021)*
4.	Canadian National Defence: "ARCHIVED – The Use of Herbicides at CFB Gagetown from 1952 to Present Day" –	*Canadian National Defence* (last updated December 13, 2018)
Selections from "CFB Gagetown Herbicide Spray Programs: 1952 - 2004 Fact Finders' Report" (Furlong 2007)		
	Material	**Source**
5.	Selection from "Task 3A-1: Toxicological Risk Assessment Pertaining to Potential Occupational and Related Exposures Associated with Herbicide Spraying Operations at CFB Gagetown – Tier 1 – 1966-67 U.S. Trials – Manufacturing Impurities (Contaminants)"	*Cantox Environmental* (July 2006)
6.	"Summary" and "Further Research" sections from "CFB Gagetown Herbicide Spray Programs: 1952 - 2004 Fact Finders' Report"	*Dr. Dennis Furlong* (2007)
7.	Appendix H: "Peer Review Comments, Health Canada Comments and Cantox Environmental Response to Comments"	*Peer Review: Michalek et al. (2006 June 23)*

Information published by the United States Department of Veterans Affairs		
	Material	**Source**
8.	United States Department of Veterans Affairs: "Agent Orange Exposure and Disability Compensation"	*United States Department of Veterans Affairs* (updated September 15, 2025)
9.	United States Department of Veterans Affairs: "The PACT Act and Your VA benefits"	*United States Department of Veterans Affairs* (updated June 2, 2026)
Media Coverage		
	Material	**Source**
10.	Article: "60 years ago, Agent Orange was sprayed at CFB Gagetown. Vets want to know: are toxins still in the soil?"	*CBC* (June 18, 2026)
11.	Petition 451-00899 (Environmental): Petition to the Canadian Government to conduct an inquiry into the history of CFB Gagetown's toxic herbicide program and the Base Gagetown and Area Fact Finding Project/Report	*Shared by commission member Jan McColm*
Materials from Commission Members		
	Material	**Source**
12.	Example of National Guard Compensation for Training at Base Gagetown	*Shared by commission member Karen St. Peter*
13.	"Sample of Arguments Frequently Presented to [Veterans Review and Appeal Board] VRAB"	*Provided by Jan McColm, from, then Acting Director of Appeals for the Bureau of Pensions Advocates in Canada, Lisa Laird*
14.	"Appendix B: Limitations of the Furlong Report and Task 3A-Tier 1 Risk Assessment"	*Provided by commission member Jan McColm, from Pensions Advocate Lisa Laird*

Materials from Commission Members (cont'd)		
	Material	**Source**
15.	"Exhibits frequently filed with the Veterans Review and Appeal Board"	*Provided by commission member Jan McColm, from Pensions Advocate Lisa Laird*
16.	Article: "Ex-soldier says he watched barrels of Agent Orange being buried at Gagetown base"	*CBC* (May 23, 2018); *shared by commission member Dana Michaud*

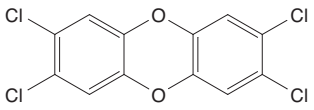
2,3,7,8-Tetrachlorodibenzo-*p*-dioxin

CAS No. 1746-01-6

Known to be a human carcinogen

First listed in the *Second Annual Report on Carcinogens* (1981)

Also known as dioxin, TCDD, or 2,3,7,8-TCDD



Carcinogenicity

2,3,7,8-Tetrachlorodibenzo-*p*-dioxin (TCDD) is *known to be a human carcinogen* based on sufficient evidence of carcinogenicity from studies in humans, both epidemiological and on the mechanism of carcinogenesis. TCDD was first listed in the *Second Annual Report on Carcinogens* as *reasonably anticipated to be a human carcinogen.* Subsequently, a number of studies were published that examined cancer in human populations exposed to TCDD occupationally or through industrial accidents. A concerted research effort examined the molecular and cellular events that occur in tissues of humans and animals exposed to TCDD. Based on the new information, the listing was revised to *known to be a human carcinogen* in the January 2001 addendum to the *Ninth Report on Carcinogens*.

Cancer Studies in Humans

Epidemiological studies of four industrial cohorts with high exposure to TCDD, in Germany (two separate studies), the Netherlands, and the United States, found increases in overall mortality from cancer. An exposure-response relationship was observed in the largest and most heavily exposed German cohort. The International Agency for Research on Cancer evaluated data from the most heavily exposed subcohorts in studies published through 1996 and found that the risks of all cancer combined, lung cancer, and non-Hodgkin lymphoma were significantly increased. Increased risks of certain types of cancer also were found in an updated examination of the population exposed to TCDD during a 1976 industrial accident in Seveso, Italy (IARC 1997). After TCDD was listed in the *Ninth Report on Carcinogens*, IARC concluded that there was sufficient evidence of the carcinogenicity of TCDD in humans based on increased risk of all cancer combined (Baan *et al.* 2009).

Studies on Mechanisms of Carcinogenesis

There is scientific consensus for a common mode of action of TCDD and other chlorinated dibenzodioxins, dibenzofurans, and planar polychlorinated biphenyls (PCBs). In humans and rodents, this mode of action involves events that stem from the initial binding of TCDD to the aryl or aromatic hydrocarbon (Ah) receptor. The Ah receptor is a ubiquitous protein in the cells of vertebrates (including rodents and humans), which acts as a signal transducer and activator for gene transcription. Of all the chlorinated dioxins and furans, TCDD has the highest affinity for both rodent and human forms of the Ah receptor. Through activation of the Ah receptor, TCDD causes a wide spectrum of biological responses considered important to the carcinogenic process, including changes in gene expression, altered metabolism, altered cell growth and differentiation, and disruption of steroid-hormone and growth-factor signal-transduction pathways. Similar Ah-receptor-mediated responses have been observed in humans and rodents at similar body burdens or tissue concentrations of TCDD (DeVito *et al.* 1995). The scientific consensus is that binding to the Ah receptor is a necessary, but not sufficient, step in eliciting these TCDD-induced responses, including cancer.

One major difference between humans and rodents has been noted: TCDD has a half-life of 5.8 to 11.3 years in humans (Olson 1994), compared with generally 10 to 30 days in rodents (IARC 1997). Thus, TCDD accumulates in human tissue at a higher rate than in most experimental animals as a result of chronic low-level exposure. This increased accumulation suggests that TCDD-induced responses would occur in humans following prolonged exposure at lower daily intakes than would be required to elicit similar responses in experimental animals.

TCDD is not believed to be mutagenic. *In vivo* and *in vitro* genotoxicity studies of TCDD in human and animal cells have given inconsistent findings, and findings of chromosomal aberrations in humans exposed *in vivo* to TCDD are equivocal (IARC 1997).

Cancer Studies in Experimental Animals

Since 1977, many independent studies have all found TCDD to be carcinogenic in experimental animals. TCDD caused tumors in various strains of rats, mice, and hamsters, in both sexes, at numerous tissues sites, and by several different routes of exposure, including oral (dietary or by stomach tube), dermal, and intraperitoneal. Tissue sites at which cancer occurred included the liver, thyroid gland, lymphatic system, respiratory tract, adrenal cortex of the kidney, hard palate, nasal turbinates, tongue, and skin (Huff *et al.* 1994). TCDD caused cancer in a dose-dependent fashion and was also a potent promoter of liver and skin cancer in initiation-promotion studies. In addition, a compelling body of evidence indicates that the biochemical and toxicological responses to TCDD in experimental animals and humans have a similar mechanism of action.

Properties

TCDD is member of the class of polychlorinated dibenzo-*p*-dioxins, which vary in their degree of chlorination, resulting in different forms or congeners. TCDD is the index constituent for dioxin-like compounds. It occurs as colorless-to-white needles at room temperature. It is insoluble in water and very slightly soluble in *o*-dichlorobenzene, chlorobenzene, benzene, chloroform, acetone, *n*-octanol, methanol, and lard oil. Physical and chemical properties of TCDD are listed in the following table.

Property	Information
Molecular weight	322.0
Melting point	305°C to 306°C
Log K_{ow}	6.8
Water solubility	2×10^{-7} g/L at 25°C
Vapor pressure	1.50×10^{-9} mm Hg at 25°C

Source: HSDB 2009.

Use

TCDD has no known commercial applications, but it is used as a research chemical. It was tested, but never used commercially, as a flameproofing agent and as a pesticide against insects and wood-destroying fungi (ATSDR 1998, HSDB 2009). TCDD occurred as a contaminant in chlorophenoxy herbicides, including 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), that were widely used in the 1960s and 1970s to control weeds (including controlling weeds on pastureland and food crops) and as a defoliant during the Vietnam War (see Production and Exposure, below).

Production

TCDD is not currently produced commercially in the United States, but it is synthesized on a laboratory scale. Polychlorinated dibenzo-

p-dioxins (CDDs), including TCDD, are inadvertently produced by paper and pulp bleaching (Silkworth and Brown 1996), by incineration of municipal, toxic, and hospital wastes, in PCB-filled electrical transformer fires, in smelters, and during production of chlorophenoxy herbicides (Schecter 1994, IARC 1997, Schecter *et al.* 1997b). The greatest unintentional production of CDDs occurs from waste incineration, metal production, and fossil-fuel and wood combustion (ATSDR 1998).

Because TCDD is a by-product of the manufacture of polychlorinated phenols, it has been detected in commercial samples of 2,4,5-trichlorophenol (2,4,5-TCP), pentachlorophenol (a wood preservative), and the herbicide 2,4,5-T. Before 1965, commercial 2,4,5-T contained TCDD at concentrations of up to 30 ppm or more. By the mid 1980s, however, commercial 2,4,5-T contained no more than 0.01 ppm TCDD. Since 1971, regulatory agencies in a number of countries worldwide have enforced a maximum TCDD concentration of 0.1 ppm in 2,4,5-T. Millions of gallons of Agent Orange (a 50:50 mixture of the *N*-butyl esters of 2,4,5-T and 2,4-dichlorophenoxyacetic acid [2,4-D]) used as a defoliant in the Vietnam War during 1962 to 1970 contained 2 to 30 ppm TCDD. TCDD has also been detected in the herbicide 2-(2,4,5-trichlorophenoxy)propionic acid (Silvex) and may be present in *o*-chlorophenol, 1,2,4,5-tetrachlorobenzene, Ronnel (fenchlorphos), and 2,4-D. Chlorophenoxy herbicides were banned from use on food crops, pastures, rice paddies, or rangelands in 1983, and the use of 2,4,5-T was completely banned in the United States (ATSDR 1998).

Exposure

Occupational exposure to CDDs, including exposure of military personnel to Agent Orange in Vietnam, has been primarily through inhalation and dermal contact (ATSDR 1998). In occupations where CDDs may be present as contaminants (e.g., waste incineration; fire fighting; chemical research; paper bleaching; chlorophenoxy herbicide production, use, and disposal; or production and use of pentachlorophenol and other chlorinated compounds), workers may be at an increased risk of exposure; however, the number of workers potentially exposed to CDDs is not known.

Many studies of Vietnam veterans exposed to Agent Orange have been conducted (ATSDR 1998). Elevated exposure to TCDD was confirmed in the Air Force unit that was responsible for spraying herbicides in Vietnam (known as Operation Ranch Hand) (Pavuk *et al.* 2003). Operation Ranch Hand veterans were divided into three groups: background, low exposure, and high exposure. The mean serum TCDD concentration in the background group was 5.8 ppt and was not significantly different from that for a matched comparison group (4.6 ppt). Mean serum concentrations in the exposed groups were much higher, at 15.6 ppt (range = 10 to 25.6 ppt) in the low-exposure group and 69.4 ppt (range = 18 to 617.8 ppt) in the high-exposure group. Based on the biological half-life of TCDD, mean serum concentrations were extrapolated back to the end of the last tour of duty in Vietnam and were estimated at 55 ppt for the low-exposure group and 302.5 ppt for the high-exposure group.

CDDs and their structural analogues are highly persistent and widespread environmental contaminants. Exposure to these compounds is typically expressed in terms of TCDD equivalents based on the concentrations and toxicity of the specific CDD and polychlorinated dibenzofuran (CDF) congeners relative to that of TCDD. CDDs and CDFs have been detected in air, water, soil, sediments, and animal and human tissues. They are known to bioaccumulate throughout the food chain because of their lipophilic character and slow metabolism *in vivo*. TCDD is very persistent in the environment and readily bioaccumulates in the food chain, because of its extreme lipophilicity.

Evidence that people in the United States are exposed to TCDD is provided by the 2009–2010 National Health and Nutrition Examination Survey, which detected TCDD in the serum of adults over the age of 40 (CDCC 2018). The lipid-adjusted arithmetic mean serum TCDD levels in adults aged 60 or older (1.34 to 3.54 pg/g of lipid) were about twice the levels seen in adults aged 40 to 59 (0.781 to 1.17 pg/g). Among adolescents and younger adults, the proportion of results below the limit of detection (0.78 pg/g) was too high to allow means to be calculated. The presence of higher levels in older individuals supports a decrease in exposure to TCDD over time, consistent with the major source of exposure being persistence in the environment and bioaccumulation in the food chain.

Meat, fish, and dairy products are the major source (> 90%) of human exposure to CDDs (Schecter *et al.* 1997a). The average daily intake of TCDD for a U.S. adult from meat alone was estimated at 23 pg, or approximately 50% of the total daily intake from food sources. The average daily intake of TCDD was 13 pg from milk, 5 pg from produce, and 5 pg from fish; however, for certain subpopulations (recreational and subsistence fishers), fish consumption may be the most important source of exposure. The maximum daily intake of TCDD for residents of the Great Lakes region who regularly consumed fish was estimated to range from 390 to 8,400 pg. The developing fetus may be exposed to CDDs transferred across the placenta, and breastfed infants may be exposed to CDDs in their mother's milk. In the United States, breastfed infants might have been exposed to TCDD equivalents at 35 to 53 pg/kg of body weight per day through their mother's milk during their first year of life (ATSDR 1998).

Other pathways of exposure for the general population include inhalation of TCDD from municipal, medical, and industrial waste incinerators or other combustion processes (about 2% of daily intake) and ingestion of TCDD in drinking water (< 0.01% of daily intake). Fires involving capacitors or transformers containing chlorobenzene and PCBs are potential sources of CDDs. TCDD has been found in plastic packaging, clothes-dryer lint, vacuum-cleaner dust, room and car air filters, furnace-filter dust, and bleached paper products (ATSDR 1998). In a survey of 116 chemicals in blood and urine from 2,500 people across the United States in 1999 and 2000, the average concentration of TCDD was below the limit of detection for people of all ages (CEN 2003). U.S. weighted arithmetic mean lipid-adjusted serum TCDD levels from the 2009–2010 National Health and Nutrition Examination Survey by age group and race or ethnicity group are shown in the following table.

The U.S. Environmental Protection Agency's National Dioxin Study, conducted in the mid 1980s, detected TCDD at about 8% of urban sites and less than 1% of rural sites that were not expected to be contaminated with dioxins (i.e., background sites). The maximum concentration reported for these background sites was 11.2 ppt. However, soil concentrations in areas with past sources of TCDD contamination (i.e., hazardous-waste sites or sites where 2,4,5-TCP was produced and stored) typically were in the parts-per-billion range, with a maximum of about 2,000 ppm (ATSDR 1998). The data from the National Dioxin Study were consistent with concentrations of TCDD reported from previous studies of contaminated sites at Love Canal, in Niagara Falls, New York, and at various sites in Missouri that were sprayed for dust control in the early 1970s with dioxin-contaminated waste oil (Tiernan *et al.* 1985). TCDD concentrations in storm-sewer sediments collected at Love Canal in the late 1970s and early 1980s ranged from below detection (typically 10 to 100 ppt) to about 670 ppm. Concentrations of TCDD reported in the mid 1970s to early 1980s in soil from contaminated sites throughout Missouri, including the town of Times Beach, ranged from 4.4 to 1,750 ppb.

Both Love Canal and Times Beach were evacuated after the contamination was discovered. Love Canal was contaminated with many different organic and inorganic chemicals, but dioxins were the only chemicals of concern at Times Beach. Dioxin contamination at Times Beach was confirmed in November 1982; all residents (about 2,000 people) and businesses were permanently relocated, and all structures were torn down (EPA 2001). TCDD concentrations in some soil samples exceeded 100 ppb, with a maximum concentration of 317 ppb (Tiernan *et al.* 1985). More than 37,000 tons of dioxin-contaminated soil and other materials was removed from Times Beach and incinerated (EPA 2001). The ash residue from the incinerator was disposed of on site (on land), and all areas with residual dioxin concentrations between 1 and 20 ppb were covered with clean soil and revegetated (EPA 1988).

Regulations

Department of Transportation (DOT)

TCDD is considered a hazardous material, and special requirements have been set for transporting this material in tank cars.

Environmental Protection Agency (EPA)

Clean Air Act

Mobile Source Air Toxics: Dioxin and furans are listed as a mobile-source air toxic for which regulations are to be developed.

National Emission Standards for Hazardous Air Pollutants: Listed as a hazardous air pollutant.

New Source Performance Standards: Regulations to limit dioxin emissions from various types of waste combustion and incineration units have been developed.

Urban Air Toxics Strategy: Identified as one of 33 hazardous air pollutants that present the greatest threat to public health in urban areas.

Clean Water Act

Effluent Guidelines: Listed as a toxic pollutant.

Water Quality Criteria: Based on fish or shellfish and water consumption = 5×10^{-9} µg/L; based on fish or shellfish consumption only = 5.1×10^{-9} µg/L.

Dioxin-containing wastes are prohibited from underground injection.

Comprehensive Environmental Response, Compensation, and Liability Act

Reportable quantity (RQ) = 1 lb.

Emergency Planning and Community Right-To-Know Act

Toxics Release Inventory: Listed substance subject to reporting requirements.

Resource Conservation and Recovery Act

Listed Hazardous Waste: Waste codes for which the listing is based wholly or partly on the presence of TCDD = F020, F022, F023, F026, F027, F028, F032, K174.

Listed as a hazardous constituent of waste.

Safe Drinking Water Act

Maximum contaminant level (MCL) = 3×10^{-8} mg/L.

Toxic Substances Control Act

Manufacturers, importers, or processors of chemical substances specified under 40 CFR 766.25 must test for halogenated dibenzodioxins/dibenzofurans.

Food and Drug Administration (FDA, an HHS agency)

Maximum permissible level in bottled water = 3×10^{-8} mg/L.

Guidelines

National Institute for Occupational Safety and Health (NIOSH, CDC, HHS)

Listed as a potential occupational carcinogen.

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ARCHIVED - The Use of Herbicides at CFB Gagetown from 1952 to Present Day

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Agent Orange Ex-gratia Payment

The new deadline for applications is June 30, 2011.

On December 22, 2010, the Honourable Jean-Pierre Blackburn, Minister of Veterans Affairs and Minister of State (Agriculture), announced that the Government of Canada is extending the one-time, tax-free ex gratia payment of $20,000 related to the testing of unregistered U.S. military herbicides, including Agent Orange, at Canadian Forces Base (CFB) Gagetown in 1966 and 1967.

For more information on eligibility criteria, contact Veterans Affairs Canada by visiting www.vac-acc.gc.ca or calling 1-866-522-2122.

For three days in June 1966 and four days in June 1967, Agent Orange, Agent Purple and other unregistered herbicides were tested at Canadian Forces Base (CFB) Gagetown in cooperation with the U.S. military to evaluate their effectiveness. These are the only known instances that these military test chemicals were used at CFB Gagetown. Agent Orange, Agent Purple and other unregistered herbicides are not used at the base today. The base uses only federally regulated herbicides for brush control during its annual vegetation management program.

In August 2005 the Department of National Defence, with participation from Veterans Affairs Canada, Health Canada, and additional departments and agencies, initiated a fact-finding

mission to gain information on the history of herbicides tested and used at CFB Gagetown from 1952 to the present day, and the potential risks to human health and the environment. A major interdepartmental effort has occurred over the past two years to conduct the analysis necessary to provide all the facts.

An independent Fact-finding and Outreach Coordinator, Dr. Dennis Furlong, was named to oversee this process. His work included providing input on the plans and reports for each fact-finding task, as well as being the principal contact for those seeking information about herbicide testing and use at CFB Gagetown. The fact-finding tasks were conducted by contracted, highly qualified non-governmental experts.

The draft reports of the scientific research were peer-reviewed by qualified, independent experts. The contractors addressed their comments, and the final reports were provided directly and concurrently to the Ministers of National Defence, Veterans Affairs, and the Fact-finding and Outreach Coordinator. Reports involving human health aspects were also provided to the Minister of Health. The Fact-finding and Outreach Coordinator, accompanied by the appropriate experts, then shared the results of each report with the public.

All of the fact-finding tasks are now complete, and there is a much clearer understanding and greater knowledge of the testing and use of herbicides at CFB Gagetown. Scientific study from the excavations, soil, water and vegetation sampling, human health risk assessments, and the epidemiological study indicates that most people who lived near or worked at CFB Gagetown were not at risk for long-term health effects from the herbicides applied there. The science also indicates that the base is safe today.

Results of the Fact-finding Tasks

Task 1

As part of the fact-finding initiative, the Department of National Defence committed to producing a comprehensive list of individuals and military units who were present at CFB Gagetown during the testing of Agent Orange, Agent Purple and other herbicides in 1966 and 1967, and during the eight to 12 weeks per year (between June and August) from 1952 to the present day when application of herbicides took place.

The contractor for this task, Canadian Development Consultants International Inc, compiled a database with relevant information on more than 115,000 individuals. Information that was not deemed to be of a personal nature (this includes such information as the names, ranks and units of some individuals, as well as the dates they were in Gagetown) was made public. Personal

information (this includes such things as age, employee numbers, home addresses and family information) will not be made public.

Any information collected from individuals by the Fact-finding and Outreach Coordinator's office is also considered personal and will not be made public. Individuals who wish to submit a request for personal information may do so under the Privacy Act through the Directorate Access to Information and Privacy at National Defence.

Task 2A

The objective of this task was to review the history of the use of herbicides at the CFB Gagetown range and training area from 1952 to the present day, to compile a comprehensive database for this information, and to provide information on the types of herbicides used and how they were used.

The contractor, Jacques Whitford, determined that aside from the military products used in the herbicide trials in 1966 and 1967, the herbicides applied at CFB Gagetown over the past fifty years were regulated and commonly used across Canada. The herbicide application program at CFB Gagetown followed the policies, science, and best practices of the time, as regulated by Federal and Provincial governments. Where specific information could be obtained from historical records, rates of application of herbicides used at CFB Gagetown were either within, or in many instances lower than, the recommended application rates suggested by the manufacturer.

Task 2B

The purpose of this task was to conduct an environmental site assessment of the range and training area at CFB Gagetown.

Based on the laboratory tests, only concentrations of dioxins and arsenic in some of the soil samples exceeded the Canadian soil quality guidelines. The highest concentrations of dioxins in soil were found in the location of the 1967 test plots. Concentrations slightly above Canadian guidelines of dioxins in soil were also found in the Clones bivouac site, the Murphy bivouac site, the Enniskillen

Range, the 1966 test plots, and four other discrete sites in the range and training area. In a proactive precautionary measure, DND temporarily restricted site access to areas where dioxins concentrations were the highest (1967 test plots), as well as where human exposure to surface soils would be the most concentrated (in the bivouacs) until the results of a site specific risk

assessment were completed. Further study determined that the dioxin levels in these areas posed no risk to human health.

Groundwater and surface water samples had concentrations of dioxins less than the Ontario Ministry of the Environment drinking water quality objective, which was used as a comparison due to the absence of a Canadian drinking quality guideline.

Task 2C

This task aimed to conduct a barrel investigation, and excavation program and analysis. During the excavation process, no herbicide barrels were discovered.

Task 2D

This task modelled how herbicides migrated through the air from aerial application in order to provide exposure scenarios for the health risk assessment identified in Task 3A-1.

Task 2E

The goal of this task was to assess whether herbicides and associated contaminants may have migrated through groundwater and/or surface water.

The contractor for this task, Jacques Whitford, concluded that it would be difficult, expensive and take considerable time to quantitatively estimate surface water migration. It is not possible to quantitatively estimate groundwater migration due to the variability of conditions across the base and the lack of adequate data on soils and geology. Cantox Environmental used the Jacques Whitford scoping report, together with a qualitative approach, to eliminate the water exposure pathway from further consideration in the health risk assessments.

Task 3A-1

The objective of this task was to conduct a historical human health risk assessment to determine how humans may have been exposed to herbicides and military test chemicals at the time of use, and the potential risks to human health. This study was done in three tiers. Tier 1 concentrated on the contaminants related to the 1966 and 1967 testing of unregistered military chemicals. Tiers 2 and 3 concentrated on all other years of registered herbicide use.

The contractor for this task, Cantox Environmental, concluded that the military chemicals tested at CFB Gagetown in 1966 and 1967, the known contaminants in the herbicides used at CFB Gagetown during the annual spray program in the period prior to the late 1960s, and the active ingredients in the herbicides used at CFB Gagetown during the annual spray program posed no long-term risk to human health and safety for most individuals. Those who were directly

involved during applications or who worked in the bush immediately after application may have some increased risk. The contractor also concluded that the known contaminants in the herbicides used at CFB Gagetown during the annual spray program after the late 1960s posed no long-term risk to human health and safety.

Task 3A-2

For this task, a present day contaminated site human health risk assessment, using data gathered from Task 2B, was conducted to assess current exposures and human health risks for all contaminants of potential concern identified in the water, soil, sediment, and vegetation environmental media sampled and analyzed at CFB Gagetown.

The results of this task indicate there is currently no risk to human health (as a result of herbicide use) in the areas of the base where access was restricted as a precautionary measure following the environmental site assessment.

Task 3B

The objective of this task was to perform a literature review of all epidemiologic studies examining the relationship between herbicides (those applied at CFB Gagetown) and human health, and to conduct a descriptive epidemiological study to determine whether the communities surrounding CFB Gagetown had a higher incidence of illness as compared to the general population of the province of New Brunswick.

The contractor for Task 3B, Dalhousie University led by Dr. Judy Guernsey, concluded that the communities surrounding CFB Gagetown do not have a significantly higher incidence of illness, as compared to the province of New Brunswick.

Task 3

A consolidated report for all parts of Task 3 was completed. This report includes the results of the epidemiology research integrated with the results of the human health risk assessments.

Task 4

The purpose of Task 4 was to provide information on tissue dioxin concentrations in fish and freshwater clams sampled within the CFB Gagetown Range and Training Area. These data provide estimates to whether there is a potential risk to humans from consumption of fish and freshwater clams at CFB Gagetown.

The contractor for Task 4, G.A. Packman and Associates, concluded that the levels of dioxins in fish and freshwater clams at CFB Gagetown were either below or consistent with regulated limits and values for fish and freshwater clams from other locations.

DND Wide Herbicide Use Project

In 2006, Golder Associates Ltd. (Golder) was retained by Public Works and Government Services Canada on a series of contracts on behalf of the Department of National Defence (DND) to research, organise and analyse all available information concerning the herbicides used at each Canadian Forces (CF) site across Canada. An objective of this undertaking was to confirm whether tactical herbicides such as Agent Orange and Agent Purple tested in 1966 and 1967 at CFB Gagetown were ever tested at other current and former CF Bases, Stations or Wings.

Golder's review of the information has found no evidence of spray applications of the tactical herbicides Agent Orange or Agent Purple at any Bases, Stations or Wings aside from CFB Gagetown. Records do indicate that the non-tactical and commercially available herbicides 2,4,5-T and 2,4-D were potentially concurrently used, stored or disposed at each of Carp (Ontario), CFB Chatham and CFB Gagetown (New Brunswick), CFB Borden (Ontario) and another unidentified site.

As such, evidence to-date is to the effect that Agent Orange and Agent Purple were only applied at CFB Gagetown.

Health Information Summary for CF Members

The following information was issued on behalf of the Canadian Forces Surgeon General. It was intended to assist CF medical staff in placing the health risk in context and to serve as a direct reference for concerned CF members who desire more detailed and specific information than is available from existing herbicide and dioxin information sheets produced by various health authorities.

This document summarizes the findings of scientific studies and reviews specific to Agent Orange or otherwise relevant to recent concerns regarding human exposure and health effects of unregistered herbicides tested at CFB Gagetown June 14-16, 1966, and June 21-24, 1967. This document is organized into four main sections. The first three sections ("GENERAL INFORMATION" , "HEALTH EFFECTS" , and "FATE IN THE ENVIRONMENT") provide background information. Much of this background information is related to the United States use of Agent

Orange and other herbicides during the Vietnam War and the scientific study of exposed U.S. Vietnam veterans. This background information is necessary to provide context for the discussion in section four ("HEALTH EFFECTS FROM SPRAYING IN GAGETOWN") of health risks related to the testing of Agent Orange and other unregistered herbicides at CFB Gagetown June 14-16, 1966, and June 21-24, 1967.

DND has also used other (registered) herbicides at CFB Gagetown and across Canada since the 1950s. This broader use of registered herbicides will be reviewed over the next several years and relevant health information will be provided separately in the future. Although this document focuses on the testing of unregistered herbicides at CFB Gagetown June 14-16, 1966, and June 21-24, 1967, parts of this document would also be relevant to the discussion of potential health effects from chemical exposures in general (see especially "Under what circumstances might Agent Orange or its ingredients lead to health effects?").

- **General Information**
  - What is Agent Orange?
  - What is Agent Purple?
  - What is TCDD?
  - How much is a part per million (ppm)?
  - How much is a part per trillion (ppt)?
  - How much TCDD did Agent Orange and Agent Purple contain?
- **Health Effects**
  - What health effects are associated with Agent Orange?
  - What is the difference between an "association" and a "cause"?
  - What are chance, bias, and confounding?
  - Under what circumstances might Agent Orange or its ingredients lead to health effects?
  - What are the health risks associated with large exposures to TCDD?
  - Have Vietnam veterans in general been harmed by Agent Orange?

    - Have Army Chemical Corps Vietnam veterans been harmed by Agent Orange?
    - Have Air Force Ranch Hand Vietnam veterans been harmed by Agent Orange?
    - Why have disability pensions been awarded in the US and Canada for illnesses associated with Agent Orange?
- **Fate in the Environment**
    - What happens to Agent Orange after it is sprayed?
    - What happens to Agent Orange after it lands on the ground?
    - Is Agent Orange the only source of TCDD?
    - Can TCDD be measured in our bodies?
- **Health Effects From Spraying in Gagetown**
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General Information

What is Agent Orange?

The U.S. military used several different herbicide mixtures during the Vietnam War. These mixtures contained herbicides that were commercially available in the 1960's, but the mixtures themselves were made specifically for the U.S. military. In order to readily identify these different mixtures in the field, the storage drums for these mixtures used in Vietnam were painted with coloured bands, such as pink, purple, blue, white, green, and orange. The herbicide in the orange drums was an equal mixture of 2,4-D and 2,4,5-T (2,4-dichlorophenoxyacetic acid and 2,4,5-trichlorophenoxyacetic acid). It became known as "Agent Orange", as this was the colour of the bands on the drums it was stored in. In Vietnam, more than 45 million liters of Agent Orange were sprayed (the most of any herbicide formulation) and less than 2 million liters of Agent Purple were sprayed during the war (Stellman et al., 2003).

What is Agent Purple?

Both Agent Orange and Agent Purple were 50-50 mixtures of 2,4-D and 2,4,5-T; the distinction is in the type of 2,4,5-T. Agent Orange was a 50-50 mixture of n-butyl ester 2,4-D and n-butyl ester 2,4,5-T. Agent Purple contained 50% n-butyl ester 2,4-D, 30% n-butyl ester 2,4,5-T, and 20% isobutyl ester 2,4,5-T.

What is TCDD?

TCDD is an abbreviation for 2,3,7,8-tetrachlorodibenzo- p -dioxin (which can also be abbreviated as 2,3,7,8-TCDD). TCDD was an unintended contaminant in the production of 2,4,5-T. Therefore, TCDD was also a component of herbicide mixtures containing 2,4,5-T, such as Agent Orange. According to the U.S. Institute of Medicine, " TCDD is thought to be the most toxic of the compounds " used in Vietnam (Institute of Medicine, 2005).

TCDD is one specific type of chemical from a family of chemicals known as "dioxins". Some of the chemicals within the dioxin family are considered to be toxic whereas others are much less toxic. TCDD is considered to be the most toxic of the dioxins. Because of this, the toxicity of mixtures of dioxins is usually described in relation to TCDD. The scientific term for this is "toxic equivalent", or TEQ: the toxicity of a mixture of dioxins, expressed as an amount of TEQ, is comparable to the toxicity of the same amount of pure TCDD.

In later parts of this document ("Is Agent Orange the only source of TCDD?" and "Can TCDD be measured in our bodies"), some of the cited references discuss amounts of TEQ and amounts of TCDD. For simplicity, only the term "TCDD" is used in those sections.

How much is a part per million (ppm)?

The term "part per million" is used to describe the concentration of one substance (the "part") contained within another substance (the "per million"). Using the example of 2 ppm TCDD contamination, every million parts of Agent Orange would contain 2 parts of TCDD. If the TCDD contamination were 2 ppm, then a 55-gallon drum of Agent Orange would contain 4 drops of TCDD. If the TCDD contamination were 47 ppm (such as an Agent Purple sample), a 55-gallon drum of Agent Purple would contain about one third of a one-ounce shot glass of TCDD.

How much is a part per trillion (ppt)?

A part per trillion is a very tiny amount. One ppt is equivalent to 1 second in about 32 000 years, 1 drop of water in 40 Olympic size swimming pools, or the distance of 1 centimeter (the width of your "pinkie" fingernail) in 1200 round trips between Fredericton and Vancouver.

How much TCDD did Agent Orange and Agent Purple contain?

It is not known with certainty how much TCDD was in the Agent Orange and Agent Purple used by the United States during the Vietnam War. Because TCDD was an unintended contaminant, it was not routinely measured at the time these herbicide mixtures were made. However, the TCDD content can be estimated from samples collected from these herbicides. A survey of 15 million pounds of Agent Orange (200 samples) conducted by the U.S. Air Force revealed that the average TCDD content of the mixture was 1.91 ppm (parts per million, equivalent to mg/kg), and 68% of the samples contained 0.5 ppm or less of TCDD (Kearney et al., 1973). Four saved samples of Agent Orange left over from testing at Eglin Air Force Base in Florida had a mean TCDD concentration of 2.4 ppm (range 0.04 to 6.4 ppm); an analysis of 490 Agent Orange samples from U.S. and Pacific inventories had an average concentration of 2 ppm (Young et al., 2004b). Recently, it has been suggested that these values are an underestimate, and that an average TCDD contamination of 13 ppm for Agent Orange may be more realistic (Stellman et al., 2003).

Less information is available for Agent Purple. In the testing of 200 Agent Orange samples mentioned above, the four highest TCDD values of 17, 22, 33, and 47 ppm were actually Agent Purple, and not Agent Orange (Stellman, 2003). One saved Agent Purple sample at Eglin Air Force Base contained 45 ppm TCDD (Young et al., 2004b).

Health effects

What health effects are associated with Agent Orange?

In 1991, because of uncertainty about the long-term health effects on Vietnam veterans of herbicide exposure, the U.S. Congress passed legislation that enabled the National Academy of Sciences' (NAS) Institute of Medicine (IOM) to perform a comprehensive evaluation of scientific and medical information regarding the health effects of exposure to Agent Orange.

In response to this legislation, the IOM conducts and publishes extensive reviews of scientific evidence regarding associations between health outcomes and exposures to TCDD and other chemical compounds in herbicides used in Vietnam. The IOM is widely considered to be the definitive source for medical information related to Agent Orange (Frumkin, H., 2003).

The IOM's most recent publication is "Veterans and Agent Orange: Update 2004" (http://www.iom.edu/report.asp?id=25476). The IOM has identified several health outcomes that are statistically "associated" with exposure to Agent Orange. Based on the scientific evidence available, the IOM has not concluded that exposure is the actual "cause" of these health outcomes.

With respect to Agent Orange, the IOM concluded there was "sufficient evidence of an association" for five health outcomes:

- Chronic lymphocytic leukemia (CLL)
- Soft-tissue sarcoma
- Non-Hodgkin's lymphoma
- Hodgkin's disease
- Chloracne

The IOM has also found "limited or suggestive evidence of an association" for another seven outcomes:

- Respiratory cancer (of lung and bronchus, larynx, and trachea)
- Prostate cancer
- Multiple myeloma
- Early onset transient peripheral neuropathy
- Porphyria cutanea tarda
- Type 2 diabetes
- Spina bifida in the children of veterans

According to the IOM, the designation "limited or suggestive" means that the scientific evidence of an association is limited because chance, bias and confounding could not be ruled out with confidence.

The vast majority of the associations noted above have only been observed in studies of heavily-exposed populations, such as workers involved in chemical manufacturing or who have applied herbicides for many years. The IOM states " many conclusions regarding associations between exposure to TCDD or herbicides and diseases are based on studies of people exposed in occupational and environmental settings rather than on studies of Vietnam veterans ".

What is the difference between an "association" and a "cause"?

As mentioned above (see " What health effects are associated with Agent Orange? "), the IOM has identified illnesses that are statistically associated with exposure to herbicides, but the IOM has not determined that herbicide exposure is the cause of any illnesses. The distinction is based on the quality of scientific evidence. According to the IOM, " factors such as consistency of evidence, biological plausibility, temporality, dose-response, and strength of association may be considered when deciding whether an observed statistical association is actually causal" . For evidence from scientific studies, if the findings between different studies are not the same, or if the connections between exposure and outcomes are not very strong, or if other potential causes of the illness have not been taken into account, or if there are problems in the way the study was designed, then the scientific evidence is too weak to conclude that an exposure is the cause of a health effect, even though an association may exist.

What are chance, bias, and confounding?

Chance refers to "the luck of the draw". To use a practical example, consider flipping a coin. Each time that the coin is flipped, there is an equal chance of it coming up heads or tails. If you flip "heads" 5 times in a row, that may be unusual, but it may simply be due to chance (if you flipped the coin 1000 times in a row, for example, a run of 5 "heads" in a row may occur on a number of occasions). Alternatively, if you flipped the coin 1000 times and it came up "heads" every time, it would be highly unlikely that this pattern would be due to chance and you may suspect that there is another explanation for this observation (some sort of "rigged" coin, perhaps one that has "heads" on both sides). What if the coin came up "heads" 10 times in a row? Without knowing for certain if the coin was "rigged", would you feel confident in concluding that your observation was not due to chance? If an association is observed between an exposure and an outcome, scientific study is required to determine if the observation is a "real" association, or simply due to chance. Scientific study relies on statistics to exclude chance. If a finding is "statistically significant", then it is unlikely that chance is the reason for the finding.

Bias refers to a systematic error in the design or conduct of a study. Continuing the coin example, suppose you flipped the coin and recorded the results each time. However, you only recorded the result when the coin came up "heads" and never recorded it when the coin came up "tails". After a while, you may notice from your recorded results that you have 100 "heads" in a row, but no "tails". If you then concluded that the coin was "rigged", this would be an incorrect conclusion because your observations were biased. Scientific studies must be carefully designed, conducted, and analyzed so as to ensure that there are no biases that may lead to false conclusions.

Confounding occurs when in addition to the specific exposure and the outcome that are being studied, there is an another factor related to both the exposure and the outcome. For example, perhaps it is observed that after eating roasted marshmallows, itchy bumps appear on the skin. These bumps may last for a few days and then go away, but they reappear after eating roasted marshmallows again. One may then conclude that eating roasted marshmallows is the cause of the itchy bumps on the skin. However, if you are roasting marshmallows, you are likely doing this outside, when the weather is nice, and mosquitoes are present. While you are roasting marshmallows, mosquitoes are also biting you, which is the real cause of the itchy bumps on the skin. In this example, the mosquitoes would be a confounding factor.

Under what circumstances might Agent Orange or its ingredients lead to health effects?

In order for a health effect to be potentially caused by a chemical, several things must happen.

Firstly, an exposure to the chemical must have occurred. "Exposure" means that the chemical entered one's body, usually through inhalation, ingestion, or skin contact. For example, a person walking past a large sealed barrel of Agent Orange would not receive any exposure, and so the risk of any possible health effects from Agent Orange would be zero.

Secondly, the exposure must be of sufficient dose (amount). A central principle of toxicology is the concept of dose-response: at increasing levels of exposure to a harmful substance, health effects become more frequent and/or more severe. For example, consider the use of a painkiller medicine such as morphine. If the prescribed amount is taken, pain will be relieved with minimal side effects. However, if too much morphine is taken, it can lead to breathing problems and death. The only difference between these two scenarios is dose - it is the dose that makes the poison. It is important to consider that we are all exposed to small amounts of TCDD every day, mostly through the food we eat (see " Is Agent Orange the only source of TCDD? " and " Can TCDD be measured in our bodies? "). At present, scientific knowledge cannot determine a specific level of TCDD exposure at which a health effect will occur. The scientific study of TCDD can only determine the level of risk for health effects given a certain exposure to TCDD. The

health risk from TCDD exposure will depend on the dose received. At very low doses of TCDD, the risk of health effects is very low and not detectable, but the risk increases as the dose of TCDD increases. For more discussion on "background" TCDD exposure and the amount of TCDD exposure that is associated with increased risks for health effects, please see " Is Agent Orange the only source of TCDD? ", " Can TCDD be measured in our bodies? ", and " What are the health risks associated with large exposures to TCDD? ").

Thirdly, the health effect in question must be associated with the chemical exposure. For example, we know that too much sun exposure is associated with an increased risk of skin cancer. If someone with a great deal of sun exposure develops emphysema (a lung disease), we would not attribute this lung condition with sun exposure, simply because there is no association between sun exposure and lung disease. The IOM has found evidence of an association between Agent Orange and several illnesses (see " What health effects are associated with Agent Orange? "). The IOM has also noted that several scientific studies have not shown any association with some other health problems, such as brain or gastrointestinal cancers. In other words, these cancers have never been associated with any amount of exposure. Therefore, if someone who was exposed to Agent Orange developed brain cancer, current scientific evidence indicates that it would be unlikely that the brain cancer was due to Agent Orange.

In conclusion, before a health effect can be considered to be associated with any substance, 1) there must be exposure, with the substance somehow having gotten inside a person, 2) the exposure must have been of a sufficiently large dose, or amount, to meaningfully increase the risk of a harmful effect (see " What are the health risks associated with large exposures to TCDD? ") and 3) the health effect in question must be scientifically associated with exposure to the substance. Unless these three criteria are satisfied, there is no medical or scientific reason to suspect that a health effect is due to the substance.

What are the health risks associated with large exposures to TCDD?

The adverse health effects associated with Agent Orange are believed to be due to TCDD, which current scientific evidence indicates to be carcinogenic. In other words, sufficient exposure to TCDD under certain conditions is believed to result in an increased risk of developing certain types of cancer. The human evidence that TCDD is carcinogenic is largely based on studies of highly exposed groups of industrial and agricultural workers (Pohl et al., 2002).

For example, one of the largest and most highly exposed industrial groups was made up of 5132 workers at 12 U.S. plants that produced chemicals contaminated with TCDD (Steenland et al., 1999). It was only the workers with the highest cumulative exposure to TCDD that had a greater

risk of dying from all cancers combined, as compared with the U.S. general population. In this study, the degree of cumulative exposure depended on the level of TCDD contamination of the manufactured chemicals. For example, to reach the level of exposure of the workers in the highest exposure group, for whom the elevated cancer risk was observed, workers would have to be exposed to a chemical containing 10 ppm TCDD for their entire shift every working day for about 8 years. At a higher TCDD contamination level of 50 ppm, workers would have to be exposed for the entire shift every working day for about 1.5 years to reach the same level of exposure. It was noted that " excess cancer was limited to the highest exposed workers, with exposures that were likely to have been 100 to 1000 times higher than those experienced by the general population " (Steenland et al., 1999).

The magnitude of the increased risk of death from all cancers combined was 1.6 (Steenland et al., 1999). This means that compared to the general population, these highly exposed workers were 1.6 times more likely to die of cancer than the general population (in scientific terms, this comparison is referred to as a "standardized mortality ratio"). The results of this study were consistent with other research into the cancer risks associated with TCDD. A recent scientific review article noted that " a number of large-scale retrospective cohort mortality studies have found significant increases in cancer mortalities (all types of cancer combined). These increases were typically found in workers exposed to the highest levels of dioxin [TCDD] and in workers with the longest follow-up periods. In general, the standardized mortality ratios were low (less than 1.5); however, the high degree of consistency between studies suggests that the increases in mortalities were not due to chance " (Pohl et al., 2002).

For illnesses other than cancer, a recent scientific review article indicates that the evidence from human studies has not been strong enough (for example, the results are inconsistent or the studies are not designed well enough) to estimate specific risks associated with TCDD exposure. A more detailed discussion can be found in the article, which concludes that " although more than a dozen different adverse effects have been reported in various studies of humans in the past 25 years, the most consistent clinically important adverse effect of human exposure appears to be chloracne " (Greene et al., 2003). Chloracne is a skin condition. Typically, this condition is only observed in people when the TCDD level in their blood is several thousand times greater than the levels typically seen in the general population (Greene et al., 2003; Hays et al., 2003).

Have Vietnam veterans in general been harmed by Agent Orange?

Veterans involved in herbicide handling and spraying in the Vietnam War were exposed to a number of different herbicide formulations (see "What is Agent Orange? "). Health studies of these veterans therefore look at the potential long-term health effects of herbicide exposures in general. These exposures were mainly to Agent Orange, but exposure to other herbicide formulations, such as Agent Purple, also occurred.

In comparison to heavily exposed industrial workers, Vietnam veterans were generally exposed to lower levels of TCDD. It is estimated that t he maximum TCDD dose experienced even by the US Air Force personnel directly involved in spraying ("Ranch Hand" veterans) was about one tenth of the maximum predicted dose of industrial workers (Akhtar et al., 2004).

The most recent study of death among U.S. Army veterans in general concluded that death rates due to chronic conditions, such as cancer or heart disease, were no different in veterans who served in Vietnam as compared to non-Vietnam veterans (Boehmer, 2004).

For the vast majority of Vietnam veterans, unless they were directly involved in the handling and spraying of Agent Orange, their exposure to Agent Orange would have been very small (Young et al., 2004a; Young et al., 2004c). A serum TCDD study of US Army Vietnam veterans who served as ground troops concluded that " most US Army ground combat troops who did not handle or spray herbicides were not heavily exposed to TCDD in Vietnam " (CDC, 1988). The greatest degree of Agent Orange exposure in Vietnam would have occurred among those veterans who directly handled or sprayed Agent Orange: Army Chemical Corps personnel and Air Force Operation Ranch Hand personnel.

Have Army Chemical Corps Vietnam Veterans been harmed by Agent Orange?

Army Chemical Corps veterans were involved in the storage, preparation, and application of a variety of herbicides in Vietnam. In a recent study, the death rate among Vietnam Army Chemical Corps veterans was not significantly different than non-Vietnam veterans for all causes, circulatory disease, or cancer. Vietnam veterans in this group had a higher risk of dying due to digestive system diseases, largely cirrhosis of the liver, as compared to non-Vietnam veterans. The authors noted, however, that their study design did not account for lifestyle factors that can also cause cirrhosis of the liver, such as alcohol use: " it is possible that heavier drinking among the Army Chemical Corps Vietnam veterans than among their non-Vietnam counterparts could account for the excess deaths from cirrhosis of the liver " (Dalager et al., 1997). The Vietnam veterans' risk of death from digestive system diseases, including cirrhosis of the liver, was not higher than the risk for the general U.S. population (Dalager et al., 1997).

Have Air Force Ranch Hand Vietnam veterans been harmed by Agent Orange?

The aerial spraying of herbicides in Vietnam was conducted under the name "Operation Ranch Hand", from 1962 to 1971. U.S. Air Force veterans who took part in Operation Ranch Hand handled and sprayed herbicides, and they are the Vietnam veterans with the greatest exposure to Agent Orange. These veterans have been studied closely in the Air Force Health Study, the purpose of which was to determine if the health of veterans who handled and sprayed herbicides in Vietnam had been harmed by this exposure. The Air Force Health Study was launched in 1980 and t he most recent and reportedly final report was released in July 2005 (see http://www.brooks.af.mil/AFRL/HED/hedb/default.html , click on "Reports" in the left margin, and then select "2002 Follow-up Examination Results: May 2002 to March 2005" to access the full report).

The Air Force Health Study examined more than 300 health-related outcomes in these veterans, grouped broadly into 12 areas. The overall significant findings in each area can be found in the executive summary of the 2005 report and are summarized below.

General Health: Measures of general health were not related to herbicide exposure. The one exception was that body mass index (a crude measure of body fat) was greater with increasing blood TCDD levels. It was noted that this possibly reflected " the pharmacokinetics of dioxin [TCDD] elimination " (higher body fat levels slow down the removal of TCDD from the body - as body fat increases, blood TCDD increases, but TCDD does not cause higher body fat).

Cancer: Mixed patterns of associations were found, but no consistent or meaningful patterns that would suggest that herbicide exposure caused cancer. The report stated that " these patterns did not suggest an adverse relation between cancer and herbicide exposure" . [The enlisted ground crew, the sub-group with the highest TCDD exposure, had a decreased risk of cancer, but this was not statistically significant (in other words, chance could not be excluded as the reason for the decrease).]

Neurology: Of the many neurological tests that were performed, only differences in pinprick sensation and reflexes were observed in those with the highest TCDD exposure, providing " some support for a relation between dioxin [TCDD] exposure and peripheral nerve function ".

Psychology: No measures of psychological health were associated with herbicides or TCDD exposure.

Gastrointestinal: Of the many tests performed, there was no association between the gastrointestinal test results and herbicide or TCDD exposure. The only exception was a relation between TCDD and higher levels of triglycerides, a type of blood fat. Although measurable, this relationship was not considered to be of any health significance.

Skin: There was no evidence of chloracne (which is associated with TCDD exposure) in the Ranch Hand veterans.

Cardiovascular: A variety of health outcomes were studied, such as heart attacks, heart disease, vascular disease, strokes, and high blood pressure. The 2005 report concluded that " overall, cardiovascular health did not appear to be adversely associated with herbicide or dioxin [TCDD] exposure ".

Blood System: Several factors were measured in the blood of Ranch Hand veterans. Overall, there was no indication of an " adverse relation between herbicide or dioxin [TCDD] exposure and any haematological [blood disease] diagnosis ".

Kidneys: There was no indication of " adverse relation between renal [kidney] function and herbicide or dioxin [TCDD] exposure ".

Hormones (Endocrine System): There was a slightly increased risk of Type 2 (adult-onset) diabetes among the Ranch Hand veterans with the highest exposure. There were no consistent findings relevant to health for thyroid or sex hormones.

Immune System: There was no consistent association of health significance between any measure of immune function and herbicide or TCDD exposure.

Lungs: There was no association between lung health and exposure to herbicides or TCDD.

The 2005 Air Force Health Study report concluded that overall, only type 2 diabetes was associated with exposure to TCDD among these veterans with the greatest herbicide exposure. The Ranch Hand veterans were not more likely to be diagnosed with Type 2 diabetes than the comparison veterans without significant herbicide expsoure, but their risk of Type 2 diabetes increased with increasing blood TCDD level. The study confirmed associations between diabetes and other known risk factors: diabetes was more common in veterans who were older, who were obese, who smoked, and who had a family history of diabetes. The 2005 report noted that " the epidemiologic studies suggest that any increased risk of Type 2 diabetes from herbicide or dioxin [TCDD] exposure is small when compared to the known predictors - family history, obesity, physical inactivity - for diabetes ". The IOM has also found limited or suggestive evidence of a link between adult-onset (Type 2) diabetes and herbicides used in Vietnam, including Agent Orange, but concluded that other traditional risk factors for diabetes far outweigh the risks of Agent Orange.

The most recent study of causes of death among Ranch Hand Vietnam veterans was published in May 2005. Compared to Vietnam veterans who did not spray herbicides, Ranch Hand

veterans did not have a greater risk of death due to cancer. When all Ranch Hand veterans were examined, the risk of death from all causes and from circulatory disease was slightly increased, but this was not statistically significant (in other words, chance could not be excluded as the reason for this slight increase). When only enlisted ground crew were examined, they had a slightly greater risk of death due to circulatory diseases than the comparison veterans. However, when veterans with serum TCDD measurements were examined, the risks of death from all causes, from cancer, or from circulatory disease were not significantly increased. In other words, those with measurable TCDD exposure did not have a greater risk of death from any cause compared to Vietnam veterans without significant herbicide exposure (Ketchum et al., 2005).

More information is available from the Air Force Health Study website (http://www.brooks.af.mil/AFRL/HED/hedb/default.html - click on "Articles" in the left margin for a summary of all published scientific studies of Operation Ranch Hand veterans).

Why have disability pensions been awarded in the US and Canada for illnesses associated with Agent Orange?

As a result of political and policy decisions, the US Veterans Administration automatically presumes that veterans who served in Vietnam were exposed to Agent Orange (http://www.va.gov/pressrel/aoiss400.htm). They are also required by law to presume that, if a veteran develops an illness that is among those associated with Agent Orange, the illness is related to military service (Section 2, US Agent Orange Act of 1991, Public Law No. 102-4). The IOM notes that they have not found that Agent Orange is the cause of any illness, that the associations they found were largely based on studies of heavily-exposed chemical and agricultural workers, and that their conclusions " are not intended to imply or suggest policy decisions ".

Veterans Affairs Canada grants pensions for service-related disabilities, with the pension process designed to give applicants every chance to show how their disability is related to military service. Veterans Affairs Canada requires evidence of exposure and a medical diagnosis of the condition (ie. illness, injury or disease) that the applicant believes is related to the exposure. Pension Adjudicators take into account the latest scientific evidence available to establish an association between the condition and exposure to Agent Orange during service. Pension Adjudicators have flexibility in weighing the evidence presented in individual cases and, in the absence of credible evidence to the contrary, any doubt that arises in weighing evidence regarding a service-related illness associated with exposure is resolved in the applicant's favour. In fact, the Department is obliged, under the Pension Act, to give the "benefit of the doubt" to the Veteran.

Fate in the Environment

What happens to Agent Orange after it is sprayed?

The environmental fate of Agent Orange has been described in a recent review article (Young et al., 2004a). For Agent Orange to be as effective a herbicide as possible, the maximum amount of spray had to reach the vegetation as quickly as possible. To achieve this, aircraft flew very close to the treetops in calm weather conditions to minimize the amount of spray drifting outside of the target area. Rapid settling of the spray droplets was also important. The spray system used during the Vietnam War used spray nozzles designed to produce a droplet size of 320 to 350 m m (over 98% of the droplets produced were greater than 100 m m). Droplets of this size generally fall rapidly. Tests at Eglin Air Force Base in Florida showed that 87% of sprayed herbicides hit the vegetation within one minute (the remaining 13% took longer to settle due to vortices at the wing tips, drift, or evaporation). US studies showed that even the droplets smaller than 100 m m would have hit the vegetation less than 3 minutes after spraying (Young et al., 2004a).

For spray drift beyond the target area to occur, herbicide would have to remain in the air for extended periods of time, where it would be rapidly degraded by sunlight. Aerial photographs of herbicide-sprayed areas in Vietnam show very distinct and sharp lines between treated (dead) and untreated (healthy) trees. Had there been significant drift either way from the swath of aerial spraying, traces of damage would have been visible as streaks of discoloured foliage (Young et al., 2004a).

The studies showed that little aerially-sprayed Agent Orange reached the forest floor as liquid droplets. In relatively undisturbed dense forests, the forest canopy intercepted 87-97% of the sprayed herbicide. Vegetation below the forest canopy also took up some of the spray, such that the underbrush or forest floor received about 1-6% of the total aerial spray. The Agent Orange that lands on plant surfaces is absorbed into the wax layer of the plant cuticle within minutes and cannot be physically dislodged (Young et al., 2004a) . Agent Orange left on the plant surface breaks down in sunlight within hours (Crosby et al., 1977). It is estimated that very little, if any, Agent Orange can be dislodged from the plant surface 24 hours after spraying (Young et al., 2004a). It is likely that due to the degradation by sunlight of TCDD on leaf surfaces that little material would be left by the time the leaves fall to the ground.

What happens to Agent Orange after it lands on the ground?

The main contaminant of concern in Agent Orange was TCDD. TCDD is not very soluble in water and binds tightly to soil particles. Estimates of the half-life of TCDD (the amount of time it will take for the concentration of TCDD to be reduced by half) on the soil surface range from 9 to 15 years, whereas the half-life in subsurface soil may range from 25 to 100 years (ATSDR, 1998). Because of tight binding to soil particles, TCDD is unlikely to leech into underlying groundwater (ATSDR, 1998). However, TCDD may enter surface water secondary to soil erosion and runoff. Although some of the TCDD that makes its way to surface waters will be broken down by sunlight or evaporate, most will remain strongly attached to small particles of soil or organic matter and eventually settle to the bottom. TCDD attached to this organic matter may enter the aquatic food chain. Small aquatic organisms absorb TCDD that is attached to sediment and organic matter in bodies of water. Larger fish then consume these smaller organisms and accumulate TCDD in their fatty tissues. Human consumption of contaminated fish is thus a potential route of exposure (ATSDR, 1998).

Root uptake and translocation to upper plant parts is very minimal. The ATSDR described a laboratory study in which plants were grown in soil heavily contaminated with TCDD: " the amount of 2,3,7,8-TCDD applied to these soils was many thousands of times greater than that which would occur in soils from herbicide applications containing a few ppm 2,3,7,8-TCDD as an impurity. Even upon exposure to these high concentrations in the soil, significant amounts of 2,3,7,8-TCDD could not be measured in plants " (ATSDR, 1998). The vast majority of TCDD found in plants is due to absorption of airborne TCDD that settles on the plant surface. This has been demonstrated in studies of fruits and vegetables that show TCDD concentrations in the outer peel that are up to ten times greater than the TCDD concentration in the pulp (ATSDR, 1998).

Herbicide testing was conducted at Eglin Air Force Base in Florida from 1962 to 1970, when roughly 75 000 kg of 2,4-D and 76 000 kg of 2,4,5-T (the ingredients of Agent Orange) were aerially sprayed on an area of less than 3 square kilometres. It is estimated that 3.1 kg of TCDD contaminant was released in this area. Because of the extent of the testing, each hectare on the Eglin test grid received at least 1300 times more TCDD than a hectare sprayed with Agent Orange in Vietnam. Much of the vegetation on the test site had been removed, allowing an opportunity to study ground-based residues that would not be affected by interception of the sprayed herbicides by the forest canopy (Young et al., 2004b).

Small but detectable levels of TCDD (in the parts per trillion range) were found in some soil samples 20 years after the last application of herbicide. It was estimated that the vast majority of TCDD that reached the ground had been degraded by sunlight within 24 hours of spraying and would not have persisted in the environment. For the small amounts of TCDD that were detected, the majority of TCDD was confined to the top 15 cm of soil, indicating that there was

little travel of TCDD deeper into the soil. In the years that followed the herbicide testing, vegetation growth gradually returned to normal, indicating that there was no persistent herbicide effect. Examination of animal species that lived in close contact with the soil did not reveal significant health effects (Young et al., 2004b).

In summary, very large quantities of herbicides were applied to the Eglin Air Force Base test site, far more than would be applied during typical aerial spraying, and far more that were used during the herbicide tests at CFB Gagetown June 14-16, 1966, and June 21-24, 1967 (see " How much Agent Orange was sprayed at CFB Gagetown? "). These herbicides were applied over areas where vegetation had been removed, thereby maximizing the amount of herbicide that reached the ground. No long-term negative effects on vegetation or wildlife were detected. Although TCDD could be detected in the soil years after the testing, the amounts present were extremely small and did not appear to have a significant adverse effect on the environment (Young et al., 2004b).

Is Agent Orange the only source of TCDD?

Agent Orange is not a significant source of TCDD in the environment. Most of the TCDD released into the environment comes from combustion sources, such as municipal and medical waste incineration, backyard burning of household waste such as plastics, cement kilns, forest and brush fires, and burning of fuel for agricultural purposes and home heating. TCDD can be formed in metals operations, such as aluminum smelting, steel production and scrap metal recovery. TCDD can also be formed as a byproduct in the manufacture of chlorine-bleached wood pulp and chlorinated chemicals (ATSDR, 1998; Hays et al., 2003; Sullivan et al., 2001; Travis et al., 1991).

Because of this past and continued production and release of TCDD, it is everywhere in our environment in very small quantities. Everyone is exposed to small amounts of TCDD every day, mostly through food (Birmingham et al., 1989; Gilman et al., 1991; Travis et al., 1991; Huwe, 2002). Cigarette smoke is also an important source of exposure (Muto et al., 1989). It has been estimated that the average Canadian or American adult takes in about 40-150 picograms of TCDD every day (ATSDR, 1998; Health Canada, 1994; Gilman et al., 1991). A gram is a relatively small amount: one teaspoon of water weighs about 5 grams and there are 450 grams in one pound. A picogram is a trillionth of a gram. Put another way, one picogram is one part per trillion of a gram (see "How much is a part per trillion (ppt)?"). Therefore, 40 to 150 picograms of TCDD is a very small amount, but it is equivalent to about 100 billion molecules of TCDD (see " Calculation "). Every day, the average adult is exposed to about 100 billion molecules of TCDD.

In a study of industrial workers for whom an elevated cancer risk was observed (see " What are the health risks associated with large exposures to TCDD? "), it was noted by the authors that " excess cancer was limited to the highest exposed workers, with exposures that were likely to have been 100 to 1000 times higher than those experienced by the general population " (Steenland et al., 1999).

Recently, the World Health Organization (WHO) established a tolerable daily dioxin intake equivalent to 1 to 4 picograms of TCDD per kilogram of body weight per day (http://www.who.int/mediacentre/factsheets/fs225/en/print.html), which is similar to other international health assessments (Pohl et al., 2002). Health Canada's tolerable daily intake value is currently under review, but will likely be equivalent to the WHO value. Based on the assessment of health authorities, the tolerable daily intake is the amount of TCDD that people can be exposed to every day of their lives without harm. The tolerable daily intake is expressed in a manner that takes into account differences in body weight between different people. For example, the tolerable daily intake of TCDD for a 70 kilogram adult is 280 picograms (4 picograms of TCDD per kilogram multiplied by 70 kilograms) per day. For a 80 kilogram adult, the tolerable daily intake would be 320 picograms (4 picograms of TCDD per kilogram multiplied by 80 kilograms) per day.

Can TCDD be measured in our bodies?

Because of continuous low-level exposure to TCDD, we all have measurable amounts of TCDD in our bodies, referred to as a "background" level of TCDD. It is estimated that in North America, the average body burden of TCDD (the amount of TCDD contained within our bodies) is 3-7 parts per trillion (ppt), measured either in body fat or in blood lipids (Hays et al., 2003; Travis et al., 1991, ATSDR 1998).

In comparison, the average serum level of TCDD in a sample of Ranch Hand personnel (who handled and sprayed herbicides in Vietnam) was 49 ppt in 1987, many years after exposure had occurred. Because half the TCDD in our bodies is naturally eliminated every 7-12 years (TCDD's half-life), it was estimated that 2 to 4 half-lives had passed since the time of their exposure and that their serum TCDD levels around the time of exposure had probably been several hundred ppt (MMWR, 1988). Other Vietnam veterans who did not directly spray or handle herbicides in Vietnam had body burdens of TCDD that were no different than normal background levels, in the range of 2 to 4 ppt (Young et al., 2005). A serum TCDD study of US Army Vietnam veterans who served as ground troops concluded, " most US Army ground combat troops who did not handle or spray herbicides were not heavily exposed to TCDD in Vietnam " (CDC, 1988).

It is estimated that the maximum TCDD dose experienced by Ranch Hand veterans was only about one tenth of the maximum predicted dose of industrial workers (Akhtar et al., 2004). In a study of heavily exposed industrial workers (for whom evidence of associations between TCDD and cancer was observed), the average estimated serum level of TCDD at the end of exposure was 1589 ppt, with a maximum value of 210 054 ppt (Steenland et al., 2001). People who have serum TCDD levels greater than 12000 ppt develop a skin condition known as chloracne (Greene et al., 2003).

We are all exposed to TCDD. It can be measured in our bodies. The risk of health effects associated with TCDD is entirely dependent on the degree of exposure, or dose (see "Under what circumstances might Agent Orange or its ingredients lead to health effects?").

Health Effects From Spraying in Gagetown

How much Agent Orange was sprayed at CFB Gagetown?

Agent Orange was one of a number of different herbicide mixtures tested at CFB Gagetown June 14-16, 1966, and June 21-24, 1967 . Several of these mixtures, including Agent Orange, contained the herbicide 2,4,5-T, which was potentially contaminated with parts per million of TCDD (see " How much TCDD did Agent Orange and Agent Purple contain? " for discussion). During the tests, records indicate that helicopters sprayed the herbicide in an unused and remote area of the base, not in proximity to any residential or working areas, under strictly controlled conditions, and with little to no wind. The total area sprayed by various herbicides containing 2,4,5-T (eg. Agent Orange, Agent Purple, and others) was 126.5 acres in 1966 and 12.0 acres in 1967, for a total of 138.5 acres, or about 0.6 square kilometres. The total amount of all herbicides containing 2,4,5-T that were sprayed during the 1966 and 1967 tests was 883 kg, of which 338 kg was Agent Orange and 267 kg was Agent Purple (AD 843989 Technical Memo 141, 1968; AD 842825 Technical Memo 145, 1968). On average, 1.6 grams of herbicides containing 2,4,5-T were sprayed per square meter.

What is the health risk for CF members exposed to Agent Orange and Agent Purple at CFB Gagetown?

The greatest amount of herbicide exposure resulting from the June 14-16, 1966, and June 21-24, 1967 tests would likely have occurred among those people who directly handled or were sprayed by herbicides. In considering their health risks, it is important to consider the concept of dose-response (see "Under what circumstances might Agent Orange or its ingredients lead to health effects?" and "What are the health risks associated with large exposures to TCDD?").

Most of the associations between TCDD exposure and health outcomes have been observed in heavily exposed industrial workers. Vietnam veterans with the greatest amount of herbicide exposure (Operation Ranch Hand veterans) had less overall TCDD exposure than heavily exposed industrial workers. Their long-term health outcomes are described above (see " Have Air Force Ranch Hand Vietnam veterans been harmed by Agent Orange?") . Personnel exposed to herbicides during June 14-16, 1966, and June 21-24, 1967 testing at CFB Gagetown would generally have had less exposure than Ranch Hand veterans, who on average spent more than a year in Vietnam (Akhtar et al., 2004).

Without knowing specific details of how the herbicides were handled during the June 14-16, 1966, and June 21-24, 1967 tests, subsequent activities that might have resulted in exposure, and the specific TCDD concentrations of the herbicides used, it is not possible to make definitive statements about the degree of potential exposure and health risks for particular individuals involved. Given the relatively small herbicide quantities applied, relatively brief duration of exposure, and the findings of health studies of more heavily exposed groups, the scientific evidence reviewed above suggests that the health risks would generally be lower than the risk for more heavily-exposed Vietnam veterans and lower still than the risk for the heavily-exposed industrial and agricultural workers on whom most of the Institute of Medicine associations are based.

With respect to CF members travelling through the targeted area after the spraying or conducting activities elsewhere in the training area, the evidence summarized above suggests that, in the absence of an unusual exposure incident, it is unlikely that they would have received a level of exposure significant enough to harm human health (Young et al., 2004a; CDC, 1988). (see "What happens to Agent Orange after it is sprayed?" and "What happens to Agent Orange after it lands on the ground?")

Has the health of CF members living in PMQs or in communities near CFB Gagetown been affected by Agent Orange?

The only study on the question of health effects of people living near CFB Gagetown was conducted in 1981 by Health and Welfare Canada and it looked at limited data and limited health information. In order to assess if the use of Agent Orange and other herbicides had resulted in detectable health effects in the communities surrounding CFB Gagetown, Sunbury County (which borders the area of CFB Gagetown where the June 14-16, 1966, and June 21-24, 1967 herbicide testing occurred) was the area chosen for study. Death rates due to all causes, circulatory diseases, and cancer were either lower or no different than expected (Wigle et al., 1981). Potential reproductive health effects were evaluated by studying the outcomes of babies

born around the time of spraying and in the months that followed. The study concluded that the herbicide testing at CFB Gagetown " resulted in no significant increase of adverse pregnancy outcome events in the population adjacent to Camp Gagetown "(Wigle et al., 1981). The study also noted " Based on climatic conditions, spray technique, knowledge of the chemicals used and the results of other studies it is unlikely that persons outside the confines of Camp Gagetown would have received a significant exposure to any of the defoliants tested " (Wigle et al., 1981). DND is assessing what further health study may be required.

The evidence summarized above and what is currently known about the spraying suggest that it is unlikely that the herbicides sprayed at CFB Gagetown June 14-16, 1966, and June 21-24, 1967 would have travelled a significant distance beyond the target area or resulted in sufficient environmental contamination to harm human health (see "What happens to Agent Orange after it is sprayed?" and " What happens to Agent Orange after it lands on the ground?").

I know of people in the communities near CFB Gagetown who are sick or dying - isn't this due to Agent Orange?

Sufficiently great exposure to TCDD-containing herbicides could potentially increase the risk of illnesses associated with Agent Orange (see " Under what circumstances might Agent Orange or its ingredients lead to health effects?" and "What are the health risks associated with large exposures to TCDD ? ").

Unfortunately, it is rare for anyone to live his or her entire life without any sort of health problem. The Public Health Agency of Canada contains a wealth of information on the burden of disease in Canada (http://www.phac-aspc.gc.ca). For example, by the middle of 2005, more than 35 000 Canadians had died of cardiovascular disease and more than 30 000 Canadians had died of cancer (http://www.phac-aspc.gc.ca/ccdpc-cpcmc/index_e.html). According to Diabetes in Canada Second Edition (2002), it is estimated that 30 000 Canadians die each year from diabetes and diabetes-related complications (http://www.phac-aspc.gc.ca/publicat/dic-dac2/english/01cover_e.html). According to Congenital Anomalies in Canada 2002, roughly 2 to 3% of babies in Canada are born with a serious congenital anomaly, usually with no family history or known risk factors (http://www.phac-aspc.gc.ca/publicat/cac-acc02/index.htm l). According to Canadian Cancer Statistics 2005 (http://www.cancer.ca/ccs/internet/standard/0,,3172_14291__langId-en,00.html), the lifetime probability of developing cancer for males is 44% and for females is 38%. In other words, the average Canadian male has a 1 in 2.3 chance and the average female has a 1 in 2.6 chance of developing cancer in their lifetimes. Males have a 29% and females a 24% chance of dying from cancer in their lifetime; roughly one chance in four for the two sexes combined. It is estimated

that in 2005, 448 out of every 100 000 men in Canada and 355 out of every 100 000 women will develop cancer. Roughly 149 000 Canadians will be diagnosed with cancer and 69 500 Canadians will die from cancer in 2005.

In New Brunswick, it is estimated that 3 900 people will be diagnosed with cancer and 1 800 people will die of cancer in 2005. In order to compare these numbers for New Brunswick with the rest of Canada, it is necessary to look at standardized cancer rates, which take into account differences in age and population size between provinces. The rates of new cancer diagnoses and cancer deaths in New Brunswick are higher than the Canadian average, but the New Brunswick rates are generally the lowest of the Maritime Provinces (Canadian Cancer Statistics, 2005).

There are many potential causes and risk factors for the illnesses that affect Canadians. Of all the people who have or will develop these illnesses, few have been exposed to Agent Orange or Agent Purple.

What about other herbicides used at CFB Gagetown that contained some of the same ingredients as Agent Orange?

A total of 251 products containing 2,4,5-T, which contained TCDD contamination, were registered for use in Canada between 1948 and 1981. The last product was registered in 1981, but thereafter the registration of all of these products was discontinued. For information on 2,4-D, which is still registered for use in Canada, see the following Health Canada website: http://www.pmra-arla.gc.ca/english/consum/2,4-DFAQ-e.html.

DND's use of herbicides will be reviewed over the next several years. Some of the health information noted above would also generally apply to other chemical exposures, in that the risk for adverse health effects would depend on the dose and duration of exposure (see especially "Under what circumstances might Agent Orange or its ingredients lead to health effects?").

What can I do to know more?

Talk to your MO and look at these or any other references for yourself. If you do not see a web link to a reference you would like, ask your MO for a copy and an explanation of any technical language or concepts that are not clear to you. Although there are many other sources of information, the references consulted are trusted by the Surgeon General, are believed to be based on sound scientific evidence and analysis, and are believed to represent the general consensus about Agent Orange in the medical and scientific community. Do not hesitate to consult your MO if you have questions about this or any other health concern.

Resources And References

Calculation

(See discussion in " Is Agent Orange the only source of TCDD? ")

- average daily TCDD intake estimates: 47 pg/day (ATSDR, 1998); 39-147 pg/day (Health Canada, 1994; Gilman et al., 1991): assume 50 pg/day daily intake
- 1 pg = 10 -12 g
- molecular weight of TCDD = 321.96 g/mol
- Avagadro's number = 6.022 x 10 23

50 pg/day) x (10 -12 g/pg) x (1 mol/321.96 g) x (6.022 x 10 23 molecules/mol

= 9.35 x 10 10 molecules/day (93 500 000 000 molecules per day)

Agent Orange, TCDD ("dioxin"), and Herbicide Resources

U.S. Institute of Medicine

- Veterans and Agent Orange 2004 Update: http://www.iom.edu/report.asp?id=25476

U.S. Air Force Health Study

- http://www.brooks.af.mil/AFRL/HED/hedb/default.html (click on "Articles" in the left margin for a summary of all published scientific studies of Operation Ranch Hand veterans; click on "Reports" in the left margin, and then select "2002 Follow-up Examination Results: May 2002 to March 2005" to access the most recent report)

U.S. National Agricultural Library special collection on Agent Orange:

- http://www.nal.usda.gov/speccoll/findaids/agentorange/index.htm

Health Canada

- It's Your Health": http://www.hc-sc.gc.ca/iyh-vsv/environ/dioxin_e.html

Health Canada's Pest Management Regulatory Agency

- Information on 2,4-D and other herbicides: http://www.pmra-arla.gc.ca/

Agency for Toxic Substances and Disease Registry (ATSDR)

- Public Health Statement: http://www.atsdr.cdc.gov/toxprofiles/phs104.html

World Health Organization

- Fact Sheet: http://www.who.int/mediacentre/factsheets/fs225/en/print.html

U.S. Environmental Protection Agency (US EPA)

- Questions and answers: http://www.cfsan.fda.gov/~lrd/dioxinqa.html

European Union

- Dioxin exposure and health: http://europa.eu.int/comm/environment/dioxin/

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Who Do I Contact? / Requests for Information

Do you have information about the use of herbicides at CFB Gagetown?

If you do, the Government of Canada encourages you to share that information and discuss your experience by participating in its Fact Finding Initiative.

The Government of Canada does not consider any information about the use of herbicides (including Agent Orange) at CFB Gagetown to be secret. Disclosure of this information will not be considered a breach of the Security of Information Act (formerly known as Official Secrets Act) or of any other obligation of confidentiality.

If you wish, the information you provide will be kept confidential (unless a court orders otherwise).

The information you provide will not jeopardize your:

- Canada pension plan;
- VAC disability pension; or
- Canadian Forces pension plan

Former Canadian Forces members, DND employees and civilian contractors should follow the steps outlined below if they feel they have suffered health problems stemming from exposure to Agent Orange:

Former and Current CF Members

Veterans Affairs Canada's mandate is to provide disability pension and health care services to Canadian Forces veterans who suffer a service-related illness or disability.

Former and still-serving Canadian Forces members who think they have a service-related illness are encouraged to contact Veterans Affairs Canada.

The Veterans Affairs Canada national referral numbers are 1-866-522-2122 (English) and 1-866-522-2022 (French). Information is also available on their website at http://www.vac-acc.gc.ca/.

Inquiries can also be made to the Centre for the Support of Injured and Retired Members and Their Families (The Centre) at 1-800-883-6094 or by visiting the Centre's website at www.forces.gc.ca/centre.

Former and Current Employees of the Department of National Defence

Current and former employees of National Defence who feel they may suffer from an occupational illness as a result of exposure to Agent Orange during the course of their employment may submit the details of their claim to the DND Civilian Human Resources Office in Gagetown. Current employees should submit their claims through their normal local management contacts to ensure that their claims are processed in the most efficient manner possible. Former employees should submit the details of their claim to:

Civilian Human Resources Office Atlantic Civilian Human Resources Service Centre Compensation Administrator CFB/ASU Gagetown P.O. Box 17000 Station Forces Oromocto, New Brunswick E2V 4J5

Instructions on the completion of claims and the forms can be found at the following website: http://www.whscc.nb.ca/forms_e.asp#frmwrk.

Former and Current Federal Government Employees

The Government Employees Compensation Act (GECA) provides compensation benefits to the employees of federal departments, agencies and Crown corporations for injuries and illnesses arising from their employment. It covers approximately 400,000 employees across Canada. Information on the GECA can be found on the Federal Workers' Compensation Service website at http://www.hrsdc.gc.ca/asp/gateway.asp?hr=en/lp/lo/fwcs/geca.shtml&hs=fxf.

The Minister of Labour and Housing has agreements with the ten provincial workers' compensation boards to adjudicate claims under GECA. Federal employees receive benefits based on the rates and conditions of the province where they are usually employed.

Compensation claims for employees working in New Brunswick should be forwarded to the Regional Injury Compensation Unit, Human Resources Skills Development Canada, in Moncton, New Brunswick, for transmission to the New Brunswick Workplace Health, Safety and Compensation Commission.

Their mailing address is:

1045 Main Street Moncton, New Brunswick E1C 9G8

Former and Current Civilian Contractor Employees

The Workplace Health, Safety and Compensation Commission of New Brunswick provides accident prevention services, occupational health and safety assistance and cost-effective disability and liability insurance to workers and employers in New Brunswick. It also administers pension benefits related to workplace accidents and workplace related illnesses.

Former and current employees of civilian contractors who believe that they may have been exposed to Agent Orange and Agent Purple during the 1966 and 1967 testing conducted at CFB Gagetown can apply for compensation to the Workplace Health, Safety and Compensation Commission of New Brunswick.

Queries should be referred to Mr. Omer Robichaud at (506) 738-4150.

Information can also be found on the New Brunswick Workplace Health, Safety and Compensation Commission website at http://www.whscc.nb.ca.

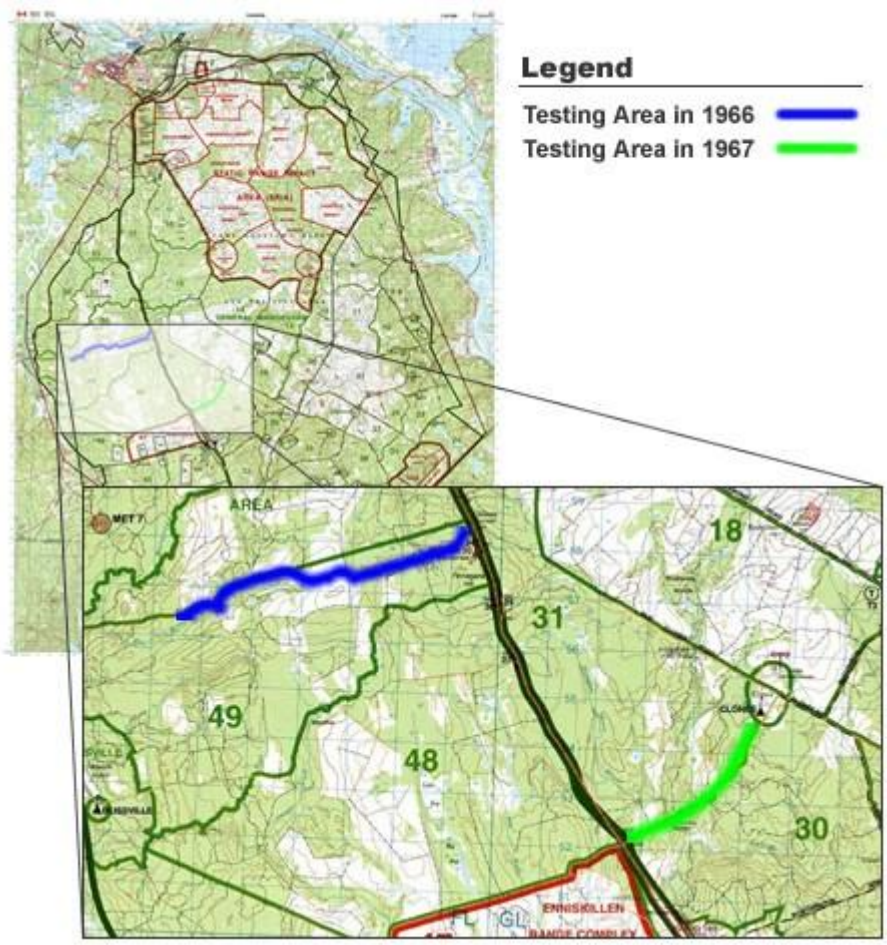
Our Neighbours

Based on the information we have to date, it is unlikely that civilians outside the base were exposed to Agents Orange or Purple as a result of this testing. Nevertheless, we understand and acknowledge the concerns expressed by some individuals. We take such concerns very seriously. DND will continue to work with key departments to research this issue and to communicate the information to concerned citizens in a timely fashion.

If there is evidence that civilians were exposed to Agents Orange and/or Purple during the testing in 1966 and 1967, the Government of Canada will deal with the issue.

The Government of Canada has also established a toll-free number to assist people with general inquiries related to this matter. The number is 1-866-558-2945 and it is operated from 8:00 a.m. to 4:30 p.m. (EST) daily, Monday to Friday.

Gagetown Range and Training Area



This map is also available for download:

- 762 x 1000 pixels (JPG - 562 Kb)
- 2305 x 3023 pixels (JPG - 3711 Kb)

Frequently Asked Questions

What are dioxins?

Dioxins encompass a large family of about 200 chemicals. Certain types of dioxins (2,3,7,8-TCDD) are much more toxic than others and are classified as "dioxins of concern."

In the past, some herbicides were contaminated with dioxins. In light of emerging knowledge and concerns regarding dioxins, the manufacturing processes of herbicides have been improved

to reduce or eliminate such contamination. In the case of 2,4-D for example, manufacturing processes were modified in the early 1980s to essentially eliminate contamination with dioxins of concern.

Is Agent Orange the same as any 50:50 mixture of 2,4-D and 2,4,5-T?

No. Agent Orange and other "Agent" chemicals were never registered for use in either Canada or the U.S. These "Agent" chemicals were manufactured specifically for the U.S. military. Some of the manufacturing processes of these military "Agent" chemicals were different than the manufacturing processes of registered herbicides. Production was accelerated to supply the U.S. military with the large quantities needed for use in Vietnam. There are reports that the accelerated manufacturing processes sometimes resulted in higher dioxin levels for Agents Orange and Purple than for registered herbicides of similar formulation.

Why are the dioxin levels in soil samples from Ripon Road and the Clones and Murphy Bivouacs not a concern if levels are much higher than the Canadian Council of Ministers of the Environment (CCME) guidelines?

The Canadian Council of Ministers of the Environment (CCME) soil quality guideline for dioxins of 4 parts per trillion is based on the average or background level of dioxins typically found in Canadian soils. The risks associated with background levels of dioxin in soil is considered to be minimal.

It is not uncommon to find levels across the country that are higher than the background levels. These higher levels can be from numerous sources, including forest fires and natural geological anomalies. However, when dioxin levels in soil are higher than average, it does not automatically mean that there would be a risk of adverse health effects. The key to determining whether there is any risk is to look at the combination of the dioxin level in the soil, how people might have been exposed and for how long they may have been exposed.

In the case of CFB Gagetown, a site-specific risk assessment was conducted to estimate the exposures that people could receive from the levels of dioxins measured in the soil. The independent contractor concluded that there is no increased risk of dioxin-related illness from living or working at CFB Gagetown today.

In the task 3A-2 report, it confirms that dioxins were detected in every single soil sample that was taken. Does this mean that the whole base is contaminated with dioxins?

As explained above, dioxins naturally occur in the environment and are released from many sources, including forest fires. They are often found in soils across Canada.

TASK 3A-1: TOXICOLOGICAL RISK ASSESSMENT PERTAINING TO POTENTIAL OCCUPATIONAL AND RELATED EXPOSURES ASSOCIATED WITH HERBICIDE SPRAYING OPERATIONS AT CFB GAGETOWN – TIER 1 – 1966-67 U.S. TRIALS – MANUFACTURING IMPURITIES (CONTAMINANTS)

- FINAL REPORT -

The Contents Of This Report Encompass Task 3A-1, Tier 1 Portion Of:

"Investigation of Potential Health Effects from The Use of Herbicides and any Herbicide-Related Contaminants, Particularly Dioxins Used at CFB Gagetown From 1952 to the Present"

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July, 2006







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2.0 DESCRIPTION OF TIER 1

In March, 1965 the Canadian Ministry of Defence offered Crops Division of the Department of the Army of the United States the use of large areas of densely forested land at CFB Gagetown for the purpose of testing defoliant chemicals then under testing for use in Southeast Asia (Demaree and Creager, 1968). A test site that contained a mix of conifers and deciduous broadleaf species was selected for carrying out this experimental test program. It was determined that this dense, undisturbed forest cover was similar to vegetation densities encountered in temperate and tropical areas of Southeast Asia. This suggests that data regarding important factors such as rates of application and deposition that have been developed for exposure models used for Vietnam (Stellman and Stellman, 2004) were similar to the experimental applications of herbicide at CFB Gagetown. This data can be used where data specific to activities at CFB Gagetown are lacking.

The tests occurred over a few days during the two year period, with separate areas tested in 1966 and 1967. The two areas of CFB Gagetown that were affected by herbicide application in 1966 and 1967 are shown on the map below (Figure 2-1).

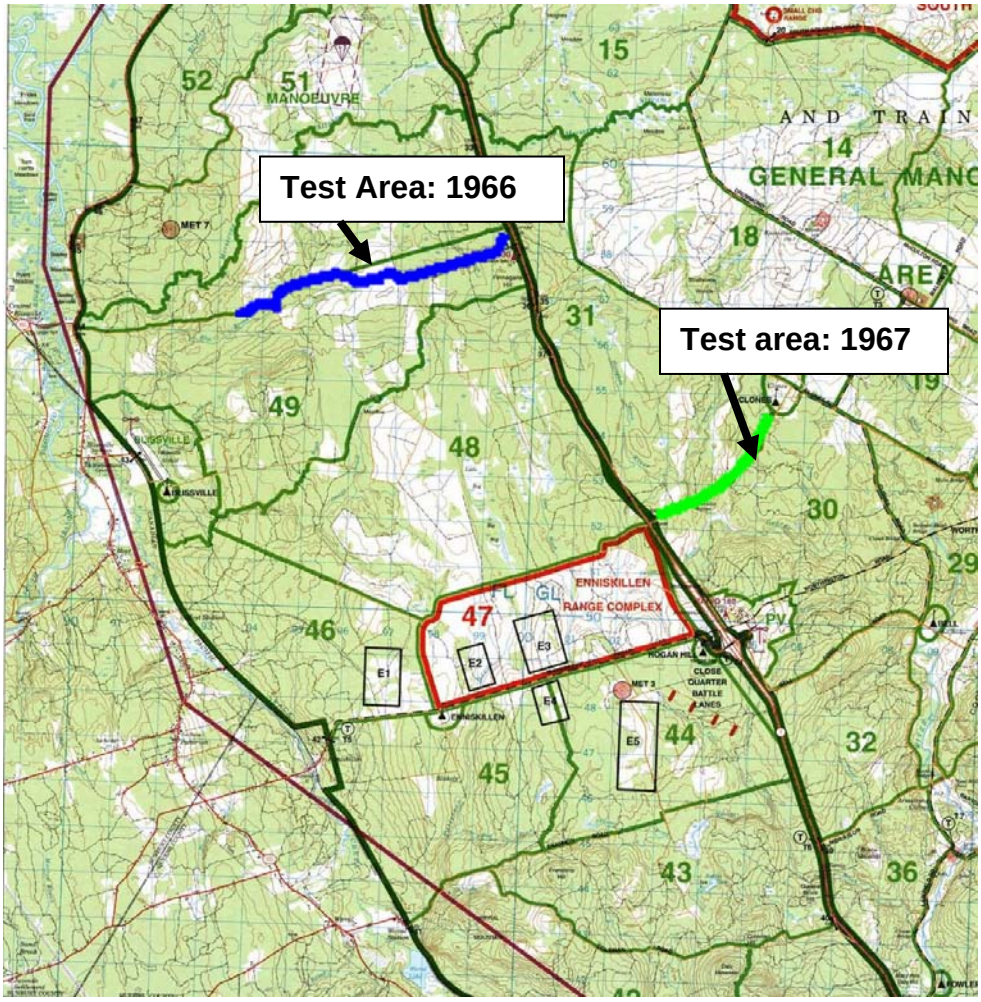


Figure 2-1 Map Section of CFB Gagetown Showing Area of Herbicide Application for 1966 (shown in blue) and for 1967 (shown in green)

The test area used in 1966

The test site at CFB Gagetown that was used in 1966 was approximately 360 m (1,200 ft) wide by 6.4 km (4 miles) long. The height of vegetation ranged from 6 to 22.5 m (20 to 75 ft). The terrain was difficult to navigate, and could only be accessed along an east to west oriented path by tracked vehicles. Clearly it was not easy for an individual on foot to move quickly from one part of the test area (characterized as 'mud and mire' by Demaree and Creager (1968)) to another. A total of eight enlisted men and three Officers (the Commanding Officer, a Range Officer and a co-pilot) from the Canadian Military were listed as participating in the project (Demaree *et al.*, 1966).

A total of 116 plots were prepared for the test applications of herbicides of various kinds. Ten of the 116 plots received no herbicide of any kind. Each plot was 200 ft by 600 ft wide (60 m x 180 m) and plots were separated by from one another by a 100 ft buffer zone. Each plot was 2.75 acres (1.1 hectare) in area. These were established on either side of the access trail with fifty-two plots on the north side and sixty-four to the south (the width of the access buffer strip was not specified but can also be presumed to be 100 ft (30 m). The corners of each plot were marked and one corner was identified by the plot number.

Application method used in 1966

A helicopter was used for all test applications. Sorties (missions) were flown from a small airstrip located outside Blissville, NB, approximately 2 to 4 miles from the test area.

All herbicides were applied from a U.S. Army helicopter supplied for the tests. The spray apparatus consisted of a boom that extended 25 ft either side of the helicopter, an electric pump and a 200-gallon holding tank. Spray nozzles were located at intervals of six inches along the boom (fifteen in total per boom). Delivery of herbicide for application was metered *via* the nozzles which were designed to deliver a specified size of droplet at a specified rate (Note: The rate of application could not be changed for the entire operation. Variation in concentration of the herbicide applied to each test plot was achieved by dilution of herbicide loaded into the tank aboard the helicopter or by repeated passes). The aircraft flew at a speed of 65 knots at treetop level (~15 feet over the canopy). Each concentration of herbicide was applied in duplicate to pairs of plots that were well separated geographically, and each plot received a series of four passes (50 ft x 4 = 200 ft per plot) to complete coverage (Demaree and Creager, 1968).

Plots were flagged at each corner to orient the pilot and the flagman stood on the trail halfway between plot markers. Flags were on extensible poles approximately 50 ft in height. In the event that the flag did not reach the surface of the canopy (was not visible from the air) a smoke signal was used. A system of time runs were used during application such that activation of the spray equipment was initiated at the flag and terminated after the number of seconds of flying time equal to the six hundred feet of test plot length (Demaree and Creager, 1968).

Accuracy of application was an important goal of the project. The same pilot was used throughout this test process to minimize variability. However, it might be expected that on some occasions the flagger on the ground received direct exposure to spray delivered at very low level (~90 ft). In addition for some runs in which 2 or three gallons per acre was applied double (8) or triple (12) the number of passes was required to complete the required coverage with herbicide.

Spray applications took place over a thirty hour period, from daylight to dark on June 14th, 15th and 16th , 1966. According to Demaree and Creager (1968), weather conditions during spraying was influenced by a low pressure atmospheric condition resulting in little or no wind. Some rainfall was noted over the three day period (Last *et al*., 1981).

The test area used in 1967

In 1967 thirty-seven (37) plots located on Rippon Road, east of Broad Road in the area of CFB Gagetown situated approximately ten miles (16 km) from the borders of the base were sprayed. Each plot measured 200 ft by 660 ft (3.0 acres) or slightly larger than plots from 1966. Plots were treated in duplicate but at a fixed volume of 3 gallons per acre (Demaree and Haws, 1968).

Unlike the report prepared for 1966, in 1967 no indication or record was kept to show which of the test plots received a particular herbicide preparation (Demaree and Haws, 1968). For the purposes of this assessment, plots located on either side of the road were deemed duplicates. Each plot received exactly the same measured volume of herbicide (no multiple passes were reported).

Application method used in 1967

Plots were sprayed using a civilian helicopter. The aircraft again performed time and distance flights to deliver the fixed amount of herbicide across the area of the plot. The aircraft flew at forty knots (40 kn) at treetop height.

Plots were flagged only at the corners adjacent to the road. The bush on either side of Rippon Road was characterized as very dense and impenetrable (Demaree and Haws, 1968). Other conditions of spray application were analogous to the tests carried out in 1966. The 1967 tests occurred between June 21st and 24th, 1967. Demaree and Haws (1968) reported unfavourable weather conditions during spraying; however, no details were provided.

Herbicide applications from 1966 and 1967 addressed in this report

The focus of this report is on the contaminants present in some herbicide products applied at CFB Gagetown in the U.S. trials in 1966 and 1967. The chemicals of concern addressed in this report are:

1. 2,3,7,8-Tetrachlorodibenzo-*p*-dioxin (TCDD), present in various forms of 2,4,5-T, which were components of Agent Orange and Agent Purple and an unregistered mixture that contained 2,4,5-T in acid form. At the time of application, there was no discernible contamination of 2,4-D by PCDDs or PCDFs;
2. A second contaminant of concern was hexachlorobenzene (HCB) present as a contaminant in picloram (Tordon formulations Tordon 22K and Tordon 101);
3. One herbicide formulation (M-2993) contained both 2,4,5-T (contaminated with TCDD) and picloram (contaminated with HCB); and,
4. A third group of contaminants present in one herbicide preparation that was applied (only in 1967) was PCDDs and PCDFs in pentachlorophenol (PCP).

The following Table (2-1) contains a summary of herbicide applications that occurred in 1966 and 1967. Only those herbicide products known to have been contaminated with either dioxins or HCB have been included. Other active ingredients will be addressed as part of the Tier 3 risk assessment. Information related to application rates has been obtained from Demaree and Creager (1968) and Demaree *et al.*, (1966) for 1966 and Demaree and Haws (1968) for 1967.

Table 2-1 Summary of Herbicide Application in 1966 and 1967

Herbicide Product	# of Plots	Application Rate (herbicide product)		
		gallons/acre	pounds/acre	g/m^2
1966				
Agent Purple (no diluent)	2	1	10.5	1.18
	2	2	21.0	2.35
	2	3	31.5	3.53
Agent Purple (1:1 dilution)	2	1	5.25	0.59
	2	2	10.5	1.18
	2	3	15.75	2.35
Agent Purple (1:2 dilution)	2	3	10.5	1.18
Agent Orange (no diluent)	2	1	10.5	1.18
	2	2	21.0	2.35
	2	3	31.5	3.53
Agent Orange (1:1 dilution)	2	1	5.25	0.59
	2	2	10.5	1.18
	2	3	15.75	2.35
Agent Orange (1:2 dilution)	2	3	10.5	1.18
70% 2,4-D & 30% 2,4,5-T	2	1	10.5 (combined)	1.18
(no diluent)	2	2	21.0	2.35
	2	3	31.5	3.53
70% 2,4-D & 30% 2,4,5-T	2	1	5.25 (combined)	0.59
(1:1 dilution)	2	2	10.5	1.18
	2	3	15.75	2.35
Agent White (Tordon 101)	4	1	0.27 (picloram)	0.03
(1:1 dilution)	4	2	0.54	0.06
Tordon 22K (1:1 dilution)	4	1	1	0.11
	4	2	2	0.22
	4	3	3	0.33
Tordon 22K (1:3 dilution)	2	1	0.5	0.06
M-2993	2	1	0.5 (picloram)	0.055
(picloram & 2,4,5-T)	2		2.0 (2,4,5-T)	0.11
(1:1 dilution)		2	1.0 (picloram)	0.22
			4.0 (2,4,5-T)	0.44
M-2993	2	2	0.66 (picloram)	0.073
(picloram & 2,4,5-T)			2.66 (2,4,5-T)	0.29
(1:2 dilution)				
1967				
Agent Orange	3	3	26	2.91
Timbertox (pentachlorophenol)	2	3	12	1.35
HCA + 2,4,5-T	2	3	6	0.67
Tordon 22K	6	3	2	0.22
	4	3	3	0.34
	4	3	4.5	0.5
M-3142 (picloram ester)	2	3	6	0.67
Agent White (Tordon 101)	2	3	1.6	0.18

Agent Orange: Equal volumes of concentrated *n*-butyl esters of 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-T herbicides. No 2,4,5-T that was manufactured later than 1970.
Agent Purple: both *n*-Butyl ester (30%) and *iso*-Butyl ester (20%) of 2,4,5-T and the *n*-Butyl ester of 2,4-D. Initially formulated in 1953.
Agent White [Tordon 101]: 1:4 mixture of triisopropanolamine salt of picloram (4-amino-3,5,6-trichloropicolinic acid and 2,4-D.

Appendix A provides details related to the levels of contaminants in the herbicide products used in 1966 and 1967. Appendix A1 provides details related to dioxin contamination and Appendix A2 provides details related to HCB contaminant levels. This information is also summarized in Tables 2-2 and 2-3.

For the purposes of the current assessment all Agent Purple was assumed to be contaminated at levels ranging from 17 to 45 ug TCDD/g AP (ppm TCDD mass:mass) (average of 33 µg/g). All Agent Orange was assumed to have levels of contamination by TCDD ranging between 0.02 and 15 ug TCDD/g AO (average of 2 µg/g). For all other products that contain 2,4,5-T, as the phenoxy acetic acid, the level of contamination by TCDD was assumed to be similar as for Agent Orange. Contaminant levels in PCP ranged from 2.2 to 45 ug TEQ/g PCP (mean value of 9.2 ug TEQ/g PCP). The HCB content in Picloram was determined to be 200 ug HCB/g Picloram (ppm mass:mass).

Table 2-2 Contaminants in Herbicides Applied to Test plots in 1966 (66 of 116 plots)

Number of Plots	Herbicide	Contaminant	Contaminant Concentration (µg/g; ppm mass:mass)		
			Low	Central (mean)	High
1966					
14	Agent Orange containing 2,4,5-T butyl ester	TCDD	0.02	2	15
14	Agent Purple containing 2,4,5-T isobutyl ester	TCDD	17	33	45
12	Other herbicides containing 2,4,5-T acid	TCDD	0.02	2	15
6	M-2993 (picloram and 2,4,5-T)	TCDD HCB	0.02 200	2 200	15 200
20	Picloram	HCB	200	200	200
40	Diquat or cacodylic acid mixtures	--	--	--	--
10	Not sprayed	--	--	--	--

Table 2-3 Contaminants in Herbicides Applied to Test Plots in 1967 (25 of 37 plots)

Number of Plots	Herbicide	Contaminant	Contaminant Concentration (µg/g; ppm mass:mass)		
			Low	Central (mean)	High
1967					
2 (or 3)	Agent Orange containing 2,4,5-T	TCDD	0.02	2	15
2	2,4,5-T	TCDD	0.02	2	15
18	Picloram	HCB	200	200	200
2	Pentachlorophenol (PCP)	PCDDs and PCDFs	2.2 (TEQ)	9.2 (TEQ)	45 (TEQ)
12	Preparations that did not include focus contaminants	--	--	--	--

- Detailed analysis for exposure-related health effects was not possible due to the nature of the data that were available. It was not possible to calculate herbicide-specific population attributable risk estimates. It was also not possible to comment, due to the fact that individual level information was not available, on the extent to which other known risk factors, such as smoking or genetic factors, influenced the health findings. Due to the uncertainty of the data, absence of evidence from these analyses does not necessarily mean that there were no health effects resulting from the exposures to the CFB Gagetown herbicides.

Summary

In summary, the results of the conservative assumptions used in the human health risk assessment (HHRA) proposed that only certain identifiable segments of the population may have been at greater risk for developing adverse health outcomes that could be linked to herbicide use at CFB Gagetown. The epidemiological literature review assisted to identify priority health outcomes that might be observed in this population. Due to data limitations and other difficulties in identifying the key population of interest (those exposed to the agents), the epidemiologic investigation was constrained to a study of primarily the cancer experience of residents of the Gagetown Study Region. No overall consistent patterns of significantly increased risk emerged over the four study time periods. Though this investigation provided preliminary information about the number of cases and suggestive increased risks for certain disease outcomes during more recent time periods, significant limitations precluded drawing conclusions that there was or was not an increased risk in CFB Gagetown exposed personnel. Further research may potentially provide more detailed evidence of effects in support of predictions of the HHRA.

Recommendations for Future Research

Based upon the findings from the risk assessment, further investigations into the state of health of individuals who were directly involved with herbicide applications and post application brushclearing activities, are warranted. These further investigations could involve either targeted epidemiological evaluation of these populations or body burden analysis. The epidemiological studies might focus on the 'at risk' CFB Gagetown populations, as described above. Due to the period of time that has lapsed since exposures occurred, predictions indicate that in even the most highly exposed individuals, body burdens would likely be indistinguishable from the general population and will likely not be helpful.

Feasibility studies would be needed to determine whether the populations at risk have been documented in a systematic way, and whether these records contain details about when and where these individuals worked, before a larger epidemiological study could go forward. Power calculations would also be required to estimate the likelihood that sufficient numbers of cases have occurred to allow a meaningful analysis. As encountered in the descriptive epidemiological study, small numbers limit the likelihood of finding statistically significant conclusions. Other study design issues, such as problems of survival of those who may have been highly exposed, and sources of study bias, would need to be carefully considered before proceeding with such an investigation.

APPENDIX H

PEER REVIEW COMMENTS, HEALTH CANADA COMMENTS AND CANTOX ENVIRONMENTAL RESPONSE TO COMMENTS

Peer Review of Task 3A-1: Toxicological Risk Assessment Pertaining to Potential Occupational and Related Exposures Associated with Herbicide Spraying Operations at CFB Gagetown – Tier 1 – 1966-67 U.S. Trials – Manufacturing Impurities (Contaminants)

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23 June 2006

Introduction:

This review was conducted in accordance with the Terms of Reference for the Peer Review of The Toxicological Risk Assessment Pertaining to Potential Occupational and Related Exposures Associated with Herbicide Spraying Operations at Canadian Forces Base (CFB) Gagetown from 1952 to Present: Task 3A.1, Tier 1, a document prepared by Health Canada describing the peer review process for risk assessment reports addressing human exposures and potential health hazards associated with 2,3,7,8-tetrachlorodibenzo-p-dioxin and hexachlorobenzene, two manufacturing impurities present in herbicides sprayed at CFB Gagetown for three days in June 1966 and four days in June 1967.

Overall Comments:

The report appears to summarize a well-researched and scientifically defensible assessment of potential health risks. Cantox has demonstrated a high degree of creativity and knowledge in their application of the various scientific tools available for the estimation of risks from the contaminants of concern. Notwithstanding the above, several issues should be resolved prior to giving full endorsement of the methods, results, and conclusions.

Assessment:

Our overall opinion is that the report is acceptable with major revision (as outlined).

Major Issues:

1) **Exposure Estimates**

Issue:
From our perspective, there does not appear to be enough information provided to arrive at the same exposure estimates that are reported in Tables 5-12 to 5-17. We have tried to verify the estimated exposures in "ng/kg bw" and have not been able to arrive at the same values. More specifically, when we completed the exposure calculations using the supplied information, we arrived at different exposure estimates for the following receptors:

- Mixer/Loader Accident 1966 Scenario: Using the Cantox data and equations to the fullest extent possible, our estimate for *high end* exposure to PCDD is 7,300 ng/kg/day (for 3 days) versus 5,100 ng/kg (presumably for each of 3 days but this is not specified) estimated by Cantox. For HCB, our estimate for *central* exposure is 5,600 ng/kg/day (for 3 days) versus 394 ng/kg (presumably for each of 3 days) estimated by Cantox. The Appendix provides the assumptions that were used in our worked example calculations.

- Mixer/Loader Routine 1967 Scenario: Using the Cantox data and equations to the fullest extent possible, our estimate for *high-end* exposure to PCDD is 0.042 ng/kg for each day versus 0.77 ng/kg (presumably for each day) estimated by Cantox. The Appendix provides the assumptions that were used in our worked example calculations.

- Field Scout 1967 Scenario: Using the Cantox data and equations to the fullest extent possible, our estimate for *high-end* exposure to PCDD is 2 ng/kg/event versus 0.030 ng/kg/event estimated by Cantox. The Appendix provides the assumptions that were used in our worked example calculations.

It is stressed that it is possible that we have erred in our review but these and all other calculations in the report should be resolved prior to finalization of the report. In making these calculations, we found ourselves having to guess at certain assumptions or parameter values and it is possible that further clarification by Cantox would provide the reasons why we could not reproduced their exposure estimates. Of fundamental importance to the entire assessment, we did not have access to the PHED database and so were unable to check the PHED Unit Exposure Values summarized in Tables 5-6, 5-7 and 5-8. We suggest that Cantox show by example how they arrived at the some of the values in these critical tables.

Recommendation:
It is recommended that:

- Cantox review all of their calculations to ensure that no errors were made;
- Cantox should provide worked examples of their calculations (perhaps in an Appendix) showing the detail of their calculations, assumptions, and parameter values, for each of the receptors; and
- Cantox should ensure that all parameter values used in the formulae are provided in a separate table so that, together with the worked examples, any reader can reproduce their results.
- Illustrate by example the determination of some of the PHED Unit Exposure Values summarized in Tables 5-6, 5-7 and 5-8.

2) Background Exposure Estimates

Issue:
An article by Lorber (2002) has suggested that average background dioxin-TEQ serum lipid concentrations in the US were between 50 ppt and 80 ppt during the 1970's whereas Cantox has used a value of 21.8 ppt. It is unclear if the Lorber paper is more accurate than the Cantox estimate and/or perhaps included other considerations. Nevertheless, if the Lorber value was used in the assessment, it is possible that appreciably different results would have been found (e.g., values in Table 7-1 would need to be revisited).

Recommendation:
It is recommended that Cantox review the Lorber (2002) paper and any other data that may relevant to serum lipid concentrations around the time of the exposure events. If revised background exposure estimates are recommended, the interpretation of the risk assessment may need to be revisited.

3) Inclusion of Dioxin-Like PCBs in Background Exposure Estimates

Issue:
Somewhat related to the above, it is possible that dioxin-like PCBs may have contributed to the typical background exposures that receptors may have been receiving at the time of the spraying events. In some cases, dioxin-like PCB exposures may contribute appreciably and, thus, should possibly be considered or discussed in the Cantox report.

Recommendation:
It is recommended that Cantox review and comment on whether inclusion of dioxin-like PCB data may have altered their results and conclusions.

4) Risk Calculations

Issue:
If exposure estimates are found to require recalculation, then the Cantox risk estimates provided in Tables 7-2 to 7-24 and Figures 7-1 to 7-5 may need to be revisited. Currently, the risk estimates are reproducible only if the exposure estimates presented in earlier tables are accurate.

Recommendation:
Based on the outcome of the re-evaluation of exposure estimates, it is recommended that Cantox re-evaluate the risk calculations.

5) Discussion

Issue:
Stakeholders, health officials, and policy makers will want to know how these risks compare with those experienced by individuals in other cohorts, such as victims of the Seveso accident, industrial workers who made herbicides, agricultural workers who sprayed herbicides, or U.S. Air Force veterans of Operation Ranch Hand, the unit responsible for spraying Agent Orange and other herbicides in Vietnam.

Recommendation:
Expand Chapter 9 to put the risk estimates into perspective by comparing some of the CFB Gagetown risks with those that may have been experienced by individuals in other cohorts. Strengthen the discussion by mentioning that the high Mixer/Loader exposure estimates (some exceed baseline by 80 times) are consistent with your simulation (summarized in Appendix D) and with exposure estimates in Ranch Hand ground crew. The Ranch Hand ground crew loaded spray tanks in aircraft with Agent Orange and other herbicides and so functioned in some ways like your Mixer/loader receptors [Michalek JE, Wolfe WH, Miner JC, Papa TM and Pirkle JL. Indices of TCDD exposure and TCDD body burden in veterans of Operation Ranch Hand. *Journal of Exposure Analysis and Environmental Epidemiology* 1995;5(2):209-223].

6) Executive Summary

Issue:
Many readers will immediately look for the bottom line (on page ix) and will seek confirmation that the overall interpretations in the Executive Summary are consistent with material presented later. As currently written, the executive summary on page ix is not written with as much conviction as the bulleted items on pages 92 and 93.

Recommendation:
Replace the current six bulleted items on page ix of the Executive Summary with the eight bulleted items from pages 92 and 93.

Point-by-Point Review:

Report Title: It may be unavoidable but the report title is long and complex. If possible, a more concise title may be useful.

ES-2.0, Page ii, item 4: Replace “include” with “included”.

Figure ES-1, Page iii and Figure 2-1, page 3:Black and white copes of the report do not show areas in “blue” and “green”. It should be ensured that a color copy of this figure is provided in the version of the report that is circulated to stakeholders.

ES-4.0, Page v, item 1, first sentence: Replace “individuals are responsible” with “individuals were responsible”.

ES-4.0, Page v, item 1, third sentence: Replace “may come” with “may have come”.

ES-4.0, Page v, item 2, first sentence: Replace “individuals are responsible” with “individuals were responsible”.

ES-4.0, Page v, item 2, third sentence: Replace “may be exposed” with “may have been exposed”.

ES-4.0, Page v, item 3, first sentence: Replace “individuals are responsible” with “individuals were responsible”.

ES-4.0, Page v, item 3, second sentence: Replace “may come” with “may have come”.

ES-4.0, Page v, item 4, first sentence: Replace “may spend” with “may have spent”.

ES-4.0, Page v, item 4, second sentence: Replace “may come” with “may have come”.

ES-4.0, Page v, item 4, third sentence: Replace “accidentally be sprayed” with “accidentally have been sprayed”.

ES-4.0, Page v, item 5, first sentence: Replace “may live” with “may have lived” and “occasionally use” with “occasionally used”.

ES-4.0, Page v: On this page and also elsewhere in the report the term “Mixer/Loader/Applicator” is used as if it was one receptor when in the risk calculations Cantox separately estimated risks for the “Mixer/Loader” and then the “Applicator”. It is suggested that the term “Mixer/Loader/Applicator” not be used as a single group or if it is, exposure and risk calculations should be summed for all of these activities to more accurately reflect this group (also see Section 4.2, page 13).

ES-4.0, Page v: Off-site civilians should not be in a bulleted list is introduced as “the following groups of people were assessed” (since it is clear they were not assessed in

TIER 1). We suggest that you mention in a separate paragraph that this group will be addressed in the TIER 2 and 3 assessments.

ES-5.0, page vi: It would be helpful to summarize the exposure routes and scenarios that were evaluated. We suggest that you expand the paragraph to mention the dermal and inhalation routes in the routine and accidental exposure scenarios that you develop in Chapter 7.

ES-6.0, Page vii, paragraph beginning "Based on epidemiological evidence…", first sentence: Replace "link" with "association".

ES-6.0, Page vii, paragraph beginning "There is only limited evidence…" first sentence: Replace "link" with "association".

ES-6.0, Page vii, paragraph beginning "There is only limited evidence…" sixth item: Replace "mellitis" with "mellitus".

ES-6.0, Page viii, paragraph beginning "There is inadequate …": Replace "link" with "association".

ES-7.0, Page ix. Replace the six bulleted items in this section with the eight bulleted items on pages 92 and 93. Revise the paragraph beginning "The mixer/loader/applicator, …" to introduce the eight bulleted items from pages 92 and 93.

Section 2.0, Page 4: Demaree and Creager (1968) reference is cited as Demaree and Creager (1968a) in reference section.

Section 2.0, Page 5: Is any information available on weather conditions during the spraying event? We are not sure if this would affect any exposure estimate but it could be presented or at least mentioned.

Section 2.0, Pages 5 and 6: Number of gallons of active ingredient used per acre does not seem to be provided but would be useful in these locations.

Section 2.0, Page 6: Third line from top of page, "hcbcontaminant" should be "HCB contaminant".

Tables 2-1 and 2-2, Page 6: Do concentrations presented in "ppm" refer to mass:mass (i.e., mg/kg) or mass:volume (i.e., mg/L)? Have appropriate corrections for density been completed if the latter is the case (these would be important to subsequent exposure calculations)? For example, in the case of PCDD in 2,4,5-T, 45 mg/kg would correspond to 81 mg/L (if a density of 1.8 g/mL was assumed) while 45 mg/L would correspond to 25 mg/kg. These are important values used in the exposure equations and it should be verified whether "ppm" referred to "mg/kg" or "mg/L" and that they were used appropriately in the risk assessment. The resolution of "ppm" as mass:mass or

mass:volume should be clearly specified in the paragraph preceding Tables 2-1 and 2-2 because "ppm" appears throughout the report.

In these tables, it may also be useful to indicate whether or not the concentration value provided represents a mean or maximum value (since a combination of values are provided).

Finally, it may be important to specify if these concentrations are specific to the herbicide or the active ingredient in the herbicide. For example, does 45 ppm represent the concentration of TCDD in 2,4,5-T? Or does it represent the concentration in Agent Orange? Some of the information provided later in the report would suggest the former but this should be specified. Does this potentially affect exposure calculations for the Mixer/Loader spill scenario?

Section 3.3.1, Page 9, paragraph beginning "Where available …", last sentence, "RfC" is probably "Reference Concentration", please define parenthetically.

Section 3.4, Page 10: Perhaps present the equation for Exposure Ratio or Hazard Quotient as one or the other (but not both, since it could be a bit confusing for some). Also, in the example equation the units are provided as "μg/kg/day" while throughout the report exposure estimates are provided with units as "ng/kg", "ng/kg/day", "ng/kg/event", "pg/kg", "pg/kg/day" and "pg/kg/event". In order to avoid confusion, it is recommended that Cantox consider the following:

- use one of "μg", "ng" or "pg" and then primarily only that value;
- whenever a dose rate is provided, use terms where it is clear that rates are mass per kilogram body weight per day (e.g., 5,100 ng/kg bw/day) to avoid confusion with body concentrations that can be expressed as mass per kilogram (e.g., 5,100 ng/kg);
- adopt consistent terminology for "2,3,7,8-TCDD", "dioxin", "TCDD", "TEQ", "PCDD" and "dioxins" and then try to use just the one term if possible.

Section 3.4, Page 10: Here and elsewhere, it would be helpful if equations were numbered by chapter, using parallel notation with the figures, such as "equation 5-1".

Section 3.4.2, Page 12, paragraph beginning "The utility of the …", sentence beginning "ILCR estimates…" (near the bottom): Replace "provided by comparing the cancer slope factor" with "provided by multiplying the cancer slope factor".

Section 4.2, Page 13, paragraph beginning "The following…": Replace "might encounter" with "might have encountered".

Section 4.2, Page 13, paragraph beginning “The following…”, item 1, first and second sentences: Replace “are responsible” with “were responsible” and “It is anticipated” with “It is assumed”.

Section 4.2, Page 14, top of the page, item 2, second and third sentences: Replace “It was anticipated” with “It was assumed” and “It was assumed” with “It was also assumed”.

Section 4.2, Page 14, item 3, first and second sentences: Replace “individuals are responsible” with “individuals were responsible” and “It was anticipated” with “It was assumed”.

Section 4.2, Page 14, item 3 last sentence: Replace “impacted by the” with “contaminated by the”.

Section 4.2, Page 14, item 4, first and second sentences: Replace “personnel are those” with “personnel were those” and “may spend” with “may have spent” and “It was anticipated” with “It was assumed” and “would come into” with “would have come into”, and “which have been impacted” with “which have been contaminated”.

Section 4.2, Page 14, item 5, first and second sentences: Replace “individuals are those who may live near” with “individuals were those who may have lived near”, and “It was anticipated” with “It was assumed” and “which have been impacted” with “which have been contaminated”.

Figure 4-1, Page 15, right hand side: In the legend, Cantox should perhaps signify that “X” means no pathway while the checkmark notes an operable pathway. It is also unclear what the brackets around the checkmark signifies in the figure.

Figure 4-2, Page 16: Perhaps all receptors (not just mixer/loader) could be labeled.

Section 4.3.1.2, Page 19, paragraph beginning “Since the flagger… “, second sentence: Replace “This may occur” with “This may have occurred”.

Section 4.3.1.2, Page 19, paragraph beginning “Since the flagger…”, next-to-last sentence: Replace “accomplished Army” with “accomplished by Army”.

Section 4.3.1.2, Page 19, paragraph beginning “Additional potential exposure…”, last sentence: Replace “these exposure will be” with “these activities will be”.

Section 4.3.1.3, Page 20, paragraph beginning “Historical levels…”, sentence beginning “As a result of…”: Replace “food items may be” with “food items may have been”. Last sentence: Replace “Exposure to COCs also” with “Exposure to COCs may have also”.

Section 4.3.1.5, Page 20, paragraph beginning “Civilian receptors …”, second sentence: Replace “impacted” with “contaminated”.

Section 4.3.1.5, Page 20, paragraph beginning "Civilian receptors may also…", first and third sentences: Replace "may also be exposed" with "may also have been exposed" and "Impacted ground water" with "Contaminated ground water".

Section 5.1.1, Page 22: Unsure if these historical exposure estimates correspond with estimates provided by Lorber (2002). See our comment on Section 7.1, page 67.

Tables 5-1 and 5-2: There are two Table 5-1's (see pages 22 and 24) and two Table 5-2's (see pages 23 and 26).

Section 5.3.1.2, Page 25, top of the page, fourth line: Replace "According SERA" with "According to SERA".

Table 5-2, Page 26: All acronyms (e.g., "D", "T" and "a.i.") should be defined in the table so that the table is as stand alone as possible.

Tables 5-2 to 5-5, Pages 26 to 28: These tables present application rates in "g/m^2" whereas exposure calculations use units of "lbs/acre". Could these be harmonized in some manner? Or at least at a minimum, emphasize the conversion factor of "0.11 $g/lbs \times acres/m^2$" on page 26.

Section 5.4.1.1, Page 29, below Table 5-6, formulas for dermal routine exposure and inhalation from routine exposure: Please provide a literature references for this formulas. If Cantox derived them from first principles, please so state and give the rationale. Perhaps (as stated on page 23) these formulas and all other formulas used in this section (through page 39) are taken from reports by the PMRA, Health Canada, the US Bureau of Land Management, or the US Department of Agriculture. If so, then please ignore this comment. If not, please document or explain.

Section 5.4.1.1, Page 29: The equations presented on this page uses several parameters for which it is hard to determine which values were actually selected for use by Cantox. Specifically, the following parameters were not easily defined when we attempted to confirm Cantox's calculations:

> Application Rate (AR): Tables 5-2 to 5-5 provide the AR's but it is unclear which values were precisely used for the low, central and high exposure estimates.
>
> Area Treated (AT): It is unclear how many acres per day were assumed for the low, central and high exposure scenarios.
>
> Proportion of Dose Absorbed (P): Table 5-9 on page 34 apparently provides the values that were used but should likely be cited earlier (it is unclear to the reader that these values are available until 5 pages later in the report).

Body Weight (BW): Table 5-9 on page 34 apparently provides the value that was used but should likely be cited earlier (it is unclear to the reader that these values are available until 5 pages later in the report).

A summary table that provides the actual values selected for the low, central and high exposure scenarios would greatly clarify the risk assessment (and allow us to confirm the results of the risk assessment). (Note: This comment applies to all receptors not just Mixer/Loader.)

Section 5.4.1.2, Page 30, paragraph beginning "In addition to…", third sentence: Replace "concentrate" with "herbicide mixture".

Section 5.4.1.2, Page 30: The equations presented on this page uses several parameters for which it is hard to determine which values were actually selected for use by Cantox. In addition to the need to identify the previously mentioned parameters, the following parameters were not easily defined when we attempted to confirm Cantox's calculations:

Spill Amount (S): Unclear what the reference is for 0.5 L/day

Concentration of PCDD or HCB in Concentrate (AC): Unclear which values of these chemicals were used in units of "g/L"

A summary table that provides the actual values selected for the low, central and high exposure scenarios would greatly clarify the risk assessment (and would also allow us or any other reader to confirm the results of the risk assessment).

The reference for ENSR (2005) is not provided in the reference section.

Table 5-9, Page 34: The dermal absorption factors cited on this page should be discussed more fully. In particular, the proportion of absorbed dose cited by SERA (2001) could be discussed further since the reference for this value is not apparently available from a peer-reviewed journal. It is noted that alternate values for dermal absorption are available which include:

- Health Canada (2004) Preliminary Quantitative Risk Assessment cites a relative dermal absorption of 0.13 for hexachlorobenzene (no value provided for PCDD but many organic chemicals have values cited by Health Canada that are in the range of 0.1 to 0.2 and, thus, are greater than the values cited in Table 5-9); and

- ORNL (2006) cites a dermal absorption value of 0.03 for 2,3,7,8-TCDD and 0.01 for hexachlorobenzene.

It is important to note that we are not suggesting that the above listed values are more appropriate for use in the risk assessment. Instead, because it is a relatively sensitive parameter (i.e., dermal absorption is the major route of exposure for the Mixer/Loader which is the receptor driving the results of the assessment), we are suggesting that these

values and their derivation could be more precisely described and any uncertainties specified.

In the case of the values cited for PCDD, it should also be clarified that these are specific to 2,3,7,8-TCDD rather than representing a combined PCDD value.
The Cantox evaluation has been based on data that is specific to the general population (both sexes). If it is known that only men were using the area, it may be possible to revise the assessment based on male-specific data. Since Health Canada (2004) obtained much information from Richardson (1997) (which provides data for male, female and both sexes combined), it may be a relatively straightforward approach to base the risk assessment on male-specific endpoints. It should be stressed, however, that we have not been provided with any information that suggest only males were present.

Section 5.4.4, Page 36: The Application Rate in the Disolodgeable Residue calculation (note: misspelling of dislodgeable, an extra "o" is included) is in yet another different unit (i.e., $\mu g/m^2$) that is not provided in the tables. To avoid confusion, it is recommended that units be used that are similar to those previously provided (or a conversion factor provided).

Section 5.4.4, Page 36, formula for the transfer rate: The log is probably base 10. Please indicate the base of the logarithm.

Section 5.4.5, Page 38: Providing the results of the soil and berry concentration estimates would be interesting and make the risk assessment more clear.

Section 5.4.5, Page 38, third equation: The units do not balance, indicating the need for a conversion factor. Please check this equation.

It is also not immediately clear which soil half-life values were used in the risk assessment or what was the absorption factor for the chemicals via berry consumption (i.e., should not be as low as that from soil ingestion).

Perhaps the berry consumption rate could be provided as the number of servings per week.

Section 5.4.5, Page 39, first and second equations: The units do not balance, indicating the need for a conversion factor. Please check these equations.

Tables 5-12 through 5-17 Pages 41 to 44: As noted earlier, the exposure estimates provided in this table could not be reproduced with the information provided. It is highly recommended that these exposure estimates be validated by Cantox.

A separate issue is that the exposure estimates are provided as "ng/kg" or "ng/kg/event", and it is recommended that the precise units be provided. From the risk calculations, it appears that the units for all tables were "ng/kg bw/day" but it is not immediately obvious from the text. It is recommended that units be precisely provided in all cases.

A discussion on why exposure estimates vary amongst the various receptors between the various years would also be useful. Re-iterate that the reduced exposure in 1967 are due to Agent Purple not being used.

Section 6.1.2, Page 47, paragraph beginning "Wherever possible…": Insert a blank line to separate this paragraph from the preceding paragraph.

Section 6.2.4, Page 54-55: The chronic TDI for PCDD was chosen to be 2 pg/kg bw/day and is cited as Health Canada (2004; 2005). Although we cannot confirm it, we believe that the TDI provided in Health Canada (2004) was a slight error and that the intended value should have been 2.3 pg/kg bw/day (as opposed to 2.0 pg/kg bw/day) since it cites the JECFA assessment. Health Canada (2005) cited by Cantox actually provides a value of 2.3 pg/kg bw/day (not 2.0 pg/kg bw/day). Although it is likely only to have a minor effect, it is recommended that Cantox use a value of 2.3 pg/kg bw/day (as 2,3,7,8-TCDD TEQs) as the chronic TDI for PCDD.

With the above noted, the Body Burden$_{TRV}$ may change from 24.2 pg/g lipid to 27.7 pg/g lipid if the revised chronic TDI is used. However, since the TDI is expressed to 2 significant figures, this would likely be rounded to 28 pg/g lipid.

Tables 6-2 and 6-3, Page 55: As discussed earlier, it would be useful to provide dose rates in units that are similar to those used in earlier estimates.

In the case of body burden, the units should be more explicitly indicated (i.e., "kg body weight"? or "pg/g lipid" to be more consistent with the Body Burden$_{TRV}$).

The use of significant figures may be inappropriate in some of these tables (i.e., were some of the estimates in Table 6-3 really expressed to 5 significant figures?).

In Table 6-3, NR should be defined.

Section 6.3, Page 60, paragraph beginning "An analysis of the results…", sentence beginning "The only new study …": Please cite Akhtar F, Garabrant DH, Ketchum NS, and Michalek JE. Cancer in US Air Force veterans of the Vietnam War. *Journal of Occupational and Environmental Medicine* 2004;46(2):123-136.

Section 6.3, Page 60, paragraph beginning "Studies of Vietnam veterans…", sentence beginning "The Ranch Hand study …": Please cite a reference.

Section 6.3, Page 61, (first) paragraph beginning "Overall, the evidence of …", second sentence: Please cite Pavuk M, Michalek JE, and Schecter A. Prostate cancer in US Air Force veterans of the Vietnam War. J Expo Sci Environ Epidemiol. 2006 Mar;16(2):184-90. The relative risk was 2.27 for prostate cancer in the high dioxin category, hence the paragraph needs editing. Delete the first sentence of the paragraph and rewrite the second sentence as "The Ranch Hand studies showed an excess of prostate cancer in Ranch Hand veterans with elevated dioxin levels who served prior to 1969".

Section 6.3.2, Page 63, paragraph beginning "Evidence is suggestive …", sixth bullet: Replace "mellitis" with "mellitus".

Table 6-8, Page 66: Define GM.

Table 6-9, Page 66: As discussed earlier, the chronic TDI for PCDD should be revised. In addition, the more common term throughout the document has been TDI but in this table RfD is being used. It is recommended that the term TDI be used.

With respect to the term "Body Burden" it is recommended that the term "Body $Burden_{TRV}$" be used. In addition, the value provided in the table is 22.4 pg/g lipid whereas in prior text a value of 24.2 pg/g lipid was cited by Cantox. In any event, a revised value of 28 pg/g lipid would seem to be more appropriate if a chronic TDI of 2.3 pg/kg bw/day is adopted.

Section 7.1, Page 67, formula for D near the bottom of the page: The inversion of this formula appears to estimate the concentration of dioxin TEQ, not dioxin, in human tissue (pg TEQ/g) because the value estimated from it for the general population (at the top of page 68), 21.8 pg/g, is near the TEQ range previously cited on page 57, ie 22.8-32.7 ppt TEQ and because the ordinate of Figure 7-1 is cited as TEQ pg/kg/day. Please clarify the units for the concentration of dioxin. The half-life should be denoted as $t_{1/2}$ rather than $T_{1/2}$. As a check on your calculation of 21.8 pg/g, we used a simple one-compartment first order pharmacokinetic model and an EDI value of 1.8 pg TEQ/kg/day (rounded from your EDI of 1.76 pg TEQ/kg/day in Table 5-1) to arrive at an estimated steady state concentration of 20.7 pg/g lipid, relatively close to your value. Please comment in Section 5.1.1 on your EDI of 1.76 pg TEQ/kg/day, relative to the calculations summarized in Figure 6 of Lorber (2002).

Section 7.1, Page 68, paragraph beginning "Using a body burden …", please cite a reference for the half-life of 7.1 years. One such is Wolfe WH, Michalek JE, Miner JC, Patterson DG, Needham LL and Pirkle JL. Serum dioxin levels in Air Force Health Study participants preliminary report. *Morbidity Mortality Weekly Report* 1988;37:309-311. If this citation is correct, then the half-life estimate of 7.1 years was derived from repeatedly measured dioxin (pg/g lipid) in Vietnam veterans, whereas the application of it in the subsequent formula appears to estimate pg TEQ/g lipid. Please add text to reference the half-life and indicate the assumptions you have made regarding its use in this report.

Section 7.1, Page 68, formula for BB_o: The units of BB_o and BBB are probably TEQ pg/g as evidenced by the parenthetical value of 21.8 pg/g lipid. Please indicate TEQ here and elsewhere in the specified units for this formula or else clarify the unit for BB_o. Please cite a reference for the formula or explain how it was derived.

The use of the 1,000-fold unit correction factor for "pg/ng" is likely unnecessary (note: it does not appear that this factor has actually been used in Cantox equations).

It is also noted that this appears to the first time that the term "ABD_{acute}" is used. In our review of the report, it was somewhat confusing and hard to exactly replicate. It appears that the term "ABD_{acute}" refers to the values provided in Tables 5-12 to 5-17 (since these values represent absorbed doses) and if this is the case, it should be referenced.

It is also unclear how the term "ABD_{acute}" accounts for exposures on multiple days. For example, the Mixer/Loader under the Accident 1966 scenario was associated with a central estimate of 740 ng/kg bw (see Table 5-12). As noted earlier in our request for clarification, no time units were provided by Cantox but it would seem that the estimate was 740 ng/kg bw per day (or accidental spill event) and that an accidental spill event would occur once per day (see page 30) for the 3 days that spraying occurred. It is unclear if and how multiple spill events were considered in the calculations. Cantox should clarify this issue.

Section 7.1, Page 69, formula for $BB_{year\ 1}$: The units are probably pg TEQ/g lipid. Because Table 7-1 is derived from BBB (pg TEQ/g lipid) in the formula, the units cited in the table should be pg TEQ/g lipid. Please fix or explain. Please cite a reference for the formula or explain how it was derived.

Table 7-1, Page 69: The absorbed dose column is somewhat confusing. Specifically, in 1966, there would have been 3 days where the exposure was elevated (i.e., 3 days at 30,016 pg/kg bw/day); however, the table appears to imply that this exposure occurred for the entire year.

The values provided appear to be for routine exposures and no accident. Perhaps this could be specifically stated.

The values would change if the Lorber (2002) values were used (once again, it is not being suggested that these are more accurate but could be worthy of discussion since they are from the US EPA).

The use of significant figures may be inappropriate in some of these tables (i.e., 5 significant figures?).

Acronyms (e.g., BB) should be defined.

Tables 7-2 to 7-7: Risk calculations appear to match the data provided earlier; however, if the exposure estimates are revised based on the earlier comments, then these risk estimates will also change.

It is noted that the acute TRVs are typically only derived for evaluation of once per lifetime events. This was noted earlier by Cantox as an assumption that was reasonable (i.e., the same people did not participate in both 1966 and 1967 events).

Figures 7-1 to7-5: These figures work well for describing the Body Burden estimates but not so well for the absorbed dose rates. Issues with the absorbed dose rates include:

- the TDI is not accurately shown in the figures; and

- the dotted line seem to imply that the elevated absorbed dose rate persisted for a couple of years (as opposed to 3 days in some cases)

Similar to previous comments, acronyms (e.g., BB) should be defined and previously used terminology (e.g., TDI, Body Burden$_{TRV}$) should be continued to be used.

The arrows should be explained.

Section 7.3.1, Page 81, paragraph beginning "Tables 7-11 through 7-16…". As written, this paragraph conflicts with the fifth bullet on page 92. The paragraph is certainly less assertive than the material on page 92 and should be revised to harmonize with the eight bulleted items on pages 92 and 93.

Section 8.2, Page 90, sixth bullet: The formulas used for exposure assessment appear to have specified a fixed half-life of 7.1 years. Therefore "assumption of a linear half-life" should be changed to "assumption of a constant half-life".

Section 8.2, Page 90: As noted by Cantox, the chronic TRV for dioxin is of questionable relevance. Specifically, if it was known that only men were using the area, the potential lack of relevance of the chronic TRV could be further discussed. It should be stressed, however, that we have not been provided with any information that suggest only males were present.

The acute TRV from the ATSDR could also be further discussed. More specifically, it was based on immune suppression in mice exposed to dioxins and then challenged with the influenza virus. The potential reversibility of this effect could be discussed.

Section 8.3, Page 91, last bullet, first sentence: "pg/g lipid" should be "pg TEQ/g lipid".

Section 9.0, Page 92, first bullet, second sentence: Replace "effects would have occurred" with "effects will occur".

Section 9.0, Page 92, second bullet: Replace "may have experienced" with "may have already experienced".

Section 9.0, Pages 92 and 93: The bulleted items on these pages should be copied into the executive summary as a bottom line for the report.

References, Page 102: The Ruby et al reference should be 2002, not 2004. The citation of this reference on page 40 should be revised accordingly.

Page A-1, paragraph beginning "According to the …". This is a nice calculation, leading to the conclusion that PCP was applied as a salt rather than as water insoluble PCP. To

help the reader follow this more readily, please add the phrase "or, equivalently, 4 lb/gal" to the end of the third sentence.

Table A1-1.3, Page A-3: It is unclear how the mean values were derived. It is recommended that 2 or 3 significant figures be reported in the table.

Page A-4, paragraph beginning "In 1971, Elvidge …". Is it "Bionetics" or "Biometrics"?

Page A-10, paragraph beginning "Technical grade picloram …", last sentence" Replace "in the 200 region of 200 ppm" with "in the region of 200 ppm".

Page B-8, Table B1-3.3. The Longnecker and Michalek (2000) reference appears inappropriate because the table is intended to summarize results in exposed individuals, as represented in the Fingerhut reference. The Longnecker et al paper described diabetes in control subjects of the Air Force Health Study (those who had no occupational exposure to herbicides). A more appropriate reference would be Henriksen GL, Ketchum NS, Michalek JE and Swaby JA. Serum dioxin and diabetes mellitus in veterans of Operation Ranch Hand. *Epidemiology* 1997;8(3):252-258, which describes diabetes in the Ranch Hand sprayers and was used by the IOM to render their opinion regarding Agent Orange and diabetes.

Page B-11, Table B1-3.4, last item: Also mention spina bifida in Ranch Hand offspring. You might write, "A trend of increased risk of spina bifida in Ranch Hand offspring was found" and cite Wolfe WH, Michalek JE, Miner JC, Rahe AJ, Moore CA, Needham LL and Patterson Jr DG. Paternal serum dioxin and reproductive outcomes among veterans of Operation Ranch Hand. *Epidemiology* 1995;6:17-22.

Page B-15, paragraph beginning "In the U.S. EPA's draft …", first sentence: Replace "they have" with 'researchers".

Page B-19, paragraph beginning "Charnley and Kimbrough…", first sentence: Replace "argues that" with "argue that".

Page B-21, paragraph beginning "The U.S. EPA …": It appears inconsistent to spell out this agency and the CDC here because these were abbreviated throughout the report up to this point. We suggest maintaining the abbreviations and drop the parenthetical. Thus, drop the parenthetical and replace "Centers for Disease Control" with "CDC". For your information, and not to be used here, the official name of CDC is the Centers for Disease Control and Prevention.

Page B-22, top line: Replace "that TCDD are largely" with "that TCDD is largely". This section points out the variation in nomenclature for 2,3,7,8 tetrachlorodibenzo-p-dioxin. We think the reader should be advised of this at the front of the report. On page ii, for example, item 1, replace "(TCDD)" with "(TCDD, 2,3,7,8-TCDD, or dioxin)", because all three of these names are used throughout the report.

Page B-23, paragraph beginning "Peak exposures to TCDD…", last sentence: Replace "postualted" with "postulated". Also, to complete the thought, please extend the sentence to explain "inducible" means, we presume, by sequestration of TCDD in the liver by CYP1A2.

Page B-25, paragraph beginning "The discrepancies between…", first sentence: Replace "study among individuals" with "study in persons".

Page B-27, paragraph beginning "Anderson et al…": Insert a blank line preceding this paragraph and after this paragraph.

Page B-27, bottom of the page: This section summarizes PBPK modeling of dioxin elimination, concluding that use of a variable elimination rate that corresponds to enzyme induction provides better fits to experimental data than models that use a fixed rate of elimination. Yet, on page 68 and elsewhere, you indicate that a fixed half-life of 7.1 years was used in your calculations. We suspect that you used a fixed half-life because current exposure and risk estimation methods do not accommodate a variable elimination rate. Provide text to explain why you used a fixed half-life of 7.1 years.

Table B1-5.1, Page B-32: It appears that the units for the column "Related human EDI" should have been "ng/kg bw/day" (as opposed to "pg/kg bw/day").

Page B-34, paragraph beginning "The U.S. EPA began…", last sentence: As far as we know, Paustenbach is employed by Exponent, a consultation company for the pesticide industry. You might leave the sentence as it is, or rewrite as "Pesticide industry consultants, Paustenbach et al 2000, have pointed to …".

Page B-35, paragraph beginning "U.S. EPA (2004b)…", second sentence: Replace "$(mg/kg/day)^{-1}$" with "$(mg/kg/day)^{-1}$". The narrative in this paragraph is further complicated by a recent paper that shows an increased all-site cancer risk with dioxin in Air Force Health Study control subjects, nearly all of whom have background dioxin levels; see Pavuk M, Michalek JE, Schecter A, Ketchum NS, Akhtar FZ, Fox KA. Did TCDD Exposure or Service in Southeast Asia Increase the Risk of Cancer in Air Force Vietnam Veterans Who Did Not Spray Agent Orange? *Journal of Occupational and Environmental Medicine* 2005;47(4):335-342.

Page B-38, top of the page, second line: Replace "At the Elgin spray testing" with "At the Eglin spray testing".

Page B-49: The specification of the page numbers in the Murray et al reference (1979) incorrectly includes a square instead of a hyphen.

Page B-58, Table B2-2.1, Half Life (environmental) panel: It seems odd to express the half-life in hours given that later in this appendix it is expressed in years. Please convert hours to years.

Page B-63, paragraph beginning “Renal Effects”: Replace “HCB exposure in humans have not” with “HCB exposure have not”. Sentence beginning “Increased kidney …”, replace “≥7” with “greater than or equal to 7”.

Page B-69, paragraph beginning “Among a group of 85”, first sentence: As written this is not a sentence. A fix would be to combine this with the second sentence by replacing “and HCB. An in vitro” with “and HCB, an in vitro”.

Page B-70, paragraph beginning “HCB did not induce”, last sentence: Delete “there was”.

Page B-71, paragraph beginning ‘Infants and young children…”, sentence beginning “Breast-fed…”: Delete “also”.

Page D-5, top line. The conclusion of this commendable effort to validate the application of PHED data is understated. In fact, the results, as evidenced by skin 2,4-D levels in Table D-2, are consistent with the estimated exposure levels by receptor category described in Tables 5-12 through 5-17, indicating that the mixer/loader receptor had exposures at least an order of magnitude greater than the flagman receptor. This information should be added to the summary paragraph on page D-5.

References

Health Canada. 2004. Federal Contaminated Site Risk Assessment in Canada – Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA) and Part II: Health Canada Toxicological Reference Values (TRVs). Environmental Health Assessment Services, Safe Environments Programme, Health Canada, Ottawa, Ontario.

Lorber, M. 2002. A pharmacokinetic model for estimating exposure of Americans to dioxin-like compound in the past, present and future. Sci Tot Environ 288:81-95.

ORNL. 2006. Risk Assessment Information System (RAIS) On-Line Database. Oak Ridge National Laboratory, Oak Ridge, Tennessee. Web site: http://risk.lsd.ornl.gov/rap_hp.shtml.

Richardson, G.M. 1997. Compendium of Canadian Human Exposure Factors for Risk Assessment.

Appendix: Worked Example Calculations

The following worked examples illustrate how we have not been able to reproduce the Cantox exposure estimates. It is stressed that the values provided below do not represent exposure estimates that are considered to be more accurate than the Cantox estimates. Rather these worked examples serve to illustrate that it is not completely intuitive how Cantox estimated the exposure. Comments from Cantox should be sought before assuming that the Cantox estimates contained errors.

Example #1: 1966 Mixer/Loader Accident Scenario – Dermal Exposure to PCDD (High Estimate)

As provided on page 30 of the report, the following equation was used to estimate exposure:

$$EXP_{Accidental} = \frac{S \times AC \times CF \times SAR \times P}{BW}$$

S = spill amount (0.5 L/day)
AC = concentration (g/L) – this is difficult to determine which value Cantox recommended for use. For PCDD, a maximum value of 45 ppm was previously noted but it was unclear if this was 45 mg/L or 45 mg/kg (see pages 6 and 24). For this worked example, 45 ppm was assumed to be 45 mg/kg which when adjusted for a density of 1.8 g/mL is 81 mg/L or 0.081 g/L (note that density is not provided in the document).
CF = conversion factor (1,000 mg/g)
SAR = 0.44 (as provided on page 30)
P = proportion absorbed. For PCDD, Table 5-9 on page 34 provided an upper value of 0.029 which was assumed for this worked example
BW = body weight (70.7 kg) (see Table 5-9)

Based on the above, the exposure was estimated as:

$$EXP_{Accidental} = \frac{0.5 \text{ L/day} \times 0.081 \text{ g/L} \times 1{,}000 \text{ mg/g} \times 0.44 \times 0.029}{70.7 \text{ kg}}$$

$$= 7.3 \times 10^{-3} \text{ mg/kg bw/day}$$

$$= 7{,}300 \text{ ng/kg bw/day}$$

Thus, the exposure was estimated to be 7,300 ng/kg bw/day (for 3 days) while Cantox (see Table 5-12, page 41) estimated the exposure to be 5,100 ng/kg bw/day.

Worked Example #2: 1966 Mixer/Loader Accident Scenario – Dermal Exposure to Hexachlorobenzene (Central Estimate)

As provided on page 30 of the report, the following equation was used to estimate exposure:

$$EXP_{Accidental} = \frac{S \times AC \times CF \times SAR \times P}{BW}$$

S = spill amount (0.5 L/day)
AC = concentration (g/L) – this is difficult to determine which value Cantox recommended for use. For hexachlorobenzene, a central value of 200 ppm was previously noted but it was unclear if this was 200 mg/L or 200 mg/kg (see page 6 and 24). For this worked example, 200 ppm was assumed to be 200 mg/kg and when a density of 1.8 g/L was assumed this was estimated to be 0.36 g/L (once again, density is not provided in the report).
CF = conversion factor (1,000 mg/g)
SAR = 0.44 (as provided on page 30)
P = proportion absorbed. For hexachlorobenzene, Table 5-9 on page 34 provided an upper value of 0.005, which was assumed for this worked example
BW = body weight (70.7 kg) (see Table 5-9)

Based on the above, the exposure was estimated as:

$$EXP_{Accidental} = \frac{0.5 \text{ L/day} \times 0.36 \text{ g/L} \times 1{,}000 \text{ mg/g} \times 0.44 \times 0.005}{70.7 \text{ kg}}$$

$$= 5.6 \times 10^{-3} \text{ mg/kg bw/day}$$

$$= 5{,}600 \text{ ng/kg bw/day}$$

Thus, the exposure (as a central estimate) was estimated to be 5,600 ng/kg bw/day (for 3 days) while Cantox (see Table 5-12, page 41) estimated the exposure to be 394 ng/kg bw/day.

Worked Example #3: 1967 Mixer/Loader Routine Scenario – Dermal Exposure to PCDD (Upper Estimate)

As provided on page 29 of the report, the following equation was used to estimate exposure:

$$EXP_{Dermal\ Routine} = \frac{AR \times AT \times UE_{Dermal} \times P}{BW}$$

AR = application rate – this is difficult to determine which value Cantox recommended for use. The highest application rate reported in Table 5-4 (page 28) is 9.1×10^{-6} g/m^2 which according to the conversion factor on page 26 is equal to 1.0×10^{-6} lbs/acre
AT = area treated – this is difficult to determine which value Cantox recommended for use. On page 5, it seems that 12 plots per day and 3 acres per plot results in 36 acres per day is reasonable
UE_{Dermal} = Dermal unit exposure - 2.86 mg/lb (as provided in Table 5-6)
P = proportion absorbed. For PCDD, Table 5-9 on page 34 provided an upper value of 0.029 which was assumed for this worked example
BW = body weight (70.7 kg) (see Table 5-9)

Based on the above, the exposure was estimated as:

$$EXP_{Dermal\ Routine} = \frac{1.0 \times 10^{-6}\ \text{lb/acre} \times 36\ \text{acres/day} \times 2.86\ \text{mg/lb} \times 0.029}{70.7\ \text{kg}}$$

$$= 4.2 \times 10^{-8}\ \text{mg/kg bw/day}$$

$$= 0.042\ \text{ng/kg bw/day}$$

Thus, the exposure (as an upper estimate) was estimated to be 0.042 ng/kg bw/day while Cantox (see Table 5-12, page 41) estimated the exposure to be 0.77 ng/kg bw/day.

Worked Example #4: 1967 Field Scout Routine Scenario – Dermal Exposure to PCDD (Upper Estimate)

As provided on page 36 of the report, the following equation was used to estimate the dislodgeable residue was estimated as:

Dr = Application Rate ($\mu g/cm^2$) x 0.1

The Application Rate was not specifically referenced by Cantox in the equation but the highest application rate reported in Table 5-4 (page 28) is 9.1 x 10^{-6} g/m^2 which is equal to 9.1 x 10^{-4} $\mu g/cm^2$. Consequently, Dr was estimated to be 9.1 x 10^{-5} $\mu g/cm^2$.

The following equation was then used to chemical transfer rate from vegetation to skin:

$$Tr = 10^{(1.09 \times \log [Dr] + 0.05)} \times 1/1000$$

$$= 10^{(1.09 \times -4.04 + 0.05)} \times 1/1000$$

$$= 10^{-4.35} \times 0.001 = 4.5 \times 10^{-8} \text{ mg/cm}^2\text{/hr}$$

$$EXP_{\text{Dermal Routine}} = \frac{Tr \times Tc \times ESA \times P}{BW}$$

Tr = 4.5 x 10^{-8} mg/cm^2/hr
Tc = contact time (assumed to be 18 min/plot x 39 plots/day = 702 minutes = 11.7 hours) (see Table 5-10, page 37)
ESA = 9,110 cm^2/day (see Table 5-10, page 37)
P = proportion absorbed. For PCDD, Table 5-9 on page 34 provided an upper value of 0.029 which was assumed for this worked example
BW = body weight (70.7 kg) (see Table 5-9)

Based on the above, the exposure was estimated as:

$$EXP_{\text{Dermal Routine}} = \frac{4.5 \times 10^{-8} \text{ mg/cm}^2\text{/hr} \times 11.7 \text{ hr/day} \times 9{,}110 \text{ cm}^2 \times 0.029}{70.7 \text{ kg}}$$

$$= 2.0 \times 10^{-6} \text{ mg/kg bw/day}$$

$$= 2 \text{ ng/kg bw/day}$$

Thus, the exposure (as an upper estimate) was estimated to be 2 ng/kg bw/day while Cantox (see Table 5-16, page 43) estimated the exposure to be 0.030 ng/kg bw/day.

Worked Example #5: 1966 Mixer/Loader Routine Plus Accident Scenario – Predicted Body Burdens (Central Estimate)

As provided on page 68 of the report, the following equation was used to estimate the body burden (note: the 1,000-fold "pg/ng" has not been included in the equation, as it appears to be a typo that was not carried into Cantox equations):

$$BB_0 = BBB + (ABD_{acute} \times 4.04)$$

BBB = 21.8 pg/g
ABD_{acute} = 740 ng/kg bw = 740 pg/g bw (see Table 5-12)

$$BB_0 = 21.8 \text{ pg/g} + (740 \text{ pg/g} \times 4.04)$$
$$= 3{,}011 \text{ pg/g lipid}$$

Thus, the Body Burden estimate on Day 1 of 3,011 pg/g lipid matches quite closely the value of 3,022 pg/g lipid estimated by Cantox (see Table 7-9; page 75). However, it does not appear that a spill event occurring once per day for 3 days is considered in the approach. In addition, previous comments on our lack of confirmation of the exposure estimates in Table 5-12 may affect the body burden estimate.

After 1 year, the Body Burden was estimated as:

$$BB_1 = BBB + (BB_0 e^{-kt})$$

BBB = 21.8 pg/g lipid
BB_0 = 3,011 pg/g lipid
k = 0.693/7.1 years = 0.098 yr^{-1}
t = 1 year

$$BB_1 = 21.8 \text{ pg/g lipid} + (3{,}011 \text{ pg/g lipid} \times e^{-0.098})$$
$$= 21.8 \text{ pg/g lipid} + (3{,}011 \text{ pg/g lipid} \times 0.907)$$
$$= 21.8 \text{ pg/g lipid} + 2730 \text{ pg/g lipid}$$

Thus, the Body Burden estimate after 1 year of 2,752 pg/g lipid matches quite closely the value of 2,744 pg/g lipid estimated by Cantox (see Table 7-9; page 75).

HEALTH CANADA COMMENTS
TASK 3A-1 TIER 1 DRAFT RISK ASSESSMENT REPORT

General Comments

- "TCDD", "PCDD" and "PCDF" appear to be used inconsistently throughout the report.
  - When "TCDD" is used, it is unclear whether the term is inclusive only of 2,3,7,8 TCDD, all TCDDs, or of all dioxins and furans. This is particularly important when discussing the concentration of contaminants in the herbicide products and when discussing the toxicity of dioxins and furans. Throughout the report (e.g. Section ES-2.0), when contaminants are reported, it is unclear if the report is referring to only TCDD, or TEQs that would consider all congeners.
  - Throughout the main report and in the appendices, units used to report levels of mixtures of dioxins and dioxin-like substances are not consistent (e.g. in environmental media, doses, body burdens. This makes it difficult for the reader to authenticate or compare reported concentrations and involved calculations. Units are most often reported just as pg/.... or as pg TEQ/... regardless of which toxic equivalency factors scheme was used. For example, levels of PCDD/DFs in Table C1-1.10 (page C-8) should have been reported as I-TEQ pg/kd bw/day for the "historical EDIs" and as TEQ-WHO_{98} pg/kd bw/day for the "current EDIs" instead of "pg/kg bw/day."
  - The entire document needs to be carefully reviewed to ensure clarity and as much consistency as possible.

- It would be useful to present information regarding the definition of dioxins and dioxin-like substances "up front", in a stand alone section that can be easily referred too by the reader. (In the present document, there is a only very brief description in Appendix B.) This section could comprise the following elements:
  1) A definition of the classes of dioxin-like substances
  2) A concise summary of how and why Toxic Equivalency Factor schemes were created and how the calculations are done.
  3) A clear description of the nomenclature of the various schemes presented in US EPA (2003). For example:
     I-TEQ: denotes the NATO International TEF scheme.
     TEQ-WHO94:.....
     TEQ-WHO98.....
  4) A comparison table illustrating the differences between schemes and

  The contractor could consider adopting the complete US EPA (2003) nomenclature with the subscripts D, F and P such as "TEQDF-WHO98"

- Throughout the report, exposure and risk estimates are characterised using different and inconsistent terms such as "central, low and high" estimates, "realistic, yet conservative" estimates, "upper-case estimates", etc..
  - It would be helpful to use consistent terminology throughout the report.
  - As these terms are subjective and difficult to interpret, it would be helpful to clearly document and reference the basis for each assumption in each estimate and to characterize the inherent uncertainty and/or conservatism. Where the

basis is simply "expert opinion", this should be noted.

- It could be helpful to include a general discussion of uncertainty and conservatism. For example, could explain that conservative assumptions are applied when there is high degree of uncertainty around a parameter. To help put the assessments in context, the impact of multiplying a series of high end assumptions should be clearly explained (i.e. it exponentially compounds the conservatism and can result in very exaggerated exposure\risk estimates).
- A summary table of the assumptions used for each estimate, and the conservatism and uncertainties, would help the reader interpret the "central, low and high" risk results in proper context.
- Accident scenarios should be clearly differentiated from routine events (e.g the difference between the spills and plashes inherent to mixing /loading activities that are captured in the PHED estimates, and truly accidental major spills). .

• Throughout the report, there are inconsistencies between the problem formulation and the actual receptors/exposure pathways for each receptor assessed.
  - Details are provided in comments specific to each section of the report (below).

• Some the equations, data and calculations presented in the report are difficult to verify and/or reconcile.
  - For some equations, the units do not cancel out (details below).
  - Input parameters for the equations are sometimes difficult to locate - e.g.,some are only in the appendices.
  - It would be very useful to include at least one "sample" calculation for each component of the exposure and hazard quotient calculations, to help the reader follow through the calculation logic. In addition, it would be helpful to include the equations used and inputs for the equations, including the toxicity reference values, in the footnotes for each tables.

• The document would be easier to read if:

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  - Information was readily available in the relevant text sections - for example, while the derivation of the dermal absorption values are discussed in the main report, the actual values are difficult to locate, other than is the appendices.
  - A glossary of technical terms, including a list of all acronyms was included and . each acronym was clearly defined the first time it is used.
  - Equations were numbered for easy cross reference.

Plain Language Executive Summary

• The Plain Language Executive Summary needs to be written insimpler, less technical language, in order to be easily understood by a layperson.
  - Section ES-3.0 should include a summary of the key aspects of risk assessment methodology, including basic concepts such as: RISK = EXPOSURE x TOXICITY. Other specific examples are provided below.

• The glossary (see comments above) should include terms such as "defoliants,"

"herbicides," "receptor" and "conservative assumptions." In addition, each technical term or acronym should be explained the first time it is used.

ES-1.0: Introduction

- Suggest edit to first paragraph sentences 2 and 3 to clarify that herbicides as well as their contaminants will be evaluated in subsequent Tiers. Suggested edit is:
  "As part of this commitment, the Government of Canada has engaged non-governmental experts to assess the possibility of military and civilian personnel exposure to herbicides and contaminants within these herbicides, the potential herbicide and contaminant dose received by these personnel and the potential of these herbicides and contaminants to cause harm. The following report documents the human health risk assessment, which was used to estimate potential exposures, characterize potential health risks, and determine, in an objective manner, whether exposures to herbicides and associated contaminants used at CFB Gagetown may be associated with potential human health risks."
- Second paragraph: The report and the statement of work for this contract indicates a risk assessment is to be conducted for herbicide use from 1952 to the present. However, the description of the tiers indicates that herbicide use from 1956 will be considered. This should be corrected or a rationale provided as to why 1952 to 1955 need not be assessed.
  .

ES-2.0: Description of Tier 1

- Define "CO"

ES-3.0: Health Risk Assessment methodology

- The report states *"A non-measurable or very low risk is considered 'acceptable'..... Health Canada assumes that the development of an additional cancer in one person out of 100,000 people... is acceptable."* The word "acceptable" should be changed: The guidance for conducting preliminary quantitative risk assessments (PQRA)) does not specify an acceptable risk for carcinogens, but rather qualifies a risk range of 1 cancer in 100,000 as "de minimus' or "essentially negligible". Generally, Health Canada views 1 cancer in 100,000 to 1 cancer in 1,000,000 as a minimally desirable targets, depending on the specific situation and on the degree of conservatism and uncertainty in the risk assessment.

ES-4.0: Problem Formulation

- First bullet, Mixer/Loader/Applicator:
  - Does not state that accidents will be considered for this receptor, yet in ES-7.0, "mixer/loader accident" scenario is cited as resulting in elevated risks. Consider the above comment on need to clearly delineate accident scenarios from routine work scenarios.
  - Text states *"It was assumed that a single person was responsible for all three activities".* It is unclear what this assumption is based on; please cite references. Similar assessments by pesticide regulatory agencies such as the U.S. Environmental Protection Agency (EPA) do not assume the pilot and mixer/loader to be the same person, as the pilot requires a special licence to operate aircraft, which most mixers/loaders usually do not have. Technical

Memorandum 141 (Demaree and Creager 1968) states that one pilot applied all mixtures in about 30 hours of actual flying time over three consecutive days (but does not identify the number of personnel involved in mixing and loading, or the number of flagmen). Since there was only one pilot, would he have had time to also do all the mixing/loading?

- Second bullet, Flagger:
  - Ingestion is identified as an exposure pathway here, but was not the Problem Formulation (section 4-1) nor assessed in the exposure assessment. Regulatory agencies generally do not consider ingestion to be a typical exposure pathway for flaggers.
- Third bullet, Post-application Scouts:
  - The text states *"It was assumed that individuals acting as flaggers also may be the post-application scouts"*. Please discuss and reference the basis for this assumption. Similar assessments by pesticide regulatory agencies such as the U.S. Environmental Protection Agency (EPA) do not assume that the scout and flagger are the same person. Scouting is usually conducted to determine efficacy of the application. Considerations could include: Would the efficacy of a defoliant be apparent immediately after the application (as suggested by the assumption that flaggers also scout)? Would flaggers have the specific expertise that scouts require to assess efficacy? .
- Fourth bullet, On-Site Military Trainee:
  - Clarification of the types of activities conducted by this receptor, and the assumed time frames (post application) for the assessment for this receptor, is required. (See specific comments below)
- There are some possible exposure groups are not addressed in the report. It is important to either assess theses group, or to conclusively determine that these activities did not occur (at least for the Tier 1 assessment scenarios), given the concerns of individuals who believe they may have been exposed in these ways:
  - Brush clearers and brush burners. A large number of individuals believe they may have engaged in this potentially relatively high exposure activity.
  - Family members or others who may have had contact with "contaminated" clothing that personnel brought home.

ES-5.0: Exposure Assessment

- Please clarify the sentence "A range of exposures to people at CFB Gagetown in 1966-67 was estimated."
- Section refers to "high, low and central estimates". Later, new terms such s "upper-case estimate" and "worst-case scenario" are used. Later in the report (p. 35), the estimates are called "upper, lower and central approximations." See general comments (above) on the importance of consistent terminology and constructive suggestions.
- Terms used are rather technical for a plain-language summary. For example, instead of "worst-case parameter values" could say "worst-case assumptions". "
- Worst-case scenario" should be defined (in terms of the intention to overestimate the risk).

ES-6.0: Hazard Assessment

- Table ES-1:

- The non-cancer health effects for dioxins should conclude with *"...and other developmental effects".*
- The cancer effects associated with dioxins have not only been linked with occupational exposures, but also in situations where the general population has been exposed though industrial accidents (e.g., Seveso). Reference should be made to such situations.

• The diseases listed should be defined for the lay public.

ES-7.0: Risk Characterisation

• First paragraph:
- This text in paragraph appears to state that exposure = risk. For example, . *"Military trainees were assumed to have long term exposure and therefore long term risks".* Text should be clarified to avoid propagating this common misconception and to be consistent with the bullets that follow.

• Dioxins, 2nd bullet:
- Sentence is not clear and reference to "acceptable" should be removed (per comment above). It would be better to rephrase sentence as, *" Long term cancer (and other ??) risks were concluded to be negligible for military trainees experiencing long-term exposure."*

• Dioxins, 3rd bullet:
- Does this statement really mean that risks were elevated for >50 years or does it mean that body burdens were elevated for >50 years? It would be useful to provide more characterisation of the relationship between body burden (exposure) and risk, including more specificity on specific risks and on strength of the association between the estimated body burden and the risk.
- Clarify what is meant by "spray accident scenarios"

• HCB, general:
- Terminology may be too technical and in some cases is poorly defined or too subjective: e.g : *"minor exceedances", "marginal exceedance" and "highly conservative".* This is the first time the word *"conservative"* is used. The word should be defined, including a plain language explanation of what leads to conservatism in risk assessment.
- Should note that three risk estimates were made (high, low and central) and clarify whether the conclusions drawn are based on the "central" estimate, or all the estimates.

• HCB, 1st bullet:
- The conclusion that "overt signs of toxicity" would be the result of "active herbicide ingredients" is not substantiated by the risk assessment in this report. Conclusions should be made only after the risk assessment for the active ingredients has been conducted (which will be in the later tiers).

• HCB, 2nd bullet:
- It would be better to rephrase sentence as, " *Long term cancer (and other ??) risks were concluded to be essentially negligible for military trainees experiencing long-term exposure."*

ES-8.0: Uncertainties

- The sentence related to what risk managers need is irrelevant for the plain language summary and should be removed.
- The Plain Language Summary (and the report in general) is for a public audience, who needs help to understand the uncertainties in the risk estimates. This section states that over-predicting is preferred to under-predicting, but does not give any indication of factors or areas in which under-prediction is possible. A more complete and systematic discussion of uncertainty could include a table of the various factors in the risk assessment and a corresponding statement about whether the data uncertainties are likely to lead to over-prediction or under-prediction, and how this was addressed, e.g., use of uncertainty factors, etc. (see General Comments above)

Section 1.0 Introduction:

- Footnote 1, page 1:
  - To avoid confusion, consistent terminology should be used throughout the document. Here it is specified that PCDDs and dioxins refer to PCDDs, PCDFs and dioxin-like PCBs, yet elsewhere in the document, PCDFs are used with PCDDs; does that mean that dioxin-like PCBs are excluded? It would be better to use either use dioxins or PCDDs, not both, to represent the same term. See general comments for additional suggestions.
- Page 2:
  - Text states *"There is a need to examine the potential for exposure before any risk can be determined."* It is unclear why there is a need - suggest explaining the implicit point here, that if there is no exposure, then there is no risk.
  - It is noted in the report and the statement of work for this contract that a risk assessment is to be conducted for herbicide use from 1952 to the present day. However, the description of the tiers indicates that herbicide use from 1956 will be considered. A rationale as to why 1952 to 1955 will not be considered needs to be provided.

Section 2.0 Description of Tier 1:

- Page 3, 1st paragraph
  - References to Demaree and Creager, 1968 – references section has 1968a.
  - Text states: *"This is an important point since it suggests that data regarding important factors such as rates of application and deposition that have been developed for exposure models used for Vietnam...should be comparable for the experimental applications of herbicide at CFB Gagetown."* This statement needs to be substantiated further. It is unclear if the report authors actually compared the rates used at CFB Gagetown to those used in Vietnam. Various rates are used to assess the efficacy of a product as compared to actual use conditions that may have been used in Vietnam.
- Page 3, 2nd paragraph:
  - *"The tests occurred over a two year period."* This statement could be clarified to indicate the small number of days during which testing occurred in the two-year period.

- Figure 2-1:
  - In title: replace "or" with "and", to read *"Application for 1966 (shown in blue) and for 1967 (shown in green)".* Also define what the red-outlined area is.
- Page 4, 1st paragraph:
  - Define the abbreviation "CO"
- Page 4, 4th paragraph:
  - Text read *".....each plot received a series of four passes...."*. This contradicts the assumption used in the spray drift report where a single spray line with a 100 feet spray swath was assumed, as the report did not specify. Please clarify the discrepancy.
- Page 5:
  - Reference to Demaree and Hawes, 1968 - references section says 1968b.
  - The phrase *"contaminants of concern*" is elsewhere in report stated as *"chemicals of concern".* Again, it would be helpful to maintain consistent terminology throughout the report.
- Page 5, Bullet 1:
  - Text states that TCDD is present in 2,4,5-T. It is unclear if this implies that only TCDD is present and other dioxin and furan congeners are not. Please clarify.
  - Text reads *"At the time of application, there was no discernible contamination of 2,4-D by PCDDs or PCDFs."* This suggests that 2.4-D samples were analysed for PCDDs and PCDFs and none were detected. Does the statement actually mean that there was limited information on the levels of PCDDs and PCDFs in registered 2.4-D? Please clarify the basis for concluding that all the dioxin agents orange and purple arose only from the 2,4,5-T.
- Page 5/6, including and Tables 2-1 and 2-2:
  - Please provide references for reported concentrations of contaminants in Agent Purple and Agent Orange and document reasons where assumptions/conclusions differ from those of Jaques Whitford.
  - Please be careful to differentiate between unregistered agent products and registered herbicides that contained 2,4,5-T.
  - Please consistently specify whether only TCDD was measured, or all dioxin and furan congeners. If only TCDD was measured, specify whether there is the likelihood that other congeners would be present and the implications for the total TEQ and the risk assessment.
  - It would be cleared to label the last column "<u>Assumed</u> Contaminant Concentration" to indicate these are assumed and not measured or known values.
  - Please be consistent about whether contaminant concentrations are expressed as TEQs and reference the source of the TEQs for the calculation.
  - Please add a footnote referencing where the estimate of HCB in picloram came from (not explained in report).
  - Ist footnote - what does the last sentence mean - are words missing?
  - It is unclear why there are there footnotes for Agent White and Agent Blue when these chemicals are not mentioned anywhere else in the report.
  - Last row in Table 2-2 refers to "focus contaminants". Please define this term.
  - In the published literature, HCB is identified as a contaminant of PCP and should be assessed as such. See comments for Appendix A.

Section 3.0 Health Risk Assessment Methodology:

- Section 3.1, Problem Formulation:
  - Text reads *"...takes into account chemical-specific parameters, such as solubility and volatility..."* It as unclear how the identification of exposure pathways took such properties into account, or why these two particular properties and not mobility and persistence (generally recognized as more important determinants of fate/transport) were selected..
- Section 3.3.1 - 3rd paragraph:
  - When discussing "adverse effects," please specify "adverse health effects." Also, please introduce/explain the term, Tolerable Daily Intake.
- Section 3.4.1, page 11:
  - Please refer to comments about "acceptable" cancer risk above under section ES-3.0.
- Section 3.4.2:
  - Please provide references for the body burden approach, introduced here as "an accepted and well documented approach"
- Page 12, last paragraph:
  - Please provide rationales for why certain assumptions were used for the HCB risk assessment. Specifically, *"for chronic exposures/chronic risks, HQ and ILCR estimates have been provided for HCB, assuming annualized exposures over a maximum three year period"* and *"for the purpose of this evaluation, a duration of exposure of one year has been assumed."*

Section 4.0 - Problem Formulation:

- Section 4.1, page 13:
  - Subheading title: Contaminants of Concerns (COCs) - note that earlier, in Section 3.3.1, COC was defined as Chemical of Concern. In Section 5.3.2 they are called "contaminants of interest." In Table 2-2 they are called "focus contaminants." Please define and use one term consistently.
  - 1st paragraph: "PCDD/PCDF." Does this term include dioxin-like PCBs as per the footnote in Section 1? See General Comments for further suggestions.
  - 3rd paragraph. Text reads *"... the development of time-dependent EPC data for all environmental media would require a significant amount of historical spray application data and environmental fate and transport modeling."* This statement is vague and leaves the reader wondering, if it is feasible, possible or necessary to do this type of modelling.
  - Last sentence in Sec. 4.1: *"EPCs are further characterized in Section 4.0."* Should this be Section 5.0, as the statement is already in Section 4.0?
- Section 4.2, page 13:
  - Text reads *"The following is a preliminary list of receptor groups..."* It is unclear why this list is preliminary.
- Section 4.2, page 13. Mixer/Loader/Applicator :
  - Text reads *"A conservative approach may be taken in which it is assumed that a single person was responsible for all three activities."* The basis for this

assumption is unclear. Similar assessments conducted by regulatory agencies such as U.S. Environmental Protection Agency (EPA) do not assume that the pilot and mixer/loader are the same person. Considerations could include that the pilot requires a special licence to operate aircraft, which mixers/loaders usually do not have. It might also be useful to consider Technical Memorandum 141, which identifies that in 1968 one pilot applied all mixtures in about 30 hours of actual flying time over the three consecutive days, but does not identify the number of personnel involved in mixing and loading, or the number of flagmen. Would one pilot have had time to also do all the mixing/loading?

- Section 4.2, page 14. Flagger:
  - If it is assumed that the flagger and post-application scouting receptor were the same person, this should be noted here. However, the basis for such an assumption should be clearly documented. Similar assessments conducted by pesticide regulatory such as the U.S. Environmental Protection Agency (EPA) so not assume the scout and flagger are the same person. Scouting is usually conducted to determine efficacy of the application. Would the efficacy of a defoliant be apparent immediately after the application as suggested by the assumption that flaggers also scout? Scouts have specific expertise to assess efficacy. Is it reasonable to assume that flaggers have this expertise?
- Section 4.2, page 14. On-site Military Trainees:
  - A clearer description of the types of activities that military trainees typically do, and upon which the assessment is based, should be included. The time frames (post application) of the assessment for these receptors should be clarified and justified.
- Section 4.2, page 14.
  - Brush clearing and/or burning is an exposure activity that needs to be considered as there have been persistent statements that students and others engaged in this potentially relatively high exposure activity. Alternatively, it could be definitively determined that these activities did not occur in association with the Tier 1 spraying activities.
  - Some individuals have said that they had frequent contact with clothing contaminated with the herbicides used in the applications and which the personnel brought home. This exposure scenario should be addressed.
- Section 4.2, page 14. Off-Site Civilians:
  - The report states *"These individuals are those who may live near the military base and occasionally use specific areas of the base for recreational purposes.....would come into contact with various environmental media (e.g., soil, dust, local produce, etc.).....(i.e., spray drift depositing on nearby off-site residential properties)....This receptor group was not considered for the 1966-67 scenario as these spray areas are fairly small and remote resulting in limited opportunities for exposures. The 1966-67 spray areas will considered as part of the evaluation of this receptor group during Tiers 2 and 3 exposure scenarios."* While, it may be reasonable to conclude that off-site civilian exposure was minimal for this Tier, it is necessary to specifically address this receptor group to substantiate such a conclusion. Consideration of this group was included in the Draft Problem Formulation for this tier originally submitted to the Technical Authority.

- Some scenarios could be addressed by a relative comparison to quantitatively assessed receptors. For example, it might be argued that off-site civilians, and those walking or hunting on the base, would receive a much smaller dose than that received by flaggers and a smaller dose than other personnel in the direct vicinity of the application site during or after application (post-application scouts, on-site military trainees, etc).
- The spray drift report (Task 2D) for this tier includes information on the estimated fraction of the application rate deposited downwind of the sprayline. These estimates can be considered conservative as the contractor for Task 2D has indicated that they were based on "some worst case assumptions". Since the area sprayed is remote and small, this information could be used to estimate how far away the "safe zone" is. If deposit may be considered negligible at a specified distance from the flight line (e.g. 500 ft), it might be possible to conclude that is very unlikely that there is spray drift depositing on off-site areas that civilians access..
- The Task 2E scoping report includes relevant information to use in considering potential exposure from surface water and groundwater.
- For surface water: A possible approach would be to consider the distance to the nearest potential s.w. receptors. For example: Significant s.w. receptors identified in the 2E scoping report were those with known recreational uses, including several lakes and the Nerepis River. The 2E report maps these watersheds in comparison to herbicide application areas. Fig. 4 shows that the 66 spray area does not intersect any of the identified watersheds. The 67 spray area does lie within the watershed that drains to the Nerepis River; however, the 67 spray area is ~5 km from the main channel of the river. It may be possible to draw qualitative conclusions about the likelihood of s.w. impact given the watershed mapping, distance, time duration of applications, phys/chem properties of HCB/dioxins, etc.
- If there is in fact a surface water body within the deposition zone, it may be possible to consider s.w. receptors through a semi-quantitative assessment, incorporating reasonable high-end assumptions about deposition, flow rates, sediment binding, etc. that would to ensure that the risk assessments for any occasional ingestion & dermal contact during the short duration before the chemical is flushed out of the stream (or binds to the sediments) is protective.
- For groundwater: A possible approach could consider the presence/absence of potential historical groundwater receptors (wells) in the vicinity of the 66/67 spray area as identified in Task 2E. CFB Gagetown personnel have stated that the base bivouac wells were installed in the mid-1990s and the only well in the vicinity existing perhaps back as far as the 1960s is at Blissville. Cantox may wish to independently confirm this information with DND. Cantox could consider the range of estimated groundwater travel times provided in the 2E scoping report. This range is conservative, e.g. , without considering effects of adsorption (which would result in longer travel times). The effects of adsorption on groundwater velocity could be considered by using the simple equation for calculating a retardation coefficient based on Koc, aquifer porosity, and bulk density. Cantox could use the JW scoping report map of the potentiometric surface (Fig. 3) to visually estimate the general direction of regional groundwater

flow in vicinity of 66/67 spray areas. For any potential receptors identified (e.g., the Blissville well) that are generally down-gradient of the 66 or 67 application areas, could compare a conservative estimate of the groundwater travel-time to the time period of exposure used in the Tier 1 assessment. Regardless of the qualitative analysis, it is noted that DND personnel have stated that base wells were not used for drinking water, with the exception of Camp Petersville (as noted by Sheldon Downe in his comments on the 2E report). As Cantox proceeds with work on further tiers, Cantox may wish to independently confirm this information, and accordingly decide what g.w. exposure assumptions to make (no g.w. ingestion; very occasional g.w. ingestion; seasonal g.w. ingestion during training, etc.). The HC Technical Authority for the 2E scoping report is available to answer any questions Cantox may have about the report and the data used.

- The spray drift report (Task 2D) and the water migration scoping study (Task 2E) should be included as appendices to the Task 3a-1 Tier 1 report.

• Section 4.3, "Operable Exposure Pathways"
  - Please define what is meant by "Operable".
  - The term "realistic, yet conservative" is hard to understand. It would be better to clearly describe and characterise the uncertainties and conservatism that underlies the estimates. Please see general comments above for further guidance. .
  - Text reads *"From this, more detailed exposure pathways can be developed."* Suggest replacing "can be" with "were".
  - Please provide justification as to why some exposure pathway/ receptor combinations were screened out of further consideration (the ones noted with X's)
• Section 4.3, Figure 4-1
  - Indicate in title that this conceptual model is for Tier 1 (66/67 spray trial areas).
  - The exposure pathways and receptors in the figure are inconsistent with the pathways actually considered in the risk assessment. For example, the checks indicate that incidental ingestion from dermal contact with the herbicide product will be considered for the mixer/loader, flagger and scout; however, it appears that this was not a pathway considered in the exposure assessment.
  - Add a footnote clarifying that X means pathway not considered, while a check means the pathway is considered. Alternately, "yes" and "no" could be used.
  - Under the military trainee/trainer, indicate the meaning of the checks in parenthesis.
  - All potential pathways shown on the diagram should be discussed, even if not designated for further analysis. For example: volatilization to outdoor air is shown on the diagram, but not mentioned anywhere in the report. It was unclear why this pathway eliminated from detailed consideration. Justifications should be provided.
  - Surface water should be addressed either qualitatively or quantitatively (dermal exposure and/or ingestion). See detailed comments above.
  - Groundwater should also be addressed, at least in terms of discussing whether there were any receptors (wells) in the vicinity that were used for potable supply during the exposure period of interest). See detailed comments above.
  - Dermal contact with foliage should be addressed for all relevant receptor groups (i.e., all post application exposures). For scenarios where sufficient time has

passed for dislodgeable foliar residues to decline to insignificant levels, a qualitative discussion may suffice).

- Last column heading includes military "trainer" as does last footnote. "Trainer" not mentioned anywhere else in report.
- "Applicator" is not included as a receptor in the figure, yet it is considered throughout the report. -

• Section 4.3.1.1

- Text reads *"...employed the use of exposure data provided by the Pesticide Management Regulatory Agency, literature-based values, as well as a number of conservative assumptions."* This wording suggests that the first 2 sources (PMRA and literature) are not necessarily conservative. Please clarify whether the PHED is considered to be conservative or realistic (and provide references/justification for the conclusion). Were literature-based values used in a conservative manner? Please provide some clarification on the above statement .
- "Pesticide Management Regulatory Agency" should be "Pest Management Regulatory Agency"
- Text read *"Dermal and inhalation exposure data for the mixer/loader/applicator scenario can be estimated using predicted loading values from the Pesticide Handlers Exposure Database (PHED) (PMRA 2002)."* Consider deleting "PMRA 2002" and adding *" PHED model runs for various scenarios were provided by PMRA"*
- A general description of the types of studies in the PHED database would be useful. It would help characterise the risk assessment to clearly note that the studies in PHED asses exposure under typical conditions, which includes typical spills and splashes during open mixing and loading activities, and the type of direct overhead exposure that would occur during actual flagging activities. It could also be noted that some of the flagger data in PHED is from studies of agricultural applications which may overestimate exposures for forestry flaggers as there is no canopy effect during agricultural applications.
- Remove the second "generic" form the sentence beginning *"PHED provides generic passive dosimetry data for ~~generic~~ mixer/loader/applicator exposure....."*
- Please clarify what is meant (in the context of PHED subsets) by "These focussed on the fact that relatively small amounts of each pesticide formulations were prepared, but multiple combinations or dilutions were applied from a helicopter delivery system"

• Section 4.3.1.1, page 18:

- Please provide references for the protection factor of coveralls and chemical-resistant coveralls. (e.g. US EPA)
- 2nd paragraph, 1st sentence: *"Failure to....."* is not a complete sentence.
- 2nd paragraph: Text reads *"This may include the use of dermal loading data for clothing scenarios "a" to "c" as listed above which are more representative of individuals wearing casual clothing rather than clothing typically worn for handling herbicides."* Clothing scenario "a" was short pants, short sleeves and no gloves, but this scenario was not used in any of the exposure assessment scenarios. Is this clothing scenario really considered likely?

• Section 4.3.1.1, page 18, Formulation Type:

- Text reads *"Predicting exposures during the mixing and loading stages will be heavily influenced by the herbicide formulation type."* Replace "will be influenced by" with "is dependent on."

- Section 4.3.1.2, Page 19: Flagger/Post Application Scout
  - 1st paragraph: Reference is made to incidental ingestion for flagger and post-application scout; however, this pathway was not considered in the exposure assessment.
  - 3rd paragraph: Please justify assumption that flagger and post-application scout would be the same person and characterise the degree of conservatism associated with that assumption.
  - 3rd paragraph: The exposure pathways described for post-application scouting are not consistent with Figure 4-1 or with the exposure assessment conducted for this receptor. These pathways are *"dermal contact with impacted soils.....inhalation of re-suspended dusts, incidental ingestion of soil or dusts, or inhalation of smoke containing COCs from burning affected vegetation....inhalation of COCs within a lingering plume....."* Please discuss why these pathways were not considered further in the exposure assessment, as it appears only foliar contact was considered on page 36. Foliar contact was not a pathway listed in Figure 4-1.
  - 4th and 5th paragraphs: Reference is made to military personnel conducting *"maintenance activities such as felling dead trees, or clearing undergrowth."* It is further stated that *"for work crews and military personnel on manoeuvres in the area conservative default estimates of dislodgeable foliar residues and generic agricultural transfer coefficients will be used....."* This is the only place in the report that this receptor is discussed. This receptor and their possible exposure pathways are not included in Figure 4.1, nor are exposure estimates or hazard quotients calculated. It appears that this receptor is not a military scout or a military trainee. Please discuss why an exposure assessment and risk calculation was not completed for this receptor. See comments on the importance of considering this receptor above.
  - Remove words "staking, topping, training" from final paragraph on page 19. These words make no sense in this context as these activities are not relevant to the scenarios being assessed.
- Section 4.3.1.3, p20, On-site Military Trainee
  - Reference is made to inhalation exposure via impacted soil and dust yet this exposure pathway was not identified in Figure 4-1 nor considered in the exposure assessment for this receptor (Section 5.4.5). Consumption and dermal contact with water should be addressed (see above comments on water under civilian exposure for suggestions on how this could be done). Please clarify and explain which exposure pathways were considered and which were excluded. .
- Section 4.3.1.4, p20, Accidental Spray Event
  - Please discuss the uncertainty and conservatism of assessing this scenario. Comment on how the event is considered to be "unlikely." Please explain why there would be "no canopy cover protection" for this scenario. Provide a rationale for the extent of the conservative assumptions used and why.
  - It would help to discuss that for flaggers, any accidental scenarios that typically occur would have been captured in the PHED scenario.
- Section 4.3.1.5, p 20, Civilians

- See comments for Section 4.2 - Offsite Civilians. Please address water and drift as suggested in comments under Section 4.2.
- First paragraph - *text reads "Exposure events may occur .....as a result of spray drift migrating to off-site locations.*" Third paragraph - *"Civilian receptors may also be exposed to COCs as a result of herbicide spray drifting to areas outside of the military property line."* Please discuss the likelihood of this happening based on the results presented in the spray drift report (Task 2D) and considering the comments noted under Section 4.2.
- Third paragraph: *"Impacted groundwater may also be source of exposure as a result of the movement of volatile chemicals into indoor environments through vapour infiltration, or in cases where groundwater is used as a potable water source...."* As discussed in the comments for Section 4.2, please comment on the volatility of dioxins and HCB and the impact of this given the likelihood of groundwater being a source of exposure for the spray areas of 1966 and 1967.. Please refer to comments under Section 4.2.

Section 5.0 - Exposure Assessment

- "The primary objective of the exposure assessment is to predict, using a series of conservative assumptions, the rate of exposure....." This statement is too simplistic. Comment on why the primary objective is to be conservative. In general, conservative assumptions are applied in relation to the degree of uncertainty around that assumption. For each assumption the risk assessor needs to consider and document what information is available regarding that assumption and the extent of conservatism warranted based on the knowledge available. This allow the results of the risk assessment to be interpreted in proper context.
- Section 5.1 - Estimated Daily Intake (EDI)
  - See detailed comments for Appendix C below.
  - Please provide specific information on the historical and current background daily intake value for dioxins and HCB that would need to be included in the main report. For example, does the historical EDI represent the exposure in 1966 and 1967 or is it more representative of another time period? Describe the data that the current EDI is based on. For what years was the historical EDI used when determining body burden exposures? Similarly, for what years was the current EDI used? Also, it was unclear why a lifetime composite receptor was used instead of the adult, as only adult receptors are considered in the risk assessment.
- Section 5.2, first paragraph
  - As stated in the Statement of Work for this project, the U.S. EPA would also be a good source of information on exposure assessment methodologies.
- Section 5.3.1
  - It is unclear how it was decided which parameters would be estimated as single values and which would be represented by a range (high, low, central estimates). This is basically introducing probability into some variables and not into others. The report authors should indicate if all the variables were examined systematically to decide which should be treated stochastically (as a data distribution) and which to be treated deterministically (as a single point estimate), with consideration to which are driving the risk. A logical step in this process

would be some sort of sensitivity analysis, i.e., considering the effect on the results of varying the parameters over their expected ranges, to determine which parameters are most important.[1]

- Only "upper-case" is defined, while "central" and "low" are not. They warrant an explanation here. Is "central tendency" (in the subheading) the same as "central"?
- "The parameter that vary across each of the three exposure estimates are..." Neglects to mention 1) surface area of skin exposed, which was apparently treated as a range for the flagger accident and field scout scenarios, and 2) forest canopy interception factor, where a range was apparently used for the military trainee scenario. It appears the range was used only for one scenario, but the general statement in Section 8.1 implies otherwise by not being specific: "A range of canopy intercept factors were [was] employed."

• Section 5.3.1.1
  - "As previously discussed..." The reviewer could not locate where this was discussed. It would be helpful to give the report section number, as these are important assumptions in the exposure assessment.
  - Text states *"...a review of the scientific literature indicated that the PCDD content in Agent Orange was represented by a concentration of 2 ug/g."* It was not clear how the value of 2 was selected 2 from a literature review, or whether it was a Mean value, median, etc. Were all literature data given equal weight? What was the range or standard deviation? The only previous statement to be found was (p. 6): "All 2,4,5-T in Agent Orange was assumed to have a level of contamination by TCDD of 2 ppm." It was unclear what this assumption was based on, or why ? a range of PCDD content was used for Agent Purple and not for Agent Orange or picloram.
  - "The HCB content in picloram was determined to be 200 ug/g." No reference given for how it was determined, and not discussed earlier in Table 2-1 and 2-2. Please clarify the source of this value.

• Table 5-1:
  - Suggest adding "Estimated" to the title, as these values are not measured/known but represent your best estimate or assumption. Likewise for the titles to Tables 5-2, 5-3, and 5-4.
  - Values in table are expressed as a unitless fraction, yet elsewhere in ppm, then also in ug/g. Please use consistent units.

• Section 5.3.1.2 - Dermal Absorption
  - For dioxins, it is not clear which congener was the basis for deriving the dermal absorption value. For comparison with published, measured dermal absorption values (see below), it would be useful to also express estimated dermal absorption values as a rate or a percentage
  - When deciding which values to represent the upper, lower and central exposure estimates, comment on why these statistics were the only parameters considered? For example, would different congeners have varying absorption levels?

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[1] For an example of an analysis to determine the relative contribution of individual parameters to the overall risk estimates for dioxin exposure, see: Ma, H. "Using stochastic risk assessment in setting information priorities for managing dioxin impact from a municipal waste incinerator." Chemosphere 48 (2002) 1035-1040. This multimedia risk assessment had over 500 parameters, but through an uncertainty analysis, the authors identified the 15

- There are many published studies in which dermal absorption of dioxins was evaluated (e.g .those listed below). The results of these studies could be considered as part of a weight-of-evidence approach, by comparing measured and modelled values, to electing dermal absorption values for the low, central and high exposure estimates. Consider for example:
  - Anderson YB, Jackson JA, Birnbaum LS. Maturational changes in dermal absorption of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in Fischer 344 rats. Toxicol Appl Pharmacol. 1993 Apr;119(2):214-20.
  - Brewster DW, Banks YB, Clark AM, Birnbaum LS. Comparative dermal absorption of 2,3,7,8-tetrachlorodibenzo-p-dioxin and three polychlorinated dibenzofurans. Toxicol Appl Pharmacol. 1989 Jan;97(1):156-66.
  - Banks YB, Birnbaum LS. Absorption of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) after low dose dermal exposure. Toxicol Appl Pharmacol. 1991 Feb;107(2):302-10.
  - Banks, Brewster, Birnbaum. 1990. Age-related changes in dermal absorption of 2,3,7,8-tetrachlorodibenzo-p-dioxin and 2,3,4,7,8-pentachlorodibenzofuran. Fundam. Appl. Toxicol. 15, 163-173.
  - Poiger H and Schlatter CH. 1980. Influence of solvents and adsorbents on dermal and intestinal absorption of TCDD. Food and Cosmetics Toxicology 18:477-481.
- A discussion of dermal absorption of soil-bound HCB and dioxins would be useful in the main report here, not just in the Appendix.

• Section 5.3.1.3
  - The personal protective equipment described in this section is not consistent with Page 18, 2nd paragraph (see above comments for section 4.3.1.1)
• Section 5.3.2 - paragraph 2
  - The incorrect conversion factor is cited for converting application rates from g/m^2 to lbs/acre. The conversion factor cited is 1.12E-01 whereas the correct conversion factor is 8.9. This suggests that the exposure estimates could be underestimated by factor of approximately 80 times. Unfortunately, sample calculations were not provided to verify whether this error actually occurred in the calculations. Please verify that the correct conversion factor was used in the calculations.
• Table 5-2:
  - The PCDD rates for Agent Orange appear to be under the “low” heading, when they are single-value estimates. Could move them to the left under “central”, or change the column headers.
• Tables 5-2, 5-3, 5-4 and 5-5:
  - The column of “application rate of a.i.” is misleading. The a.i. or active ingredients refers to the defoliant chemical, such as 2,4-D, that would be present in the product. Please specify whether this column represents the application rate of the active ingredient, of the entire product (e.g., Agent Purple) or of the contaminant.
  - Diesel is listed in Table 5-2 as a component of the applied mixtures but is not further addressed in the report. Is the intent to address this in the other tiers or to develop a rationale for its exclusion from the assessment?

- Section 5.4
  - Include the input values with each of the parameter definitions for the equations. For example, beside BW, please report which body weight value was used.
- Section 5.4.1.1
  - "*The PHED dermal UEs, which are an expression of the amount dermally absorbed by the receptor.....*" Replace "absorbed" with "deposited." PHED provides exposure estimates of dermal deposition, not dermal absorption.
- Tables 5-6, 5-7 and 5-8:
  - It is confusing to have "low, central, high" as the rows when the previous tables had these as the columns.
  - In addition to the column-row transposition, the order of the three estimates varies among the tables, which is confusing: Table 5-2 lists central, low, high. Table 5-6 lists low, central, high. Tables 5-9 and 5-10 list central, lower, upper (note different terms used).
- Section 5.4.1 and 5.4.1.2
  - Exposure Resulting from an Accidental Spill - This is the first time that this exposure pathway has been mentioned in the report. It was not included in 4-1. PHED scenarios for mixers/loaders include any routine spills and splashes. Please provide a rationale as to why an additional spill scenario was considered necessary for this assessment. This should include a rationale for the high degree conservatism used in the assessment (eg., spills would occur every day at the highest concentration).
  - The 30% clothing penetration rate applied here is not consistent with the 75% clothing protection factor used elsewhere in the report.
- Section 5.4.2
  - It would be useful to cite Technical Memorandum 141 (which identifies that one pilot applied all mixtures in about 30 hours of actual flying time over the three consecutive days, but does not identify the number of personnel involved in mixing and loading, or the number of flagmen.) Assumptions beyond what is actually known should be justified.
- Section 5.4.3, 3rd paragraph
  - Provide a reference for the following statement: "Generally, use of PHED UEs assumes that individuals involved in flagging activities are professionally trained."
- Section 5.4.3.2
  - Why was the factor of 2.7 chosen rather than the peak factors calculated by REMSpC's modelling? It is misleading to state that the factor of 2.7 is "based on an analysis provided by REMSpC" as it could be concluded that 2.7 was the peak factor from the modelling, when in fact 2.7 is from a 1964 report on calibration trials. The modelling predicted lower peak factors, i.e., Fig. 1 shows 1.4 for the 1966 trials and Fig. 2 shows around 0.85 for the 1967 trials.
  - Similarly, the definition of 2.7, following the equation, as "worst-case multiplier based on wind speed and direction" suggests site-specific data and modelling were used to generate this factor, which is not the case.
- Table 5-9:
  - Text cites canopy intercept factor of 0.9 with reference of Karch et al. 2004. It is unclear why 0.9 is listed in this table when 0 was used as described in the text.

- It would be useful to have "a Table 5-9", not just for the flagger scenario, but also for the mixer/loader and applicator scenarios.

• Section 5.4.3.3
  - Please comment on why an alternate exposure assessment methodology was utilized for the flagging activities, including the reference for the alternate approach (if any), what are the strengths and weaknesses of both approaches (PHED vs alternate approach), inherent conservatism and uncertainties, and validation and acceptance of both methods.
  - 2nd paragraph - PMRA is misquoted. "PMRA (2006) indicated that within an agricultural setting approximately 20% of the aerial application rate would reach the soil surface." This statement would be correct as follows: "PMRA (2006) indicated that within an agricultural setting approximately 20% of the application rate is dislodgeable from foliage immediately after application." Since dislodgeable residues from foliage is not the subject of this paragraph, the entire sentence is irrelevant and should be deleted.
  - For aerial applications to forestry, the PMRA uses a 50% interception factor to calculate buffer zones. The drift modelling in the spray drift report did not assume any interception. As noted by Cantox, the published literature indicates most of the application would likely be retained in the upper canopy under dense foliage conditions.
• Section 5.4.4
  - As noted in the Statement of Work for this contract, PMRA has produced a guidance document on the principles/theories of estimating potential exposure using dislodgeable foliar residue (DFR) data and agricultural transfer coefficients (TCs) for estimating potential exposure to people entering areas treated with pesticides, including areas similar to forestry scenarios (Post-application Exposure Monitoring Test Guidelines (PRO98-04) available at http://www.pmra-arla.gc.ca/english/pubs/pro-e.html). Additional information on this topic is generated by Exposure Task Forces and can be found at: www.exposuretf.com and on the websites for PMRA and the U.S. EPA. Cantox estimated exposure to the field scout using a method developed by the USDA Forest Service. It would be useful to include a discussion in this section of the USDA exposure assessment methodology versus the standard methodology used by the PMRA and the U.S. EPA, including what are the strengths and weaknesses of both approaches, inherent conservatism and uncertainties, and validation and acceptance of both methods. Also discuss how the transfer rates are derived for both methods and whether it is validated based on actual data.
  - Text reads *".....a fraction of dislodgeable residue of 0.1 was used....."* Please specify fraction in relation to what (the application rate?) and indicate how this value was derived.
  - *"The time period assumed between initial spray operations and re-entry into each plot was short enough to ....."* Please specify what the time period was. Also specify the chemical-specific transfer rate that was calculated. Please discuss how/why it is chemical-specific.
• Section 5.4.5, Military Trainees
  - *"Military trainees were assumed to spend 2 months of the year at the 1966 spray campaign site."* It is unclear what this assumption is based upon, and whether

this is an average estimate, or is it longer than average, i.e. conservative.

- 1st paragraph: the exposure pathways listed are not consistent with Figure 4-1.
- Please provide a rationale as to why exposure pathways from surface water and groundwater were not considered. See comments about regarding exposure from surface water and groundwater for civilians.
- Was exposure from dermal contact with foliage considered?
- 2nd paragraph: What soil half-lives were used? Were the phys/chem data generated in Task 2A used?
- 2nd paragraph: Degradation of PCDD was not discussed previously in the report.
- Page 38, 1st equation: the units do not cancel. The units of soil bulk density are kg/m^3 and it appears that a conversion factor needs to be included.
- Page 38, 2nd equation: terms defined include $t_{1/2}$ but $t_{1/2}$ is not used in the equation, the rate constant k is used instead. To define k in terms of $t_{1/2}$, please create a separate equation. For cross referencing, it would help to number all the equations in the report.
- Page 38, 3rd equation: units do not cancel. Clarify the units for wild berry consumption (currently cited as g/kg/day). Also the study bioavailability would not be unitless in order for the units to cancel in this equation.
- Page 39, 1st equation: include a conversion factor to allow units to cancel.
- Page 39, 2nd equation: units do not cancel. In order for the units to cancel, the units for soil adherence factor should be $g/(cm^2\ day)$ and the dermal absorption factor would not be unitless.
- The exposure equations on pages 38 and 39 include division by an averaging time of 1095 days. Justification should be provided as to the appropriateness of the use of this averaging time when calculating the HQ for the acute exposures.
- Table 5-11: Please clarify whether consumption of berries is assumed to occur every day for 60 days per year, and the basis of that assumption.

• Sections 5.5.1 - 5.5.3

- Text reads *"As described in Section 5.3.1, the low, central and high exposure estimates were..."* . Report lists exposure parameters considered as a range but does not include canopy interception factor, which was also treated as a range for some scenarios (military trainee). A clearer summary of all the variables considered as a range for each scenario (a table perhaps) would be very helpful. Sections 5.5.4 (scout) and 5.5.5 (trainee) do not make any mention of which variables were considered as a range to arrive at three estimates.
- Based on the manner in which the equations and data are presented in the report, the calculations cannot be verified. Many of the equations in the report are difficult to understand as the units do not cancel. Inputs for the equations are not readily available; the reader has to search through the report and find some of these inputs in the appendices.
- It is recommended that sample calculations be provided such that at least one calculation per table for the exposure and hazard quotient calculations can be followed through. In addition, the footnotes of the tables should include the equations used and inputs for the equations, including the toxicity reference value.
- The spread between "low" to "high" estimates is up to five orders of magnitude. Please comment on this and how it impacts characterisation of

the exposure and risk estimates.

Section 6 - Hazard Assessment

- Section 6.1 Hexachlorobenzene
  - p. 45 - the first paragraph could note the fact that HCB was assessed by Health Canada to be a probable human carcinogen and declared toxic under CEPA in 1993 and that it was subsequently added to the Prohibition of Toxic Substances Regulations under CEPA in 2003, rather than using the Barber 2003 reference that has been cited here.
  - p. 46, 1st paragraph - *"Animal studies have...risk for cancer of the liver, thyroid and kidney."*
  - p. 47, 1st paragraph - *"CEPA (1993) reports a TD_{05}..."*, cites the wrong 1993 reference in the list of references at the back of the report. This information is taken from the 1993 CEPA assessment for HCB (ISBN 0-662-20291-0) not the 1993 Health Risk Determination publication cited.
- Section 6.2 Dioxins
  - p. 48: "Selected Exposure Limits" would be more accurate as "Toxicity Reference Values."
  - p. 49, 4th paragraph - "Previously...assuming first-order elimination ranging from 7- 9 years in adults.", i.e., more recent information indicates that elimination rates in infants may be as little as months, so there is variation in these rates depending upon age/other factors.
  - p. 52, last line - "Several other countries have or had recommended the same TDI, including the WHO (1991), the UK...", i.e., the value referred to here, of 10 pg/kg bw/day, is no longer recommended by the WHO or many other health agencies, most including the WHO, having replaced this value with a considerably lower one.
  - p. 53, 1st bullet - "...Between 5 -11 years in adult humans.", i.e., same comment as above.
  - Table 6-1 Heading - should be "Tolerable" vs. "Acceptable"
  - p. 54, 3rd paragraph - "(Canadian Environmental Protection Agency, 1997) ?? isn't listed in the list of references. Was it meant to refer to the 1990 CEPA dioxin assessment?
  - p. 54 , 4th paragraph - it would be useful to have in the main report, a description of the study from which the short term MRL of 200 pg/kg/day was derived by ATSDR.
- p. 59, Section 6.3.1, Specific Health Effects Associated with Agent Orange/Purple
  - this section mentions only carcinogenic effects, and none of the other effects such as diabetes, cardiovascular disease, chloracne, spina bifida, etc. Should either modify the title or add the other effects.
  - p. 59 - 62: the conclusions of the IOM are highlighted in italics throughout, but the text in the preceding paragraphs generally would support a different conclusion, rendering the italicized text non-sequiturs. There needs to be some background included as to the rationale for the IOM's seemingly contrary conclusions.
  - p. 62 - Other Cancers: should add female reproductive cancer (cervix, uterus,

ovary) to this list.

- p. 63, Section 6.3.1, Evidence of Health Effects Associated With Agent Orange/ Purple Exposure
  - there is considerable repetition of much of what is in section 6.3.1, i.e., these sections could be better organized and the headings should be re-worked.
- Section 6.2.5 - Body Burden of Dioxin and 7.2.5 Dioxin Body Burden Calculations
  - The whole weight blood values described in section 6.2.5 from the CDC survey should be in fg/g units and not pg/g.
  - p. 57, Table 6-5 - The current background human tissue level of dioxin TEQs (Table 6-5) may be overestimated at 22.8 pg/g lipid. Ryan et al. (Food Add. Cont., 10(4):419-428, 1993) reported an average TEQ value based on a pool of 200 Canadian human milk samples collected in 1981-82 as 24.7 pg/g. This value had decreased to 15.6 pg/g lipid for human milk samples collected in 1986-87.
  - As such, the estimated dioxin TEQ tissue concentration of 21.8 pg/g from the average daily intake figure of 1.8 pg/kg bw/day may be underestimated. Peak dioxin environmental loadings probably occurred from 1960-70 so highest human tissue concentrations would be expected in the early 1970's. This is supported by data from Lunden and Noren (Arch. Environ. Cont. Tox., 34:414, 1998). Average TCDD levels alone from U.S. adipose samples collected in the early 1970's were approximately 18 pg/g (Aylward and Hays, J. Exp. Analy. Environ. Epi., 12:319, 2002). An earlier TEQ estimation, previously provided to DND was approximately 50 pg/g lipid, based on Canadian human milk data, and is comparable to the range recommended by Lorber (Sci. Tot. Environ., 288:81, 2002) for the U.S. population during the 1970's (50-80 pg/g lipid). A background dioxin serum concentration of 50 pg/g lipid would result in an approximate total body burden of 12.5 ng TEQ/kg bw. Using the estimated absorbed dose from Table 7.1 of 30 ng/kg bw/day (single day exposure), a BB of 12.5 ng/kg bw would increase to a BB of approximately 42.5 ng/kg bw or a TEQ lipid value of 240 pg/g lipid.
  - A general recommendation would be to express all body burdens on a per kg bw basis to avoid confusion between actual body burden and tissue concentrations reported on a pg/g lipid.
  - A good comparison, from a risk perspective, is to the Ranch Hand cohort. A recommendation would be to list the various health affects in combination with the estimated body burdens.

Section 7 - Risk Characterization

- 1st paragraph - regarding the statement “plausible range of exposures”. Please refer to the general comments above on the importance of interpreting results in the context of conservatism and uncertainty. Please comment on the plausibility of spreads of four to five orders of magnitude in estimates for the same scenarios and what such uncertainty means for the risk assessment.
- Table 7.1. It could be useful to compare the body burden estimates with the measured values for Vietnam Veterans presented in Tables 6.6/6.8. It might be possible to assess how the estimated body burdens compare with those measured for Vietnam Veterans who

did and did not participate in the Vietnam spray program. It might also be useful to recommend measuring dioxins/lipid for some of the individuals who had possible higher exposures to validate the range of estimated values (see additional comments under conclusions).

- Section 7.1 - equation - please clarify what the absorption factor is, i.e, absorption into what tissue?
- Section 7.2.1
  - "Several risk estimates exceed levels that would be indicative of a concern." Please state which ones – otherwise you make the reader do the work of looking in the tables to identify values >1.
  - Last sentence: "HQ estimate for... the flagger scenarios were quite elevated..." Actually, the PHED flagger scenario is < 1 except for the "high" estimate, while only the alternate flagger scenario exceeds 1 significantly. It is unclear why there is such a large difference between PHED and alternate method and which would be more valid. These results need interpretation and discussion.
  - Similarly, the elevated HQs for the mixer/loader "accident" scenarios need more context with respect to their conservatism, as the estimates derived from PHED already incorporate the spills that happen during open mixing/loading.
- Tables 7-2 through 7-8 and 7-11 through 7-24:
  - It would help to bold or underline the values that exceed risk benchmarks.
  - It would also be useful to present HQs and body burdens relative to background exposure and relative to the body burdens that have been associated with observed adverse effects in humans. . This would help answer the question of what is the contribution of risk from the Gagetown scenarios compared to background risk for the Canadian population.
- Section 7.2.3:
  - The wording relating body burden versus possible risk is clearer her and should be replicated elsewhere (per comments above). However, please provide more details on the recommendation for an epidemiology study. Please clarify what "who were present in the vicinity" means. Is the exposed group big enough to design an epi study with any power? Would it be more useful to investigate the utility of the existing ranch Hand studies to the Gagetown scenario?
- Section 7.3.1
  - Please specify whether background exposures for HCB were added into the exposure estimates and that is the basis for comparing the HQ to 1

Section 8 - Uncertainties

- Section 8.1
  - "...the central tendency represents the most likely case." How does this methodology compare to risk assessments that have exposure estimates representing the 95th % Upper Confidence Limit of the mean?
  - This section lists the assumptions that have uncertainty, but provides no context for interpreting the effects of such uncertainty on the resulting risk estimates. Suggest adding discussion including sensitivity analysis of the effect of these assumptions on the results. This bulleted list leaves little assurance that the

assumptions collectively lead to a conservative (protective) estimate of risk.

- How would the incremental risk added by considering a worst-case scenario for surface water and/or groundwater affect the existing range between the low-central-high risk estimates? It might help to discuss the risks from the various exposure pathways to put them into perspective, especially with regard to the overall uncertainty in the assessment (as reflected by the range).
- Suggest discussing the possibility of cumulative risk posed by exposure to both dioxins and HCB.

• Section 8.2
  - Bullet 5 - The uncertainty factor for the long-term dioxin TDI is 10. Ten is debatable in terms of whether it is a large uncertainty factor.

Section 9.0 - Conclusions and Discussion

• Conclusions section is confusing. A re-structure with sub-headings such as acute and chronic wold help. For example, the second bullet could be a sub-point under the first bullet as both deal with acute exposure. It is unclear if the conclusions are based on the central exposure estimates. Sometimes the "high end" estimate is invoked, when it indicates risk. It may be better to organize the conclusions by receptor group rather than by chemical.
• Structuring results by chemical emphasizes that the risks were evaluated separately. It is unclear what the cumulative risk from exposure to both dioxins and HCB (if this was possible) would be? Would this be calculated by summing the HQs?
• Dioxins
  - 1st bullet - "Acute effects examined through this evaluation have been classified as 'less serious' by ATSDR." - the way this is written, it suggest that the effects have no connection with the exposure levels. For clarity, it would be better to say, "The acute effects associated with these levels are among those classified as 'less serious' by the ATSDR."
  - The second bullet seems to be definitive ("some individuals may have experienced effects"), even taking into consideration the uncertainties described. The fifth bullet could include possible biological monitoring of individuals who were estimated to have been involved with mixer/loader accident scenarios.
  - 3rd bullet - "...as a result, no dioxin related adverse health risks are predicted for military trainees...". Again, this is the wrong tense, in view of the fact that we are looking at past risks. It would be better to use a time-independent verb, such as "would be expected".
  - 5th bullet - it is recommended that further epidemiological investigations focussing on individuals who were present in the vicinity of the 1966 and 1967 spray applications, be undertaken. An alternative approach might be to recommend serum dioxin analyses for these individuals where possible, particularly for the two occupational categories highlighted. These data could then be compared to the body burdens of Vietnam veterans, etc. and to the associated epidemiology and health studies.
• Hexachlorobenzene
  - Last bullet "ILCR estimates for the central tendency receptor are essentially

equivalent to the benchmark for the 1967 spray period." Meaning is unclear. Should be reworded to clearly indicate what is meant by the "benchmark" the ILCR estimates are being compared to.

- The section is called "Conclusions and Discussion" yet there is very little discussion.

References:

- CDC. 1998 - appears to be the same as ATSDR. 1998. - please verify
- Demaree and Creager - should be 1968, not 1968a
- Demaree and Haws – should be 1968, not 1968b
- Health Canada. 2004. Federal Contaminated Site Risk Assessment in Canada. Part I: Guidance on Human Health Preliminary Risk Quantitative Assessment Health Canada..... - should become Health Canada. 2004a. This reference has been cited on numerous occasions in the text while citing TRVs. The proper reference in those cases should be: Health Canada. 2004b. Federal Contaminated Site Risk Assessment in Canada. Part II. Toxicological Reference Values (TRVs). Environmental Health Services. Safe Environments Program. September 2004.
- Health Canada. 2005. Please insert "Factsheet" in the citation.
- IARC. 1997. Citation incomplete - please insert : Volume 69. Polychlorinated Dibenzo-para-Dioxins and Polychlorinated Dibenzofurans. Summary of Data Reported and Evaluation.
- Karch et al. Typo "Cietnam"
- PMRA, 2005. This reference is not cited anywhere in the report.
- PMRA. 2006. Personal Communication with Mary Mitchell – suggest providing her title and division.

Appendix A:

Major comments:

The following Canadian reviews on pentachlorophenol and its contaminants should have been consulted during the preparation of these comments, to obtain additional data sources for levels of impurities in PCP formulations:

- Jones, P.A. (1981). Chlorophenols and their Impurities in the Canadian Environment. Report EPS 3-EC-81-2, Environment Canada, 434 pp.
- National Research Council Canada.. 1982. Chlorinated phenols: Criteria for environmental quality. NRCC No. 18578. 191 pp.
- Gilman, A.P.; Douglas, V.M.; Newhook, R.C.; Arbuckle, T.E. (1988) Chlorophenols andtheir impurities: a health hazard evaluation. Health and Welfare Canada.. Document No. H46-2/88110E.

Based on the above reviews, additional dioxin levels in American PCP products, should be provided and considered for the exposure and risk assessments. For example, papers from Rappe et al (1982), Nilsson et al, (1978), Rappe et al (1978), Rappe et al (1979) and Arsenault et al (1976) all contain such information.

Specific comments (typos and minor insertions are generally noted in bold fonts):

- The main report text needs to reference this appendix where appropriate
- Section A1-1.0 Pentachlorophenol
  - Page A-1, para.. 1, last sentence states: "The use and uncontrolled incineration of technical grade PCP is one of the most important source (typo, singular) of PCDDs and PCDFs in the environment". Please provide reference for this statement. This statement may have been true at one time in the past but the current uses of PCP are strictly limited to industrial uses (heavy duty wood treatment). Reference: Agriculture Canada.. 1992. Re-evaluation of heavy duty wood preservatives. Announcement A92-02. Available at: http://www.pmra-arla.gc.ca/english/pdf/rev/rev_a9202-e.pdf)
  - Page A-1, para. 5 states that: "The water soluble form of PCP (pentachlorophenate **salt**) generally had lower concentrations of PCDDs and PCDFs when compared to organic soluble **penta**chlorophenol. However, Table A1-1.1 clearly shows that detectable amounts of TCDDs (0.05-0.25ppm) were ONLY found in Na-PCP samples. This is also contrary to the statement below table A1-1.1 : "These reports all agree that the lower substituted congeners (....) were below the detection limit. These unexpected results were later found to be an unusual 1,2,3,4- substituted isomer (Buser and Rappe 1978 in: Rappe et al 1982). Please revise the text accordingly.
  - Page A-2, Table A1-1.1. In the title, please replace the term "commercial" by "commercially available". Commercial grade PCP was a formulation that contained up to 20% tetrachlorophenol, a product very different from the technical grade PCP that was available at the time (REF).
  - Page A-3, Table A1 1.2, title, as above
  - Page A-3, Table A1 1.3. Title: please change to .... based on Tables A1-1.1 and A1 1.2
  - Page A-3, Table A1 1.3. The values in the min and max rows are inverted
  - Page A-3, Table A1 1.3. last row: "Total ppm by TEF" should read : Total ppm **as WHO-TEF**
- Section A1-2.0 2,4,5-Trichlorophenoxyacetic Acide (2,4-T)
  - Page A-4 states "one sample of 2,4,5-T contained about 27 ppm..." but Table A1-1.4 reportedly citing the same study (Elvidge, 1971) does not list any TCDD concentration greater than 0.50 ppm. Additional information is provided by Firestone et al (1978) who reported levels of 2,3,7,8-TCDD in stored drums of Agent Orange (before 1970), and estimated levels as high as 100 µg/g (100 ppm) in individual 2,4,5-T formulations.
  - Page A-6: para. 4: Edmunds et al (1973) in not cited in the reference section.
  - Section A1-2.1 Agent Purple, Page A-6: It seems very probable that the dioxin level (45 ppm) reported by Young et al. (2004) in a single agent purple sample would be referring to the same sample reported earlier as 45 ppm TCDD by the same author. Please verify. The "Detrick" reference is not cited in the reference section
  - Page A-6: Agent Orange weighted mean concentration of TCDD was 1.98 ppm. But the maximum detected was 15 ppm, so using 2 ppm is not a worst case, i.e., the TCDD content could have been higher. Why was a range used for Agent

Purple and not for Agent Orange, when there are data on the range measured in Agent Orange?

- Page A-7 states "For the purposes of the current assessment all 2,4,5-T in Agent Purple should be assumed to be contaminated at a level of 45 ppm TCDD." In the report, however, a range of 5 to 45 with a central estimate of 32.8 ppm is used.
- Report text needs to reference this appendix where appropriate.

Reviewers' citations for Appendix A:

Arsenault, R.D. 1976. Pentachlorophenol and contained chlorinated dibenzodioxins and dibenzofurans in the environment. A study of environmental fate, stability, and significance when used in wood presenvation. Proceedings of the American Wood Preservers Association 20: 122-148. (Reporting levels in American products)

Firestone, D. 1978. The 2,4,7,8,-tetra..... problem: a review. Ecol. Bull. (Stockholm) 27: 39-52

Rappe, R.D., Gara, A. And Buser, H.R. 1978. Identification of polychlorinated dibenzofurans (PCDFs) in commercial chlorophenol formulations. Chemosphere: 12: 981-991

Rappe, C., Buser, H.R. and Bosshardt. 1979. Dioxins, dibenzofurans and other polyhalogenated aromatics: production, use, formation and destruction. N.Y. Acad. Sci 320: 1-18

Rappe, C., Nygren, M., Buser, H.-R., and Fauppinen, T. 1982. Occupational exposure to polychlorinated dioxins and dibenzofurans. In: Chlorinated Dioxins and Related Compounds: Impact on the environment. Hutzinger, O., Frei, R.W., Merian, E. and Pocchiari, O. (Eds.). Pergamon Series on Environmental Science, Vol. 5., Pergamon Press, Oxford, England. Pp. 495-514.

Appendix B

- Major comment: Dioxins and furans are not the only contaminants found in PCP formulations. HCB is also generated during the manufacture of pentachlorophenol (for example: Canada Gazette (1991), volume 135, No 39; Rappe et al 1982). Please provide information on the HCB content of PCP formulations. This information should be taken into account in the exposure and risk assessments.

- Table B1-2, Chem/Phys properties of TCDD:
  - Many of these values are different from those in Task 2A, Table A-1, which were supposed to provide a common database for all other tasks. The two sets of phys/chem values should be reconciled.
  - TCDD half-life in soil is listed as 10,000-30,000 hours, which converts to a range of 1.1 to 3.4 years. What is the value in parentheses - an approximate mean? The half-lives in soil vary over a wide range; was this range reflected in the exposure assessment calculations of soil concentration 1 year after spray event (p. 38), or was a single value used? It is unclear where the values were used. Using the low end (10,000 hours), the fraction remaining after 1 year is 0.54, while using the high end (30,000 hrs), the fraction remaining after 1 year is 0.82. How

sensitive is the risk estimate to this range?
  - Half-life in sediment water is listed as >30,000 hours. This converts to 3.4 years, which does not match value in parentheses (~6 years).
  - Text on page B-37 states that half-lives in soil and sediment range "from 2 to greater than 6 years". Not consistent with Table B1-2, which has 1.1-3.4 yrs for soil, and >3.4 years for sediment.

- Table B2-2.1: Chem/phys properties HCB
  - Values are different from those in Task 2A, Table A-1.
  - Half-lives in soil in table are referenced as Mackay et al. 1992, but half-lives in soil on page B-76 are referenced as Griffin and Chou, 1981.

- Page B-7, para. 2: the reference "COT 2001" should be presented as "UK COT 2001" to conform with the citation in the reference section. Please review the entire Appendix B and make the appropriate changes
- Page B-8, last para., last sentence ".... are summarised in Table B1-3.1. Do you mean Table B1-3.3 ?.
- Page B-9, first sentence: "Table B1-3.3....". Do you mean Table B1-3.4 ?.
- Table B1-3.4: make the following insertion in the title: "Summary of Human Health effects of 2,3,7,8-TCDD Exposure"
- Table B1-3.4: Summary of effects of 2,3,7,8-TCDD Exposure, comments for Respiratory effects: please provide specific references for "....other occupational studies" (line 5); "Operation Ranch Hand and follow-up cohort studies of those involved in Seveso...." (line 6)
- Table B1-3.4: Summary of effects of 2,3,7,8-TCDD Exposure, comments for Renal effects: please provide specific references for :" Similar to other studies..." (line 4)
- Table B1-3.4: Summary of effects of 2,3,7,8-TCDD Exposure, comments for Dermal effects: please provide specific references for :"Studies of a chemical laboratory (line 4 and others in the same sentence.
- Table B1-3.5: Please provide units for the exposure duration (1st column)
- Page B-12. 1st para., line 4: the "COC, 2001" should be presented as "UK COC 2001" to conform with the citation in the reference section. Please review the entire Appendix B and make the appropriate changes.
- Page B-15, para. 3, line 13.: Please define "ED01"
- Page B-17, para. 2. "In an NTP study completed in 2003 (NTP, 2004a, b, c, d)...". Four references are listed. Which is the correct one?
- Page B-17, para. 3. Again 4 references are listed. Which is the correct one?
- Page B-20 . Table B1-3.6: Significant Exposure to 2,3,7,8-TCDD. Which animal species were studied? Also please provide references in every case.

- Section B1-4.1 Absorption
  - Most of the references in this section are quite old. Please provide more updated information and revise text.
  - Page B-21, 1st para. It is surprising to find an MOE (1985) reference to provide such information. Please use more appropriate recent references.
  - Page B-22, para. 2 and 3: Please provide references for those 2 paragraphs as it is unclear if all the information presented here is from Dann (1989)

- Page B-24 - See comments for main report regarding body burden.
- Page B-25, last para.: What does AUC stand for?
- Page B-27. Insert a blank line to separate first 2 paragraphs
- Page B-30, 2nd para. Health Canada is in the process of re-evaluating the TRV for "dioxins" but provisionally the Food Directorate uses the FAO/WHO JECFA TMI of 70 pg TEQ_{DFP}-WHO_{98}/kg bw/month (TEQ includes dioxins, furans and dioxin-like PCBs) which corresponds to 2.3 pg TEQ_{DFP}-WHO_{98}/kg bw/day.
- Page B-38, last para., line 3: please replace "principle" by "principal"
- Page B-76:
  - "The average half-life of HCB estimated from results of a number of studies is ~9 years." What type of half-life? Soil (aerobic or, anaerobic), or water?
  - HCB half-lives in soil vary over a range; was this range reflected in the exposure assessment calculations of soil concentration 1 year after spray event (p. 38)? The values could not be located

Appendix C

Major comments:

- An average daily intake estimate of PCDD/DFs and dioxin-like PCBs via food consumption specifically for adults has not been calculated to estimate current exposure levels. Instead, the present day average exposure estimates of PCDD/DFs and dioxin-like PCBs through food consumption are given in the form of just one value, "0.88 pg TEQ/kd/day" for all Canadians (all age groups and genders combined) from the Total Diet Study (1992 to 1999). This mean value, calculated by the Food Safety Division, comprised all the individual daily food intake rates from all the respondents from the Nutrition Canada Survey (1970-1972) that were combined the respective contaminant levels in each of the analysed food composites (Personal communication from Dr. Xu-Liang Cao, Food Research Division, Bureau of Chemical Safety, Health Products and Food Branch, Health Canada). The resulting EDI, "0.88 pg TEQ/kd/day", is the overall mean calculation for all individuals, regardless of age or gender. It is not a calculated lifetime EDI weighted by age as inappropriately presented in Tables C1-1.6 and C1-1.7. It was unclear why a lifetime composite receptor was used instead of the adult, as only adult receptors are considered in this risk assessment. In addition, more background information on the Total Diet Study and the Nutrition Canada Survey should be provided in this Appendix (see Cao, 2005).
  - Therefore, adult age-specific DLC (dioxin-like compounds?) intake estimates should be calculated using a complete set of data on levels of DLCs detected in analysed food commodities from the Total Diet Study (1994-1995 and 1995 to1999). These latter, more recent concentrations of DLCs were provided to Mr. Elliot Sigal of Cantox Environmental Inc. on January 5, 2006 by Ms. Deborah Schoen of Health Canada regarding Cantox (2006). These data were obtained in a personal communication from Dr. Jake Ryan (Senior Research Scientist, Food Research Division, Bureau of Chemical Safety, Health Products and Food Branch, Health Canada). Please contact Health Canada to obtain these data sets if they are currently unavailable.
  - For the background values for the other exposure media (air, water and soil)

please provide additional information on the data sets: dates, types of surveys, complete references, etc.... In addition, provide a discussion on how representative the historical EDI represent the exposure in 1966 and 1967 or if it is more representative of another time period?

- A review of previous Canadian exposure assessments to dioxins and furans has not been performed. What is the rationale for this data gap? A good starting point would the exposure assessments presented in the 1990 CEPA report. Other papers by Birmingham et al (1989a; b) and Ryan et al (1997) should also be considered.
- Throughout this appendix, it is difficult to compare various estimated daily intakes as they are either reported as a daily intake (x pg/day) or on a body weight basis (x pg/kg bw/day), sometimes in the same sentence. Please report the intake data in a consistent manner.
- Please note that all the above major concerns/comments also apply to HCB.
- The notable downward temporal trend in the DLC concentrations in various environmental media, even during the last decade, should be presented and discussed, when possible. For example, consider presenting Figure 23 from Cao et al (2005) to show the trend over 8 years. For example, Lorber(2002) and Aylward and Hays (2002) provide empirical evidence of this downward trend.

• Minor comments and typos (typos and minor insertions are generally noted in underlined bold fonts):

- Appendix C cover page title “Estimated Daily Intakes” is too vague. Consider replacing it by something like: “Current Estimates of Daily Intakes of Dioxins and HCB for the Canadian General Population”
- Section C1-1.0 Canadian Population Dioxin Estimated Daily Intake
- Page C-1, first paragraph states: “Estimated daily intake rates of PCDD/PCDFs for the Canadian general population were calculated in 2006 by Cantox Environmental Inc.”. Please provide more information on the context of that contract report and the reference.
- Page C-1, Table C1-1.1, the reference Health Canada (2004a) and all those cited as “Source” are not cited in the reference section.
- Page C-1, last paragraph, first sentence should read “Average food intake rates.....”
- Page C-1, last paragraph, 2nd sentence should list the name of the cities as well as the dates of sampling
- Page C-2, Table C1-1.2 title: the reference Health Canada (2006) is not cited in the reference section.
- Page C-4, para. 1, last line; The reference should be cited as Cao et al (2005), not as Xu-Ling et al. 2005). Please make the corresponding changes in the text and in the C1-2.0 reference section.
- Page C-4, Table C1-1.4 title: please insert: “.....PCDD/PCDFs and dioxin-like PCBs for....1999". Furthermore, as indicated in the general comments of this appendix, this table must be completely reworked to present current “adult” EDIs
- Page C-4, para. 3, lines 1 and 2 : the soil background level should be expressed as 4 pg WHO-TEQ/g soil (dry wt).
- Page C-4, para. 3, states that: “This value (of 4 pg WHO-TEQ/g soil (dry wt) from the previous sentence) is based on the highest mean background

concentration for Canadian soils of 5.0 pg TEQ/g". This statement is unclear: please re-phrase and/or provide more information.
- Page C-4, para. 3, reports a U.S, EPA value of 3.5 pg TEQ/g for rural background (U.S. EPA 2000). However, in Table C1-1.8, US EPA (2003) reports a current background (rural or urban?) level of 9.3 pg TEQ DF-WHO98/g in soil. In addition, a background concentration of dioxin-like PCBs is reported to be 2.3 ppt TEQ p-WHO98. U.S. EPA (2003) is the revised draft version of the U.S. EPA (2000) draft. Which value is the correct one? Would the units be different?
- Page C-5, Table C1-1.6: please provide an example of full calculations to arrive at "Historical" estimated EDIs, otherwise it is impossible to verify any of the calculations.

- North American Population Dioxin Estimated Daily Intake
  - Page C-7, Table C1-1.9: please provide average body weights for each age group.
  - Page C-7, Table C1-1.9: first row, last column - typo: WHO

- Historical Dioxin Levels
  - Page C-8, Table C1-1.10: please expand this table to provide the historical concentrations used to calculate the historical EDIs (similar to what was done in Table C1-1.8)
  - Page C-8, the last paragraph actually presents the results of a pharmacokinetic modelling exercise performed by Pinsky and Lorber (1998). The last sentence states: " This dose (1.5 to 2.0 kg/kg/day) may have dropped to as low as 0.1 pg/kg/day (7 pg/day) and less into the 1980s". How do you reconcile these estimated results with those presented in Table C1-1.10? The more recent modelling results from Lorber (2002) and Aylward and Hays (2002) would have been much more appropriate.

- Section C2-1.0 Hexachlorobenzene (HCB) Estimated Daily Intake
  - The major comments (lifetime receptor, ...) outlined above for PCDD/DFs also apply to hexachlorobenzene. Please revise text accordingly. This entire section is essentially based on the Priority substances list assessment report for HCB published in 1993. Cao et al (2005) is the only new reference added to this section. Please perform a literature review to identify new data sources to present a more current exposure assessment.
- Health Canada Total diet Study
  - Table C2-1.1 reference should be Cao et al. (2005)
  - Table C2-1.2: it is incorrect to calculate weighted averages for HCB because the exposure varies according to diet age-specific diet. Please calculate arithmetic means for each age class based on the results presented in Table 10 from Cao et al (2005)

- Canadian Environment Protection Act
  - Page C-11: the above section heading is misleading. Please consider "Priority substances list assessment report for HCB"
  - Page C-11: please indicate that all the results from this section were taken verbatim from the assessment report

- Table C2-1.3: the reference “Environment Canada, 1993" for this table and there after should read “Government of Canada/Health and Welfare Canada/Environment Canada (1993)” or CEPA (1993)

- Historical and Current HBC EDI - Table C2-1.5 is identical to Table C2-1.3: why was it necessary to present it again?
- Section C1-2.0 References - Dann, Tom : please provide his title, affiliation, etc.

Citations for Appendix C:

Lorber, M. 2002. A pharmacokinetic model for estimating exposure of Americans to dioxin-like compounds in the past, present and future. Sic. Total Environ. 288: 81-95

Aylward, L.L. and Hays, S.M. 2002. Temporal trends in human TCDD body burden: Decreases over three decades and implications for exposure levels. J. Exp. Anal. Environ. Epidemiol. 12: 319-328.

Birminghan et al. 1989a. Chemosphere 19: 507-512

Birminghan et al. 1989a. Chemosphere 19:637-642

Ryan et al. 1997. Organohalogen Compounds 32: 229-232

Comments on Style and Grammar:

Some suggestions to include the readability of the report are

- Minimise the use of phrases such as “It is important to recognize...”, “It is important to note...”, “It should be noted that...”, “It is important to understand that...”, “It should be borne in mind that...” These phrases make the document seem ponderous and pedantic.
- Minimize overuse of subjunctives such as “should” and “would.”. On seeing “should” in the report, readers may ask “Why?” For example, if the report states that a certain assumption “should be” or “must be” made, that could mean many things – because of a lack of data, because Cantox is choosing a protective or conservative value, because of a regulatory requirement, etc. Suggest replacing should/must with the more precise reason for the action or decision taken whenever possible. As for “would”, usually it can be replaced by a more definite statement. Some specific examples:
  - Section 7.2.1: “Several risk estimates exceed levels that would be indicative of a concern (HQ > 1).” Why not use “are” instead of “would be”?
  - P. 3: “...data... should be comparable” Who judges the data to be comparable? Cantox?
  - P. 6, Table 2-2 footnote: “This should reflect the concentration...” Do you mean “This was assumed to reflect the concentration...”?
  - P. 17 “...half lives of the COCs would need to be considered...” Why not simply ‘were considered’?
  - P. 18: “...conservative assumptions must be made...” Why?
  - P. 88: “... assumptions should be made...” Why not simply state “assumptions were made”?

- "Since" is sometimes used when the proper term is "because." "Since" indicates time elapsed. "Because" indicates a reason or explanation. Example: Since the report was issued, we have discovered some errors. Because the errors were discovered, we will revise the report.

Typographical Errors:

- Word consistency: Both TIER and Tier are used in the report. Tier is correct because the word is not an acronym so there is no reason for it to be all capital letters.
- ES-2.0 "defense" should be defence - use Canadian spelling. This was noted in other parts of the document as well.
- ES-2.0, paragraph 2, 4th bullet - "include" should be "included"
- ES-7 - Dioxins "Many of the people exposed for a short time could have experienced elevated short-term health risks", i.e., this is describing something which occurred in the past.
- Section 1.0 - Footnote 1, page 1: there is an extra parenthesis in front of PCDFs.
- Section 1.0 - Page 2: "This report is organized as follows.....Section 2.0: Description of Tier 1 ~~Issues~~"
- Page 4 - 5th paragraph: "A system of time runs was used during application....."
- Page 5 - 5th paragraph: "40 km"
- Page 6 - 1st paragraph: typo - "hcbcontaminant"
- Figure 4-1 - 2nd footnote, typo "areaas"
- p. 19: 3rd paragraph, missing word: "This was accomplished *by* Army personnel..."
- p. 25: "t = aamount....."
- p. 32, 1st paragraph: "39 plots"
- p. 32, 2nd paragraph, 3rd line: "....with PCDD while and additional 18 plots were sprayed..."
- p. 35, 2nd paragraph: ".....rate prior to reaching a flagger."
- p. 35, 3rd paragraph: "....including ~~an~~ upper, lower and central approximations."
- p. 59 - 1st paragraph - "In particular...in another study of..."
- references - WHO. 2001. -typo: "Roam"

CANTOX ENVIRONMENTAL – RESPONSE TO PEER REVIEW AND HEALTH CANADA COMMENTS

Unless otherwise noted, all comments have been addressed.

Responses to comments made by the Peer Reviewers		
Section	**Major Comment**	**Response**
Major Issues 1) Exposure Estimates	*Issue:* From our perspective, there does not appear to be enough information provided to arrive at the same exposure estimates that are reported in Tables 5-12 to 5-17. We have tried to verify the estimated exposures in "ng/kg bw" and have not been able to arrive at the same values. More specifically, when we completed the exposure calculations using the supplied information, we arrived at different exposure estimates...	All exposure estimates have been reviewed and verified. A complete worked example has been appended to the report (Appendix E) that will allow the reader to follow all assumptions and calculations.
2) Background Exposure Estimates	Issue: An article by Lorber (2002) has suggested that average background dioxin-TEQ serum lipid concentrations in the US were between 50 ppt and 80 ppt during the 1970's whereas Cantox has used a value of 21.8 ppt. It is unclear if the Lorber paper is more accurate than the Cantox estimate and/or perhaps included other considerations. Nevertheless, if the Lorber value was used in the assessment, it is possible that appreciably different results would have been found (e.g., values in Table 7-1 would need to be revisited).	The Lorber (2002) paper has been reviewed and included in the revised assessment. Background exposure estimates for the 1960s have been revised to better reflect the situation at the time.
Major Issue 3) Inclusion of Dioxin-Like PCBs in Background Exposure Estimates	*Issue:* Somewhat related to the above, it is possible that dioxin-like PCBs may have contributed to the typical background exposures that receptors may have been receiving at the time of the spraying events. In some cases, dioxin-like PCB exposures may contribute appreciably and, thus, should possibly be considered or discussed in the Cantox report.	Discussion of dioxin-like PCBs was included in Appendix C whenever possible. Dietary intake of dioxin-like chemicals has been shown to contribute ~95% of an individual's daily dose. Estimates of dietary intake obtained from the Total Diet Study (Cao *et al*., 2005) included dioxin-like PCBs. In many cases the concentration of dioxin-like PCBs in environmental media (air, soil, and water) was not available. In one instance dioxin-like PCBs were evaluated in Canadian air. However, these compounds were found at significantly lower concentrations than the PCDD/PCDFs and were not included in the background air concentration. Therefore, dioxin-like PCBs are not believed to significantly contribute to dioxin like compound

Responses to comments made by the Peer Reviewers		
Section	**Major Comment**	**Response**
		exposure through environmental media.
4) Risk Calculations	Issue: If exposure estimates are found to require recalculation, then the Cantox risk estimates provided in Tables 7-2 to 7-24 and Figures 7-1 to 7-5 may need to be revisited. Currently, the risk estimates are reproducible only if the exposure estimates presented in earlier tables are accurate.	Further to comment 1 above, all exposure and risk calculation have been verified and modified as necessary.
5) Discussion	Issue: Stakeholders, health officials, and policy makers will want to know how these risks compare with those experienced by individuals in other cohorts, such as victims of the Seveso accident, industrial workers who made herbicides, agricultural workers who sprayed herbicides, or U.S. Air Force veterans of Operation Ranch Hand, the unit responsible for spraying Agent Orange and other herbicides in Vietnam.	This information has been provided.
6) Executive Summary .	Issue: Many readers will immediately look for the bottom line (on page ix) and will seek confirmation that the overall interpretations in the Executive Summary are consistent with material presented later. As currently written, the executive summary on page ix is not written with as much conviction as the bulleted items on pages 92 and 93	The executive summary has been modified to reflect this concern as well as other issues required revisions.
5.4.1.1, Page 29	Section 5.4.1.1, Page 29: The equations presented on this page uses several parameters for which it is hard to determine which values were actually selected for use by Cantox. Specifically, the following parameters were not easily defined when we attempted to confirm Cantox's calculations:	All comments relating to exposure equations and the inability to follow specific calculations have been addressed through the modification of Section 5.0 and the development of Appendix E (a worked example). This appendix provides all the input data and equations used in the modeling process. An exposure calculation example has been provided for each receptor group.
Table 5-9 and elsewhere	The Cantox evaluation has been based on data that is specific to the general population (both sexes). If it is known that only men were using the area, it may be possible to revise the assessment based on male-specific data. Since Health Canada (2004) obtained much information from Richardson (1997) (which provides data for male, female and both sexes combined), it may be a relatively straightforward approach to base the risk assessment on male-specific endpoints. It should be stressed, however, that we have not been provided with any information that suggest only males were present.	DND has provided the following in response to this question: *In order to determine whether women were involved in the trials, it would pay to look at the role of women in the Canadian Forces at that time. I believe that they were established in administrative roles only at that time, and would not have had active roles in either service support or combat trades and thus have limited to nil access to the training area and the spray program. Certainly there could be exceptions to the rule but that would be difficult to determine. We have no way to confirm whether women were involved or not as we simply don't have a list of persons involved in the 1966/67 program or thereafter either.*

Responses to comments made by the Peer Reviewers		
Section	**Major Comment**	**Response**
Section 5.4.5, Page 38	Perhaps the berry consumption rate could be provided as the number of servings per week.	This consumption rate cannot practically be expressed as the "number of servings per week". This consumption rate represents the average daily intake of wild berries over the course of the entire exposure duration. It is likely that consumption would not have occurred everyday but rather on a sporadic or opportunistic basis.
Section A1-1.0 Pentachlorophenol	Page A-1, paragraph beginning "According to the …". This is a nice calculation, leading to the conclusion that PCP was applied as a salt rather than as water insoluble PCP. To help the reader follow this more readily, please add the phrase "or, equivalently, 4 lb/gal" to the end of the third sentence.	The suggested change has been made and the basis of the calculations clarified
	Table A1-1.3, Page A-3: It is unclear how the mean values were derived. It is recommended that 2 or 3 significant figures be reported in the table.	The use of significant figures (three places) have been included in the Tables despite the fact that the numbers presented originally were as reported by the authors.
	Page A-4, paragraph beginning "In 1971, Elvidge …". Is it "Bionetics" or "Biometrics"?	The reference that appears in Elvidge is to Bionetics.
Section A2-1.0 Hexachlorobenzene Contaminant Levels	Page A-10, paragraph beginning "Technical grade picloram …", last sentence" Replace "in the 200 region of 200 ppm" with "in the region of 200 ppm".	The change has been made to reflect the comment
Page B-35, paragraph beginning "U.S. EPA (2004b)…", second sentence	Page B-35, paragraph beginning "U.S. EPA (2004b)…", second sentence: Replace "$(mg/kg/day^{+1}$" with "$(mg/kg/day)^{-1}$". The narrative in this paragraph is further complicated by a recent paper that shows an increased all-site cancer risk with dioxin in Air Force Health Study control subjects, nearly all of whom have background dioxin levels; see Pavuk M, Michalek JE, Schecter A, Ketchum NS, Akhtar FZ, Fox KA. Did TCDD Exposure or Service in Southeast Asia Increase the Risk of Cancer in Air Force Vietnam Veterans Who Did Not Spray Agent Orange? *Journal of Occupational and Environmental Medicine* 2005;47(4):335-342.	This study has now been referenced in the report. "A recent paper by Pavuk et al. (2005) suggests that dioxin exposure is associated with an increase in all-sites cancer risk although the issue of a low-dose mechanism remains unclear."
Appendix D Page D-5, top line.	The conclusion of this commendable effort to validate the application of PHED data is understated. In fact, the results, as evidenced by skin 2,4-D levels in Table D-2, are consistent with the estimated exposure levels by receptor category described in Tables 5-12 through 5-17, indicating that the mixer/loader receptor had exposures at least an order of magnitude greater than the flagman receptor. This information should be added to the summary paragraph on page D-5.	Health Canada has provided further details regarding PHED; this information has been provided as part of Appendix D.

Responses to comments from Health Canada		
Section	**Major Comment**	**Response**
Page 4, 4th paragraph:	Text read ".....each plot received a series of four passes....". This contradicts the assumption used in the spray drift report where a single spray line with a 100 feet spray swath was assumed, as the report did not specify. Please clarify the discrepancy.	We believe this to be correct based on information provided by Demaree and Creager.
Section 2.0 Page 5/6	In the published literature, HCB is identified as a contaminant of PCP and should be assessed as such. See comments for Appendix A.	We were unable to locate any evidence of this in the published literature.
Section 5.3.1	Section 5.3.1 It is unclear how it was decided which parameters would be estimated as single values and which would be represented by a range (high, low, central estimates). This is basically introducing probability into some variables and not into others. The report authors should indicate if all the variables were examined systematically to decide which should be treated stochastically (as a data distribution) and which to be treated deterministically (as a single point estimate), with consideration to which are driving the risk. A logical step in this process would be some sort of sensitivity analysis, i.e., considering the effect on the results of varying the parameters over their expected ranges, to determine which parameters are most important.	We disagree with the reviewers general statements regarding the use of probability factors. We have not conducted a stochastic assessment which incorporates pre-defined probability density functions (PDF). The purpose of the 'low', 'central' and, 'high' point estimate exposure values was to provide a general appreciation for the inherent uncertainty and variability present when attempting to quantitatively reconstruct historical exposure events. Much of the site-specific and receptor time/activity patterns data are inadequate to develop meaningful PDFs. Providing a low, central and, high exposure estimates facilitates a semi-quantitative sensitivity analysis. Typically a sensitivity analysis is useful in identifying those input parameters which have the greatest influence on final exposure predictions. By identifying key input parameters, further data can be collect in an attempt to reduce the level of uncertainty in the overall exposure estimates.
Section 5.3.1.2 - Dermal Absorption	There are many published studies in which dermal absorption of dioxins was evaluated (e.g .those listed below). The results of these studies could be considered as part of a weight-of-evidence approach, by comparing measured and modelled values, to electing dermal absorption values for the low, central and high exposure estimates. Consider for example…	Based on a review of several different methods, the approach provided by the U.S.D.A. Forestry Service and SERA were considered most appropriate. It was felt that the review provided in the Appendix A was adequate.
Section 5.3.2 - paragraph 2	The incorrect conversion factor is cited for converting application rates from g/m2 to lbs/acre. The conversion factor cited is 1.12E-01 whereas the correct conversion factor is 8.9. This suggests that the exposure estimates could be underestimated by factor of approximately 80 times. Unfortunately, sample calculations were not provided to verify whether this error actually occurred in the calculations. Please verify that the correct conversion	This is an incorrect interpretation of the wording provided in the draft report. The correct conversion factor was used. This can be verified though examination of the Worked Example provided in Appendix E. This text has be modified to ensure clarity.

Responses to comments from Health Canada		
Section	**Major Comment**	**Response**
	factor was used in the calculations	
Tables 5-2, 5-3, 5-4 and 5-5:	Diesel is listed in Table 5-2 as a component of the applied mixtures but is not further addressed in the report. Is the intent to address this in the other tiers or to develop a rationale for its exclusion from the assessment?	As indicated in the scope of work, Tier I was concerned with two contaminants only.
Section 5.4.2	It would be useful to cite Technical Memorandum 141 (which identifies that one pilot applied all mixtures in about 30 hours of actual flying time over the three consecutive days, but does not identify the number of personnel involved in mixing and loading, or the number of flagmen.) Assumptions beyond what is actually known should be justified.	Noted, however, our assumption of applying all herbicide mixtures potentially contaminated with PCDD within one 12-hour day is considered reasonable. It is also in-line with the total number of hours spent spraying.
Section 5.4.1 and 5.4.1.2	The 30% clothing penetration rate applied here is not consistent with the 75% clothing protection factor used elsewhere in the report.	In the development of the PHED UEs, coveralls are assumed to provide a 75% protection factor for arms, chest, back, thighs and lower legs. This assumption was inherently accepted with the use of the PHED UEs in the routine exposure scenario for the mixer/loader (as well as other scenarios involving the use of PHED UEs). To be conservative, an additional exposure event was included in the risk assessment in which the mixer/loader was assumed to have a one-time accidental spill of 0.5 L of herbicide concentrate. Calculation of exposure resulting from this event was based on the methodologies recommended by ENSR (2005) in which a clothing penetration rate of 30% was used. Since this methodology was developed to address the specific scenario in which a given amount of herbicide concentrate was spilled on clothing, it was considered to be most appropriate to adopt this value for the current assessment. Since a more detailed description of the nature of the "protection factor" described in the PHED database was not available, it was not possible to ascertain whether this value was appropriate to use to assess a situation in which a significant amount of liquid was applied to the coveralls.
Section 5.4.3.2	Why was the factor of 2.7 chosen rather than the peak factors calculated by REMSpC's modelling? It is misleading to state that the factor of 2.7 is "based on an analysis provided by REMSpC" as it could be concluded that 2.7 was the peak factor from the modelling, when in fact 2.7 is from a 1964 report on calibration trials. The modelling predicted lower peak factors, i.e., Fig. 1 shows 1.4 for the 1966 trials and Fig. 2 shows around 0.85 for the 1967 trials. Similarly, the definition of 2.7, following the equation, as "worst-case multiplier based on wind speed and direction" suggests site-specific data and modelling	The wording in the main report has been changed to reflect this concern. However, a value of 2.7 was maintained. As the reviewer points out limited modeling was conducted, the results of which indicated the 1967 trials (which were limited relative to the 1966 campaign) could produce application rates 1.4 times the intended rate. Given the uncertainty here, the risk assessment fell on the side of caution and employed the value from the actual 1964 calibration trials.

Responses to comments from Health Canada		
Section	**Major Comment**	**Response**
	were used to generate this factor, which is not the case.	
Section 5.4.4	As noted in the Statement of Work for this contract, PMRA has produced a guidance document on the principles/theories of estimating potential exposure using dislodgeable foliar residue (DFR) data and agricultural transfer coefficients (TCs) for estimating potential exposure to people entering areas treated with pesticides, including areas similar to forestry scenarios (Post-application Exposure Monitoring Test Guidelines (PRO98-04) available at http://www.pmra-arla.gc.ca/english/pubs/pro-e.html). Additional information on this topic is generated by Exposure Task Forces and can be found at: www.exposuretf.com and on the websites for PMRA and the U.S. EPA. Cantox estimated exposure to the field scout using a method developed by the USDA Forest Service. It would be useful to include a discussion in this section of the USDA exposure assessment methodology versus the standard methodology used by the PMRA and the U.S. EPA, including what are the strengths and weaknesses of both approaches, inherent conservatism and uncertainties, and validation and acceptance of both methods. Also discuss how the transfer rates are derived for both methods and whether it is validated based on actual data.	The general Statement of Work request that a human health risk assessment be completed. Although a full literature review of all the different approaches and methodologies used by various agencies would be of interest, it was not considered part of the modified Tier I scope. The current assessment has not used an out-dated methodology but one currently used by the U.S.D.A. Forestry Service. If the review feels that a thorough review of all approaches relative to one another is necessary, this could be included (as an expanded scope) for another Tier.
Section 5.4.5	Military Trainees *"Military trainees were assumed to spend 2 months of the year at the 1966 spray campaign site."* It is unclear what this assumption is based upon, and whether this is an average estimate, or is it longer than average, i.e. conservative.	As indicated in each parameter table, this exposure parameters was assigned a single point-estimate value of 2 months. It was assumed that a trainee could spend up to 2 months of the year training in the area of the 1966 or 1967 spray campaign. There was not enough site-specific information to clearly define what is considered an average versus a conservative estimate.
Sections 5.5.1 - 5.5.3	Based on the manner in which the equations and data are presented in the report, the calculations cannot be verified. Many of the equations in the report are difficult to understand as the units do not cancel. Inputs for the equations are not readily available; the reader has to search through the report and find some of these inputs in the appendices.	All comments relating to exposure equations and the inability to follow specific calculations have been addressed through the modification of Section 5.0 and the development of Appendix E (a worked example). This appendix provides all the input data and equations used in the modeling process. An exposure calculation example has been provided for each receptor group.

Responses to comments from Health Canada		
Section	**Major Comment**	**Response**
Section 6.2.5 Body Burden of Dioxin and 7.2.5 Dioxin Body Burden Calculations	The whole weight blood values described in section 6.2.5 from the CDC survey should be in fg/g units and not pg/g.	We don't believe this to be correct, please see Table 93 in CDC (2005).
Section A1-1.0 Pentachlorophenol	The following Canadian reviews on pentachlorophenol and its contaminants should have been consulted during the preparation of these comments, to obtain additional data sources for levels of impurities in PCP formulations: -Jones, P.A. (1981). Chlorophenols and their Impurities in the Canadian Environment. Report EPS 3-EC-81-2, Environment Canada, 434 pp. -National Research Council Canada.. 1982. Chlorinated phenols: Criteria for environmental quality. NRCC No. 18578. 191 pp. -Gilman, A.P.; Douglas, V.M.; Newhook, R.C.; Arbuckle, T.E. (1988) Chlorophenols and their impurities: a health hazard evaluation. Health and Welfare Canada.. Document No. H46-2/88110E. Based on the above reviews, additional dioxin levels in American PCP products, should be provided and considered for the exposure and risk assessments. For example, papers from Rappe et al (1982), Nilsson et al, (1978), Rappe et al (1978), Rappe et al (1979) and Arsenault et al (1976) all contain such information.	In Jones (1984) it states that Agriculture Canada identified the phenolic impurities in PCP and NaPCP. In 14 samples of technical PCP from five suppliers two isomers of DCP, three isomers of TCP and three isomers of TTCP were reported. Based on percent content, the major impurities were 2,4-DCP; 2,3,5,6-TTCP and 2,3,4,6-TCCP. In three samples of NaPCP from one supplier the only major impurity was 2,3,4,6-TTCP. Concentrations of dioxins were not reported for these samples. **CEI response**: Jones (1984) does not provide data on PCDD/PCDF in technical grade PCP such as Timbertox Jones, PA (1981) concluded that " the identities and quantities of imputrities (PCDDs and PCDFs) in higher chlorinated phenols in Canadian products and in products imported from Europe are not well documented in contrast to the information on impurities in chlorophenols produced in the U.S. (Sect. 3.1)" Jones (1981) also concluded that "some PCP imported from Europe had been produced by alkaline hydrolysis of hexachlorobenzene (HCB) and, therefore, contained HCB as an impurity (Sect 2.1)." **CEI response**: The product used in 1967 (Timbertox) was manufactured in the U.S. It was concluded that this product had no HCB contamination. The purpose of the monograph produced by the NRC (NRCC 18578 (1982)) was to "provide an analysis of the scientific criteria as well as research recommendations that were specific to the chlorophenols and not to the PCDDs *per se*." This document (and its appendices) does not provide any significant information on PCDD/F contamination in PCP, but focuses primarily on the chlorinated phenols themselves as sources of contamination and adverse effects on the environment. **CEI response:** NRCC 18578 does not provide any useful information on specific congener concentration for polychlorinated dibenzo-*p*-dioxins or dibenzofurans in PCP. *Chlorophenols and Their Impurities: A Health Hazard Evaluation*. Health and Welfare Canada.. Document No. H46-2/88110E (1988) provides a summary table (Table 3, page 15) that reports the data from Rappe *et al.,* (1979) which we have cited in the document as one of the sources of information on dioxin

Responses to comments from Health Canada		
Section	**Major Comment**	**Response**
		contamination in PCP. No other information that explicitly addresses the concentration (range or quantification) of PCDD or PCDF in samples of PCP are provided in the document. The dioxin data for the "American sample" of PCP has been entered into Table A1-1.1 **CEI response**: Data for the "American product" was entered into TableA1-1.1. This single sample altered the mean $\sum TEQ_{WHO}$ upwards to 9.245 and changes the range to ~45 ppm TEQ. Rappe et al (1978): Identification of polychlorinated dibenzofurans (PCDFs) in commercial chlorophenol formulations. Chemosphere 12: 981-991. Data in this document provides concentration data (one sample) for dibenzofurans PCP. **CEI response:** The data in this paper is similar to that reported in Buser and Bosshardt, 1976 which is one of the sources of information already described in Table A1-1.1 and used to generate the $\sum TEQ$ for use in the assessment.
	The main report text needs to reference this appendix where appropriate	Reference to this section of Appendix A has been made in the Main Report
	Page A-1, para.. 1, last sentence states: "The use and uncontrolled incineration of technical grade PCP is one of the most important source (typo, singular) of PCDDs and PCDFs in the environment". Please provide reference for this statement. This statement may have been true at one time in the past but the current uses of PCP are strictly limited to industrial uses (heavy duty wood treatment). Reference: Agriculture Canada.. 1992. Re-evaluation of heavy duty wood preservatives. Announcement A92-02. Available at: http://www.pmra-arla.gc.ca/english/pdf/rev/rev_a9202-e.pdf)	The purpose of the review is to discuss the relevance to human health of the use of technical grade PCP used at the time (1967); therefore this sentence has been changed to past tense. Reference has been made to revised manufacturing practice and controlled use. Incineration of PCP: reference Karasek FW, Dickson LC., 1987. This reference appears in the text
	Page A-1, para. 5 states that: "The water soluble form of PCP (pentachlorophenate salt) generally had lower concentrations of PCDDs and PCDFs when compared to organic soluble pentachlorophenol. However, Table A1-1.1 clearly shows that detectable amounts of TCDDs (0.05-0.25ppm) were ONLY found in Na-PCP samples. This is also contrary to the statement below table A1-1.1 : "These reports all agree that the lower substituted congeners (....) were below the detection limit. These unexpected results were later found to be an unusual 1,2,3,4- substituted isomer (Buser and Rappe 1978 in: Rappe et al 1982).	The text has been revised as suggested to point out that organic solvent soluble PCP exhibited low levels of tetra- and penta-chlorodioxins. The suggested explanation of the elevated concentrations of tetrachloro-dioxins in NaPCP has also been adopted.

Responses to comments from Health Canada		
Section	**Major Comment**	**Response**
	Page A-2, Table A1-1.1. In the title, please replace the term "commercial" by "commercially available". Commercial grade PCP was a formulation that contained up to 20% tetrachlorophenol, a product very different from the technical grade PCP that was available at the time (REF).	The Table title has been changed
	Page A-3, Table A1 1.2, title, as above	The Table title has been changed
	Page A-3, Table A1 1.3. Title: please change to .... based on Tables A1-1.1 and A1 1.2	The change has been made
	Page A-3, Table A1 1.3. The values in the min and max rows are inverted	The error has been corrected
	Page A-3, Table A1 1.3. last row: "Total ppm by TEF" should read : Total ppm as WHO-TEF	The values have been changed and express TEQ according to WHO (TEQ_{WHO})
Section A1-2.0 2,4,5-Trichlorophenoxyacetic Acid (2,4-T)	Page A-4 states "one sample of 2,4,5-T contained about 27 ppm..." but Table A1-1.4 reportedly citing the same study (Elvidge, 1971) does not list any TCDD concentration greater than 0.50 ppm. Additional information is provided by Firestone et al (1978) who reported levels of 2,3,7,8-TCDD in stored drums of Agent Orange (before 1970), and estimated levels as high as 100 μg/g (100 ppm) in individual 2,4,5-T formulations	The Table A1-1.4 is correct. The text has been changed to show 0.27 ppm, not 27 ppm. The content of TCDD in Agent Orange used in the report has been changed to include a range of concentrations as indicated by Young, 1980. This range was based on nearly 500 samples of AO from unused material that remained unused in the US military at the end of the Viet Nam conflict. It was believed that this analytical data was representative of the likely content of TCDD in Agent Orange, and does not represent an "estimate".
	Page A-6: para. 4: Edmunds et al (1973) in not cited in the reference section	The reference has been included.
	Section A1-2.1 Agent Purple, Page A-6: It seems very probable that the dioxin level (45 ppm) reported by Young *et al.* (2004) in a single agent purple sample would be referring to the same sample reported earlier as 45 ppm TCDD by the same author. Please verify. The "Detrick" reference is not cited in the reference section	The references by Young in 1980 and 2004 (a review) are to the same sample of Agent Purple. The reference to reports from Fort Detrick were made by Young, so there is no need to refer to them separately.
	Page A-6: Agent Orange weighted mean concentration of TCDD was 1.98 ppm.But the maximum detected was 15 ppm, so using 2 ppm is not a worst case, i.e., the TCDD content could have been higher. Why was a range used for Agent Purple and not for Agent Orange, when there are data on the range measured in Agent Orange?	A range of concentrations of TCDD in Agent Orange (<0.02 to 15 ppm) has been used on the revised risk assessment calculations.
	Page A-7 states "For the purposes of the current assessment all 2,4,5-T in Agent Purple should be assumed to be contaminated at a level of 45 ppm TCDD." In the report, however, a range of 5 to 45 with a central estimate of 32.8 ppm is used.	

Responses to comments from Health Canada		
Section	**Major Comment**	**Response**
	Report text needs to reference this appendix where appropriate.	References to the Appendix have been made in the text of the Main Report.
Section A1-4.0 Conclusion	No comments were made but as clarification of the quantities used in the risk assessment the summary of conclusions has been included here.	Each contaminant has been assigned a range of concentrations of TCDD or TEQ_{WHO} in the conclusions for the concentrations to be used in the current assessment. These are: 2,4,5-T (isobutyl ester and butyl ester) in Agent Purple should be assumed to be contaminated at a level of 45 ppm TCDD with a range of 5 to 45 ppm TCDD. 2,4,5-T (butyl ester) in Agent Orange should be assumed to have a level of contamination by TCDD of 2 ppm with a range of 0.02 to 15 ppm. All other products that contain 2,4,5-T as the phenoxyacetic acid (Labelled in the DND documents as "Other" and "M-2993") the level of contamination by TCDD is assumed to be 2 ppm [range of 0.02 to 15 ppm]. The level of TCDD contamination (as determined by TEQ) in PCP applied in 1967 is 9.242 ppm with a range of 2.154 to 45.010 ppm TCDD (TEQ_{WHO}).
Table B1-2, Chem/Phys properties of TCDD:	Many of these values are different from those in Task 2A, Table A-1, which were supposed to provide a common database for all other tasks. The two sets of phys/chem values should be reconciled.	Values have been cross-checked to ensure consistency. However, it is noted that recent references have been used in some instances.
	1) TCDD half-life in soil is listed as 10,000-30,000 hours, which converts to a range of 1.1 to 3.4 years. What is the value in parentheses - an approximate mean? 2) The half-lives in soil vary over a wide range; was this range reflected in the exposure assessment calculations of soil concentration 1 year after spray event (p. 38), or was a single value used? It is unclear where the values were used. Using the low end (10,000 hours), the fraction remaining after 1 year is 0.54, while using the high end (30,000 hrs), the fraction remaining after 1 year is 0.82. How sensitive is the risk estimate to this range?	1) Values listed are the range and the mean (in parentheses). All values have been corrected and additional information added to the table. 2) Refer to Table 5.13 in the main report. A range of environmental half-lives, determined using JW, 2006 and Mackay et al., 1992, were utilized in the exposure assessment. The half-lives utilized were 1, 2, and 3 years for the low, central and high values, respectively.
	Half-life in sediment water is listed as >30,000 hours. This converts to 3.4 years, which does not match value in parentheses (~6 years).	Values have been corrected: Sediment water: Range: >30,000 h; Mean: 55,888 (~6 years)
	Text on page B-37 states that half-lives in soil and sediment range "from 2 to greater than 6 years". Not consistent with Table B1-2, which has 1.1-3.4 yrs for soil, and >3.4 years for sediment.	Text has been changed so that the values are consistent.

Responses to comments from Health Canada		
Section	**Major Comment**	**Response**
Table B2-2.1: Chem/phys properties HCB	Values are different from those in Task 2A, Table A-1.	Values have been cross-checked to ensure consistency. However, it is noted that recent references have been used in some instances.
	Half-lives in soil in table are referenced as Mackay et al. 1992, but half-lives in soil on page B-76 are referenced as Griffin and Chou, 1981.	Half-lives from other scientific studies are presented on page B-76, along with those values determined by Mackay et al., 1992 and JW, 2006. The values of Mackay et al., 1992 and JW, 2006 are the only values presented in the table as they are the soil half-lives utilized for modeling within this risk assessment.
Page B-17, para. 2	"In an NTP study completed in 2003 (NTP, 2004a, b, c, d)...". Four references are listed. Which is the correct one?	References have been corrected. In some instances all of the references were appropriate; while in others the correct reference was selected.
Page B-17, para. 3	Again 4 references are listed. Which is the correct one?	
Section B1-4.1 Absorption	Most of the references in this section are quite old. Please provide more updated information and revise text.	Additional references were added to this section. These included: Nolan, R.J., Smith, F.A., and Hefner, J.G. 1979. Elimination and tissue distribution of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) in female guinea pigs following a single oral dose. Toxicol Appl Pharmacol 48(1):A162. Cited in: U.S. EPA, 2003. Olson, J.R., Gasiewicz, T.A., Neal, R.A., *et al*. 1980. Tissue distribution excretion, and metabolism of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in the Golden Syrian Hamster. Toxicol Appl Pharmacol 56:78-85. Cited In: ATSDR, 1998. Poiger, H., and Schlatter, C. 1986. Pharmacokinetics of 2,3,7,8-TCDD in man. Chemosphere 15: 1489-1494. Cited In: Edmond *et al.*, 2005. Birnbaum, L.S., and Couture, L.A. 1988. Disposition of octachlorodibenzo-p-dioxin (OCDD) in male rats. Toxicol Appl Pharmacol 93:22-30. Cited in: U.S. EPA, 2003. Umbreit, T.H., Hesse, E.J., and Gallo, M.A. 1986a. Bioavailability of dioxin in soil from a 2,4,5-T manufacturing site. Science Report 232:497-499. Umbreit, T.H., Hesse, E.J., and Gallo, M.A. 1986b. Comparative toxicity of T_4CDD contaminated soil from Times Beach, Missouri, and Newark, New Jersey. Chemosphere 15:2121-2124. Cited In: Shu *et al.*, 1988. Nessel, C.S., Amoruso, M.A., Umbreit, T.H., *et al.* 1992. Pulmonary bioavailability and fine particle enrichment of 2,3,7,8-tetrachlorodibenzo-p-dioxin in respirable soil particles. Fundam Appl Toxicol 19:279-285. Cited

Responses to comments from Health Canada		
Section	**Major Comment**	**Response**
		in: U.S. EPA, 2003. Brewster, D.W., Banks, Y.B., Clark, A.M., *et al*. 1989. Comparative dermal absorption of 2,3,7,8-tetrachlorodibenzo-p-dioxin and three polychlorinated dibenzofurans. Toxicol Appl Pharmacol 97:156-166. Cited in: U.S. EPA, 2003. Banks, Y.B., and Birnbaum, L.S. 1991. Absorption of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) after low dose dermal exposure. Toxicol Appl Pharmacol 107:302-310. Cited in: U.S. EPA, 2003. Weber, L.W.D., Zesch, A., and Rozman, K. 1991. Penetration, distribution and kinetics of 2,3,7,8-TCDD in human skin in vitro. Arch Toxicol 65:421-428. Cited in: U.S. EPA, 2003.
	Page B-21, 1st para. It is surprising to find an MOE (1985) reference to provide such information. Please use more appropriate recent references.	It is unclear as to why the MOE Scientific Criteria Document for Standard Development for polychlorinated dibenzo-*p*-dioxins (PCDD's) and polychlorinated dibenzofurans is not considered a relevant reference. Other recent references were added, where appropriate, to support the adsorption rates for dioxin-like compounds via ingestion and dermal contact as cited by the MOE.
	Page B-22, para. 2 and 3: Please provide references for those 2 paragraphs as it is unclear if all the information presented here is from Dann (1989)	Sections were omitted in the revised report.
Page B-76:	HCB half-lives in soil vary over a range; was this range reflected in the exposure assessment calculations of soil concentration 1 year after spray event (p. 38)? The values could not be located	Refer to Table 5-13 in the main report. A range of environmental half-lives, determined using JW, 2006 and Mackay et al., 1992, were utilized in the exposure assessment. The half-lives utilized were 2.7, 6, and 7.5 years for the low, central and high values, respectively.
Appendix C Major Comments	1)An average daily intake estimate of PCDD/DFs and dioxin-like PCBs via food consumption specifically for adults has not been calculated to estimate current exposure levels. Instead, the present day average exposure estimates of PCDD/DFs and dioxinlike PCBs through food consumption are given in the form of just one value, "0.88 pg TEQ/kd/day" for all Canadians (all age groups and genders combined) from the Total Diet Study (1992 to 1999). This mean value, calculated by the Food Safety Division, comprised all the individual daily food intake rates from all the respondents from the	1) The value is no longer inappropriately represented as a lifetime EDI weighted by age. 2) Although it is true that only adult receptors are considered in this risk assessment, individuals would have experienced dioxin exposure both prior to and following any exposures experienced at Gagetown. Due to the long body half-lives of dioxin-like compounds utilizing a lifetime average is appropriate as it captures both early and late life stage exposure. 3) Information of this nature was considered beyond the scope of the current study. Information is readily available from other sources.

Responses to comments from Health Canada		
Section	**Major Comment**	**Response**
	Nutrition Canada Survey (1970-1972) that were combined the respective contaminant levels in each of the analysed food composites (Personal communication from Dr. Xu-Liang Cao, Food Research Division, Bureau of Chemical Safety, Health Products and Food Branch, Health Canada). The resulting EDI, "0.88 pg TEQ/kd/day", is the overall mean calculation for all individuals, regardless of age or gender. It is not a calculated lifetime EDI weighted by age as inappropriately presented in Tables C1-1.6 and C1-1.7. 2)It was unclear why a lifetime composite receptor was used instead of the adult, as only adult receptors are considered in this risk assessment. 3) In addition, more background information on the Total Diet Study and the Nutrition Canada Survey should be provided in this Appendix (see Cao, 2005).	
Major Comment related issues	Therefore, adult age-specific DLC (dioxin-like compounds?) intake estimates should be calculated using a complete set of data on levels of DLCs detected in analysed food commodities from the Total Diet Study (1994-1995 and 1995 to1999). These latter, more recent concentrations of DLCs were provided to Mr. Elliot Sigal of Cantox Environmental Inc. on January 5, 2006 by Ms. Deborah Schoen of Health Canada regarding Cantox (2006). These data were obtained in a personal communication from Dr. Jake Ryan (Senior Research Scientist, Food Research Division, Bureau of Chemical Safety, Health Products and Food Branch, Health Canada). Please contact Health Canada to obtain these data sets if they are currently unavailable.	Adult age-specific DLC intake estimates were not calculated as a lifetime receptor was utilized in the risk assessment (see above). Therefore, the average dietary intake value of 0.88 pg TEQ/kd/day for all Canadians (all age groups and genders combined) from the Total Diet Study (1992 to 1999) is appropriate to determine the current EDI rate.
	For the background values for the other exposure media (air, water and soil) please provide additional information on the data sets: dates, types of surveys, complete references, etc.... In addition, provide a discussion on how representative the historical EDI represent the exposure in 1966 and 1967 or if it is more representative of another time period?	Additional background information was added for each environmental media (air, water, soil, consumer products). The following paragraph was added to discuss what time period the environmental data was most representative of. "The studies used to estimate historical levels of dioxins, furans and dioxin-like PCBs in Canadian environmental media were conducted between 1990 and the present day. This is partially due to the low detection limits required to detect these particular contaminants. In air for instance, the detection limits (pg/m^3) required to detect dioxin-like compounds were not achieved until the mid 1980s.

Responses to comments from Health Canada		
Section	**Major Comment**	**Response**
		Therefore, the background PCDD/PCDF concentrations in environmental media (air, water, soil and consumer products) utilized to establish the Canadian current and historical EDI rates are representative of concentrations in environmental media between 1990 and present day. However, the historical EDI rates for dioxin-like compounds determined above (Table C1-11) are considered representative of historical exposures as in several instances, historical data from the early 1980s are consistent with the selected background environmental media concentrations. However, the majority (~95 to 97%) of exposure to Dixon-like chemicals for Canadians occurs through food consumption. Therefore, even large changes (ten fold) in environmental media dioxin, furan or dioxin-like PCB concentrations will not have a significant effect on the Canadian EDI rate."
	A review of previous Canadian exposure assessments to dioxins and furans has not been performed. What is the rationale for this data gap? A good starting point would the exposure assessments presented in the 1990 CEPA report. Other papers by Birmingham et al (1989a; b) and Ryan et al (1997) should also be considered.	This was conducted using Birmingham et al., 1989a,b and the 1990 CEPA report.
	Throughout this appendix, it is difficult to compare various estimated daily intakes as they are either reported as a daily intake (x pg/day) or on a body weight basis (x pg/kg bw/day), sometimes in the same sentence. Please report the intake data in a consistent manner.	Modified to be consistent.
	The notable downward temporal trend in the DLC concentrations in various environmental media, even during the last decade, should be presented and discussed, when possible. For example, consider presenting Figure 23 from Cao et al (2005) to show the trend over 8 years. For example, Lorber(2002) and Aylward and Hays (2002) provide empirical evidence of this downward trend.	The notable downward temporal trend was discussed when possible. Evidence was extracted from Cao et al., 2005, Lorber, 2002, and Aylward and Hays, 2002.
Historical Dioxin Levels	Page C-8, the last paragraph actually presents the results of a pharmacokinetic modelling exercise performed by Pinsky and Lorber (1998). The last sentence states: " This dose (1.5 to 2.0 kg/kg/day) may have dropped to as low as 0.1 pg/kg/day (7 pg/day) and less into the 1980s". How do you reconcile these estimated results with those presented in Table C1-1.10? The more recent modelling results from Lorber (2002) and Aylward and Hays (2002) would have	More recent modeling results (Lorder, 2002; Aylward and Hays, 2002) were discussed.

Responses to comments from Health Canada		
Section	**Major Comment**	**Response**
	been much more appropriate.	
Section C2-1.0 Hexachlorobenzene (HCB) Estimated Daily Intake	The major comments (lifetime receptor, ...) outlined above for PCDD/DFs also apply to hexachlorobenzene.	Although it is true that only adult receptors are considered in this risk assessment, individuals would have experienced HCB exposure both prior to and following any exposures experienced at Gagetown. Due to the long body half-life of HCB utilizing a lifetime average is appropriate as it captures both early and late life stage exposure.
	This entire section is essentially based on the Priority substances list assessment report for HCB published in 1993. Cao et al (2005) is the only new reference added to this section. Please perform a literature review to identify new data sources to present a more current exposure assessment.	A literature review to provide a more current exposure assessment was considered beyond the scope of this assessment.
Health Canada Total diet Study	Table C2-1.2: it is incorrect to calculate weighted averages for HCB because the exposure varies according to diet age-specific diet. Please calculate arithmetic means for each age class based on the results presented in Table 10 from Cao et al (2005)	This was corrected.
General	Historical and Current HBC EDI - Table C2-1.5 is identical to Table C2-1.3: why was it necessary to present it again?	The duplicate table was deleted.

In this section

Agent Orange exposure and disability compensation

If you have a health condition caused by exposure to the herbicide Agent Orange during your service, you may be eligible for VA disability compensation. Compensation provides tax-free monthly payments. Keep reading to find out if you may be eligible.

On this page

↓ Am I eligible for VA disability compensation?
↓ Full eligibility requirements
↓ How to get disability benefits for Agent Orange-related claims
↓ More helpful information

Am I eligible for VA disability compensation?

You may be eligible for VA disability compensation based on Agent Orange exposure if you meet both of these requirements.

Both of these must be true:

- You have a health condition that's caused by exposure to Agent Orange, **and**
- You served in a location that exposed you to Agent Orange

Keep reading for the full eligibility requirements.

Note: If you get a disability rating, you may also be eligible for VA health care and other benefits.

Full eligibility requirements

We determine eligibility based on the facts of each Veteran's claim. But we assume (or "presume") that certain cancers and other illnesses are caused by Agent Orange. We call these presumptive conditions. And we assume that Veterans who served in certain locations were exposed to Agent Orange. We refer to this as presumptive exposure.

New PACT Act-related presumptive conditions and locations

We've added 2 new Agent Orange presumptive conditions based on the PACT Act:

- High blood pressure (also called hypertension)
- Monoclonal gammopathy of undetermined significance (MGUS)

We've also added 5 new Agent Orange presumptive locations. Keep reading to learn about these new locations.

Requirements for Agent Orange presumptive diseases

We consider a condition presumptive when it's established by law or regulation. If you've been diagnosed with one of these conditions, you don't need to prove that it started during—or got worse because of—your military service.

Cancers caused by Agent Orange exposure

- Bladder cancer
- Chronic B-cell leukemia
- Hodgkin's disease
- Multiple myeloma
- Non-Hodgkin's lymphoma
- Prostate cancer
- Respiratory cancers (including lung cancer)
- Some soft tissue sarcomas
  Note: We don't include osteosarcoma, chondrosarcoma, Kaposi's sarcoma, or mesothelioma on our list of presumptive conditions.

Other illnesses caused by Agent Orange exposure

- AL amyloidosis
- Chloracne (or other types of acneiform disease like it)
  Note: Under our rating regulations, this condition must be at least 10% disabling within 1 year of herbicide exposure.
- Diabetes mellitus type 2
- High blood pressure (hypertension)
- Hypothyroidism
- Ischemic heart disease
- Monoclonal gammopathy of undetermined significance (MGUS)
- Parkinsonism
- Parkinson's disease
- Peripheral neuropathy, early onset
  Note: Under our rating regulations, this condition must be at least 10% disabling within 1 year of herbicide exposure.
- Porphyria cutanea tarda
  Note: Under our rating regulations, this condition must be at least 10%

disabling within 1 year of herbicide exposure.

If you have a cancer or illness that's not on our list of presumptive conditions, but you believe it was caused by Agent Orange exposure, you can still file a claim for VA disability benefits. But you'll need to submit more evidence. Keep reading to learn about service requirements and supporting evidence.

Service requirements for presumption of exposure

We base eligibility for VA disability compensation benefits, in part, on whether you served in a location that exposed you to Agent Orange. We call this having a presumption of exposure.

You have a presumption of exposure if you meet at least 1 of these service requirements.

Between January 9, 1962, and May 7, 1975, you must have served for any length of time in at least 1 of these locations:

- In the Republic of Vietnam, **or**
- Aboard a U.S. military vessel that operated in the inland waterways of Vietnam, **or**
- On a vessel operating not more than 12 nautical miles seaward from the demarcation line of the waters of Vietnam and Cambodia

Or you must have served in at least 1 of these locations that we've added based on the PACT Act:

- Any U.S. or Royal Thai military base in Thailand from January 9, 1962, through June 30, 1976, **or**
- Laos from December 1, 1965, through September 30, 1969, **or**
- Cambodia at Mimot or Krek, Kampong Cham Province from April 16, 1969, through April 30, 1969, **or**
- Guam or American Samoa or in the territorial waters off Guam or American Samoa from January 9, 1962, through July 31, 1980, **or**
- Johnston Atoll or on a ship that called at Johnston Atoll from January 1, 1972, through September 30, 1977

Or at least 1 of these must be true for you:

- You served in or near the Korean DMZ for any length of time between September 1, 1967, and August 31, 1971, **or**
- You served in an Air Force unit location where a C-123 aircraft with traces of Agent Orange was assigned, and had repeated contact with this aircraft due to your flight, ground, or medical duties, **or**
- You were involved in transporting, testing, storing, or other uses of Agent Orange during your military service

For more service requirement details, review these sources:

Public Law 116-23 (Blue Water Navy Vietnam Veterans Act of 2019) on Congress.gov (https://www.congress.gov/bill/116th-congress/house-bill/299/text)

Air Force specialty codes and units for affected C-123 aircraft (https://www.va.gov/resources/c-123-aircraft-agent-orange-exposure-and-disability-compensation)

Dates and locations of herbicide tests and storage outside Vietnam (VA public health website) (https://www.publichealth.va.gov/exposures/agentorange/locations/tests-storage/index.asp)

How to get disability benefits for Agent Orange-related claims

How do I file a claim for compensation?

If you haven't filed a claim yet for the presumptive condition

You can file a new claim online now. You can also file by mail, in person, or with the help of a trained professional.

File for disability compensation online

Learn about other ways to file a disability compensation claim (https://www.va.gov/disability/how-to-file-claim)

Learn how to submit your intent to file (https://www.va.gov/resources/your-intent-to-file-a-va-claim)

If we denied your disability claim in the past and we now consider your condition presumptive

You can file a Supplemental Claim. We'll review your case again.

Find out how to file a Supplemental Claim (https://www.va.gov/decision-reviews/supplemental-claim)

What evidence will I need to submit with my claim?

You'll need to submit these records:

- A medical record that shows you have an Agent Orange-related health condition, **and**
- Military records to show how you were exposed to Agent Orange during your service

If your condition isn't on the list of presumptive conditions, you'll also need to provide at least 1 of these types of evidence:

- Evidence that shows the problem started during—or got worse because of—your military service, **or**
- Scientific or medical evidence stating that the condition you have is caused by Agent Orange. Scientific proof may include an article from a medical journal or a published research study.

Review medical records online (https://www.va.gov/health-care/review-medical-records)

What military records will I need to submit?

You'll need to submit your discharge or separation papers that show your time and location of service. These may include your DD214 or other separation documents.

For certain claims, you may also need more supporting documents.

+ EXPAND ALL − COLLAPSE ALL

For claims related to C-123 aircraft

Submit 1 or more of these forms:

- USAF Form 2096 (unit where you were assigned at the time of the training action)
- USAF Form 5 (aircraft flight duties)
- USAF Form 781 (aircraft maintenance duties)

For claims including support for dependents

Submit your dependency records. These may include your marriage certificate and children's birth certificates.

Request your military service records (https://www.va.gov/records/get-military-service-records)

More questions about getting benefits

+ EXPAND ALL − COLLAPSE ALL

What if VA denied my claim for bladder cancer, hypothyroidism, or Parkinsonism in the past?

We added these conditions to the presumptive condition list in 2021.

If we denied your claim for any of these conditions in the past, we'll automatically review your case again. You don't need to file another claim. We'll send you a letter to let you know we're reviewing your case.

What if I'm a Blue Water Navy Veteran, and VA denied my past claim?

If we denied your claim because we determined that your disability wasn't caused—or made worse—by your active-duty service, you can file a Supplemental Claim based on the change in the law.

In certain cases, if we approve your claim, we'll pay you back to the date when you submitted your original claim. We refer to this as retroactive payment.

Find out how to file a Supplemental Claim (https://www.va.gov/decision-reviews/supplemental-claim)

To learn more about this change in the law, and how it may affect you, download our PDFs:

- Blue Water Navy Veterans and Agent Orange fact sheet (PDF) (https://www.va.gov/Blue_Water_Navy_Factsheet.pdf)
- Blue Water Navy Veterans and disability benefits FAQs (PDF) (https://www.va.gov/Blue_Water_Navy_FAQs.pdf)

What if I need help filing my claim?

You can get help from us in any of these ways:

- Call 800-827-1000 (TTY: 711)
- Go to your nearest VA regional office (https://www.va.gov/find-locations/)
- Connect with a trained professional trusted to help with VA-related claims (https://www.va.gov/disability/get-help-filing-claim)

If you're submitting a claim related to C-123 aircraft, you can also:

- Call the C-123 hotline at 800-749-8387 (TTY: 711), **or**
- Email the St. Paul regional benefit office at VSCC123.VAVBASPL@va.gov

What if I have questions about my claim?

You can:

- Call the Agent Orange help line at 800-749-8387 (TTY: 711)
- Send an email to GW/AOHelpline@vba.va.gov

Note: Please be ready to give us your name, email address, telephone number, and VA file number or Social Security number.

What's an Agent Orange Registry health exam, and how do I request one?

This is a free health exam for Veterans who meet any of the above service requirements for presumption of contact. Even if you don't have a known condition, the exam could alert you to conditions that may be related to contact with herbicides. By being part of this registry, you're also helping your fellow Veterans by giving us information so we can better understand and serve those affected by Agent Orange-related conditions.

This exam isn't a VA claim exam (also known as a compensation and pension, or C&P, exam). And you don't need to have this exam to get other VA benefits. To get disability benefits, you'll need to file a claim.

File a disability claim (https://www.va.gov/disability/file-disability-claim-form-21-526ez)

To schedule your exam:

Contact your local VA environmental health coordinator (VA public health website) (https://www.publichealth.va.gov/exposures/coordinators.asp)

To find out what to expect at your exam:

Learn more about the Agent Orange Registry health exam (VA public health website) (https://www.publichealth.va.gov/exposures/agentorange/benefits/registry-exam.asp)

To learn if you're eligible for an environmental health registry exam:

Learn more about toxic exposures and registries on our VET-HOME website (https://vethome.va.gov/)

More helpful information

Benefits for spina bifida linked to Agent Orange
If you're the child of a Veteran who served in Vietnam, Thailand, or in or near the Korean Demilitarized Zone (DMZ) and you have spina bifida, you may be able to get VA benefits. Find out if you're eligible and how to apply.

Vietnam War Veterans health issues
If you served during the Vietnam War, you may be at risk of certain health conditions. Learn about these conditions and what to do next to take care of your health.

Request your military service records (DD214 and others)
Review and print documents from your official military personnel file (including your DD214).

Review medical records online
Set up your personal health record. And download medical records, reports, and images to share with your VA and non-VA providers.

Find out how to apply for VA health care
Get instructions for how to prepare and apply for VA health care online, by phone, by mail, or in person.

The PACT Act and your VA benefits
The PACT Act expands VA health care and benefits for Veterans exposed to burn pits and other toxic substances. Learn what this means for you or your loved ones.

Last updated: September 16, 2025

Feedback

English (https://www.va.gov/resources/the-pact-act-and-your-va-benefits) | Español (https://www.va.gov/resources/the-pact-act-and-your-va-benefits-esp) | Tagalog (https://www.va.gov/resources/the-pact-act-and-your-va-benefits-tag)

The PACT Act and your VA benefits

The PACT Act is a law that expands VA health care and benefits for Veterans exposed to burn pits, Agent Orange, and other toxic substances. This law helps us provide generations of Veterans—and their survivors (https://www.va.gov/resources/the-pact-act-and-your-va-benefits/#information-for-survivors)—with the care and benefits they've earned and deserve. And starting **March 5, 2024**, we're expanding VA health care to millions of Veterans—years earlier than called for by the PACT Act.

This page will help answer your questions about what the PACT Act means for you or your loved ones. You can also call us at 800-698-2411 (TTY: 711). And you can file a claim for PACT Act-related disability compensation or apply for VA health care now.

File a disability claim online

Apply for VA health care

On this page

↓ What's the PACT Act and how will it affect my VA benefits and care?

↓ What does it mean to have a presumptive condition for toxic exposure?

↓ Am I eligible for VA health care under the PACT Act?

↓ Gulf War era and post-9/11 Veteran eligibility

↓ Vietnam era Veteran eligibility

↓ Getting benefits

↓ Toxic exposure screenings

↓ Information for survivors

What's the PACT Act and how will it affect my VA benefits and care?

The PACT Act is perhaps the largest health care and benefit expansion in VA history. The full name of the law is The Sergeant First Class (SFC) Heath Robinson Honoring our Promise to Address Comprehensive Toxics (PACT) Act.

The PACT Act will bring these changes:

- Expands and extends eligibility for VA health care for Veterans with toxic exposures and Veterans of the Vietnam, Gulf War, and post-9/11 eras
- Adds 20+ more presumptive conditions for burn pits, Agent Orange, and other toxic exposures
- Adds more presumptive-exposure locations for Agent Orange and radiation
- Requires VA to provide a toxic exposure screening to every Veteran enrolled in VA health care
- Helps us improve research, staff education, and treatment related to toxic exposures

If you're a Veteran or survivor, you can file claims now to apply for PACT Act-related benefits.

What does it mean to have a presumptive condition for toxic exposure?

To get a VA disability rating, your disability must connect to your military service. For many health conditions, you need to prove that your service caused your condition.

But for some conditions, we automatically assume (or "presume") that your service caused your condition. We call these "presumptive conditions."

We consider a condition presumptive when it's established by law or regulation.

If you have a presumptive condition, you don't need to prove that your service caused the condition. You only need to meet the service requirements for the presumption.

Am I eligible for VA health care under the PACT Act?

You're eligible to enroll now—without needing to apply for disability benefits first—if you meet the basic service and discharge requirements and any of these descriptions are true for you:

- You served in the Vietnam War, the Gulf War, Iraq, Afghanistan, or any other combat zone after 9/11, **or**
- You deployed in support of the Global War on Terror, **or**
- You were exposed to toxins or other hazards during military service at home or abroad

Specific toxins and hazards include burn pits, sand and dust, particulates, oil well or sulfur fires, chemicals, radiation, warfare agents, depleted uranium, herbicides, and other occupational hazards. Find more military exposure categories on our Public Health website (https://www.publichealth.va.gov/exposures/)

Note: Even if none of these descriptions are true for you, you may still be eligible for VA health care based on your service. Check the full health care eligibility requirements (https://www.va.gov/health-care/eligibility)

- Bahrain
- Iraq
- Kuwait
- Oman
- Qatar
- Saudi Arabia
- Somalia
- The United Arab Emirates (UAE)
- The airspace above any of these locations

You deployed in support of any of these operations:

- Operation Enduring Freedom
- Operation Freedom's Sentinel
- Operation Iraqi Freedom
- Operation New Dawn
- Operation Inherent Resolve
- Resolute Support Mission

Note: You may also be eligible if you were exposed to any toxins or other hazards during training or active-duty service, or based on other factors.

Check the full health care eligibility requirements (https://www.va.gov/health-care/eligibility)

Vietnam era Veteran eligibility

+ EXPAND ALL − COLLAPSE ALL

What new Agent Orange presumptive conditions will VA add?

Based on the PACT Act, we've added 2 new Agent Orange presumptive conditions:

- High blood pressure (also called hypertension)

- Monoclonal gammopathy of undetermined significance (MGUS)

You may also be eligible for disability compensation based on other Agent Orange presumptive conditions. These conditions include certain cancers, type 2 diabetes, and other illnesses.

Get a list of other Agent Orange presumptive conditions (https://www.va.gov/disability/eligibility/hazardous-materials-exposure/agent-orange/#requirements-for-agent-orange-)

If you think you're eligible for VA health care and benefits, we encourage you to apply now.

Are there more exposure-related presumptive conditions?

Yes. The PACT Act adds new presumptive conditions. But there are also many other health conditions that we presume are caused by exposure to toxic (or hazardous) materials. If you have any of these other conditions, you may be eligible for health care or benefits.

Learn about other presumptive conditions based on exposure to hazardous materials (https://www.va.gov/disability/eligibility/hazardous-materials-exposure/)

What new Agent Orange presumptive locations will VA add?

We've added these 5 new locations to the list of presumptive locations:

- Any U.S. or Royal Thai military base in Thailand from January 9, 1962, through June 30, 1976
- Laos from December 1, 1965, through September 30, 1969
- Cambodia at Mimot or Krek, Kampong Cham Province from April 16, 1969, through April 30, 1969
- Guam or American Samoa or in the territorial waters off of Guam or American Samoa from January 9, 1962, through July 31, 1980
- Johnston Atoll or on a ship that called at Johnston Atoll from January 1, 1972, through September 30, 1977

If you served on active duty in any of these locations, we'll automatically assume (or "presume") that you had exposure to Agent Orange.

Note: This isn't the full list of presumptive locations for Agent Orange exposure. Review eligibility requirements for more presumptive locations.

Review eligibility requirements for Agent Orange presumptive exposure (https://www.va.gov/disability/eligibility/hazardous-materials-exposure/agent-orange#full-eligibility-requirements)

What new radiation presumptive locations will VA add?

We've added these 3 new response efforts to the list of presumptive locations:

- Cleanup of **Enewetak Atoll**, from January 1, 1977, through December 31, 1980
- Cleanup of the Air Force B-52 bomber carrying nuclear weapons off the coast of **Palomares, Spain**, from January 17, 1966, through March 31, 1967
- Response to the fire onboard an Air Force B-52 bomber carrying nuclear weapons near **Thule Air Force Base in Greenland** from January 21, 1968, to September 25, 1968

If you took part in any of these efforts, we'll automatically assume (or "presume") that you had exposure to radiation.

There are also other locations where we presume that you had exposure to radiation. If you served in any of these locations, you may be eligible for health care or benefits.

Get a list of other radiation presumptive locations (https://www.va.gov/disability/eligibility/hazardous-materials-exposure/ionizing-radiation)

Am I eligible for VA health care as a Vietnam Veteran?

If you served on active duty in any of these locations during these time periods, you're now eligible to apply for VA health care:

- **The Republic of Vietnam** between January 9, 1962, and May 7, 1975

- **Thailand at any U.S. or Royal Thai base** between January 9, 1962, and June 30, 1976
- **Laos** between December 1, 1965, and September 30, 1969
- **Certain provinces in Cambodia** between April 16, 1969, and April 30, 1969
- **Guam or American Samoa (or their territorial waters)** between January 9, 1962, and July 31, 1980
- **Johnston Atoll (or on a ship that called at Johnston Atoll)** between January 1, 1972, and September 30, 1977

Getting benefits

+ EXPAND ALL − COLLAPSE ALL

How do I file a disability claim for a new presumptive condition?

If you haven't filed a claim yet for the presumptive condition, you can file a new claim online now. You can also file by mail, in person, or with the help of a trained professional.

File for VA disability compensation online (https://www.va.gov/disability/file-disability-claim-form-21-526ez/)

Learn more about how to file a disability compensation claim (https://www.va.gov/disability/how-to-file-claim)

If we denied your disability claim in the past and we now consider your condition presumptive, you can submit a Supplemental Claim. We'll review your case again.

Find out how to file a Supplemental Claim (https://www.va.gov/decision-reviews/supplemental-claim)

What if VA denied my claim but now considers my condition presumptive?

We encourage you to file a Supplemental Claim. When we receive a Supplemental Claim, we'll review the claim again.

Find out how to file a Supplemental Claim (https://www.va.gov/decision-reviews/supplemental-claim)

Note: If we denied your claim in the past and we think you may be eligible now, we'll try to contact you. But you don't need to wait for us to contact you before you file a Supplemental Claim.

What if I have a pending claim for a condition that's now presumptive?

You don't need to do anything. If we added your condition after you filed your claim, we'll still consider it presumptive. We'll send you a decision notice when we complete our review.

Can I still file PACT Act-related claims?

Yes. The PACT Act is here to stay, and Veterans and survivors can file for benefits anytime. The sooner you file, the sooner you can start getting your earned benefits.

So don't wait. File your claim—or quickly submit your intent to file—today.

File a disability claim online (https://www.va.gov/disability/file-disability-claim-form-21-526ez/)

Learn how to submit your intent to file (https://www.va.gov/resources/your-intent-to-file-a-va-claim)

When can I expect VA to make a decision on my PACT Act claim?

We will process your claim with the utmost urgency to get you the benefits you deserve as quickly as possible. In the first year of the PACT Act, we completed 458,659 PACT Act-related claims—delivering more than $1.85 billion in earned benefits to Veterans and their survivors.

The time it takes to review your claim depends on these factors:

- The type of claim you filed
- How many injuries or disabilities you claimed and how complex they are
- How long it takes us to collect the evidence needed to decide your claim

We regularly update the average number of days it's taking us to make a decision on disability-related claims on our website.

Learn about the claims process and what happens after you file your claim (https://www.va.gov/disability/after-you-file-claim)

You can also check your claim status on VA.gov or through our VA: Health and Benefits mobile app.

Check your claim status (https://www.va.gov/claim-or-appeal-status)

Learn more about the VA: Health and Benefits mobile app on our mobile app website (https://mobile.va.gov/app/va-health-and-benefits)

Toxic exposure screenings

+ EXPAND ALL − COLLAPSE ALL

Can I get a toxic exposure screening at VA?

Toxic exposure screenings are available at VA health facilities across the country.

Every Veteran enrolled in VA health care will receive an initial screening and a follow-up screening at least once every 5 years. Veterans who aren't enrolled and who meet eligibility requirements can enroll and receive the screening.

The screening will ask you if you think you were exposed to any of these hazards while serving:

- Open burn pits and other airborne hazards
- Gulf War-related exposures
- Agent Orange
- Radiation

- Camp Lejeune contaminated water exposure
- Other exposures

We'll then give you information about any benefits, registry exams, and clinical resources you may need.

Ask about the screening at your next VA health care appointment. If you want to get one sooner, contact your local VA health facility. Ask to get screened by the toxic exposure screening navigator.

You can also schedule a telehealth screening on our VET-HOME website.
Learn more about toxic exposure screenings on our VET-HOME website (https://vethome.va.gov/)

Information for survivors

+ EXPAND ALL − COLLAPSE ALL

Can Veterans' survivors get compensation payments under the PACT Act?

Yes. If you're a surviving family member of a Veteran, you may be eligible for these benefits:

- **A monthly Dependency and Indemnity Compensation (D.I.C.) payment.** You may qualify if you're the surviving spouse, dependent child, or parent of a Veteran who died from a service-connected disability.
  Learn how to apply for Dependency and Indemnity Compensation (https://www.va.gov/family-and-caregiver-benefits/survivor-compensation/dependency-indemnity-compensation)
- **A one-time accrued benefits payment.** You may qualify if you're the surviving spouse, dependent child, or dependent parent of a Veteran who we owed unpaid benefits at the time of their death.
  Learn about evidence needed for accrued benefits (https://www.va.gov/resources/evidence-to-support-va-pension-dic-or-accrued-benefits-claims)
- **A Survivors Pension.** You may qualify if you're the surviving spouse or child of a Veteran with wartime service.

Learn how to apply for a Survivors Pension (https://www.va.gov/family-and-caregiver-benefits/survivor-compensation/survivors-pension)

What if VA denied my D.I.C. claim and I think I'm now eligible?

You can submit a new application for Dependency and Indemnity Compensation (D.I.C.).

Learn about D.I.C. and how to apply (https://www.va.gov/family-and-caregiver-benefits/survivor-compensation/dependency-indemnity-compensation)

Note: If we denied your claim in the past and we think you may be eligible now, we'll try to contact you. We may be able to reevaluate your claim. But you don't need to wait for us to contact you before you reapply.

What other VA benefits are survivors eligible for?

You may be eligible for these VA benefits as the surviving family member of a Veteran:

- **Burial benefits and memorial items** such as a gravesite in a VA national cemetery or a free headstone, marker, or medallion.
- **A burial allowance** to help with the Veteran's burial and funeral costs. You may qualify if you're the Veteran's surviving spouse, partner, child, or parent.
- **Education and training.** You may qualify if you're the survivor of a Veteran who died in the line of duty or as a result of service-connected disabilities.
- **Health care through the Civilian Health and Medical Program of the Department of Veterans Affairs (CHAMPVA).** You may qualify if you're the survivor or dependent of a Veteran with a service-connected disability.
- **A VA-backed home loan.** You may qualify if you're the surviving spouse of a Veteran.

Learn more about family member benefits (https://www.va.gov/family-and-caregiver-benefits)

File a disability claim online

All Veterans

Health care

Need help?

Call the **MyVA411 main information line:** at 800-698-2411 (TTY: 711).

Last updated: June 2, 2026

Feedback

The Sunday Magazine

60 years ago, Agent Orange was sprayed at CFB Gagetown. Vets want to know: are toxins still in the soil?

Maine senate may call for more testing

Andrea Hoang · CBC News · Posted: Jun 18, 2026 4:00 AM EDT | Last Updated: June 18



Gary Goode, a veteran who served at CFB Gagetown in the 1960s, has become a vocal advocate for long-term compensation for exposure to Agent Orange, a toxic herbicide sprayed at the base during his service. (Andrea Hoang/CBC)

Gary Goode remembers digging foxholes and crawling through thick brush nearly 60 years ago at Canadian Forces Base Gagetown. The landscape in his mind remains vivid: dead leaves hanging on trees, a chemical smell overhead, like diesel.

The former infantry soldier sometimes spent weeks in those pits.

"Every time I went out into the field you could smell it," he said.

What Goode didn't know then was that the U.S. military had tested Agent Orange and other toxic herbicides on the base earlier that year, with permission from Ottawa. This week marks the 60th anniversary since that testing, something for which veterans who believe they were exposed to chemicals are still seeking disability benefits or other long-term compensation.

Access to article: https://www.cbc.ca/radio/sunday/gagetown-60-agent-orange-9.7238622
Andrea Hoang (2026, June 18). “60 years ago, Agent Orange was sprayed at CFB Gagetown. Vets want to know: are toxins still in the soil?” *The Sunday Magazine*,

Some of those veterans, military family members and some U.S. lawmakers are also raising concerns these herbicides could linger in the soil, calling for more testing as Canada redevelops the base.



Military members at CFB Gagetown during an exercise in May. Veterans have raised concerns about whether there could still be remnants of Agent Orange in the soil at the base. (Andrea Hoang/CBC)

This year, Ottawa announced more than a billion dollars to modernize CFB Gagetown, part of its promise to boost defence spending — after the U.S. administration accused NATO allies of freeloading and that they should not count on America's military support unless they beef up their own investments.

Prime Minister Mark Carney announced a $9.3-billion increase to 2025-26 defence spending, on top of the existing budget of just under $40 billion — some of which is earmarked for new military housing, including between 500 and 650 new units at CFB Gagetown over several years.

[More than $1 billion going to Base Gagetown as part of military rebuilding]

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But Goode said he worries “these builds are going to be on toxic soil,” a concern shared by fellow veterans in the advocacy group Brats in the Battlefield.

“Are they going to do the proper tests?” Goode asked in a recent interview. “And are they going to remediate what they find and make it safe to build?”

A Department of National Defence (DND) spokesperson did not directly answer questions about remediation when CBC asked via email.



Carney announces more than $1B for N.B. military base upgrades

Prime Minister Mark Carney pledged more than $1 billion for 5th Canadian Division Support Base Gagetown training facilities, troop housing and a new air defense system.

A 2005-2007 federal investigation into Agent Orange and the larger issue of spraying herbicides at CFB Gagetown concluded that “only those individuals directly involved with the application of the herbicides or clearing of treated brush soon after” would have suffered potential long-term health risks.

Its findings, however, remain controversial among veterans, their families and, most recently, in the Maine senate, which has gathered information from U.S. military members who claim to have been affected by exposure in New Brunswick.

What is Agent Orange?

The chemical herbicide was used in the Vietnam War to kill off jungle foliage in order to strip the Viet Cong and North Vietnamese of strategic hiding places and food.

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Its name came from the orange stripe on the barrels used to store the colourless cocktail of two herbicides — 2,4-D and 2,4,5-T, the latter of which contains dioxin, a chemical linked to birth defects, cancers and other illnesses.



A warning sign stands in a field contaminated with dioxin near Danang International Airport in Vietnam, during a ceremony marking the start of a project to clean up dioxin left over from the Vietnam War in this August 2012 file photo. The sign reads: Dioxin contamination zone - livestock, poultry and fishery operations not permitted. (Maika Elan/The Associated Press)

Goode developed lung cancer at 55.

He smoked, but when he saw a news report in 2007 about a government compensation package for those exposed to Agent Orange in the 1966 and 1967 testing days he wondered if there might be a connection.

“I worked there, I was trained there, I spent three and a half years there,” he said.

The one-time, tax-free payment of $20,000 came with a caveat: it was voluntary and not an admission of wrongdoing or legal responsibility on the federal government's part.

Goode was among the 5,000 approved. He argues, however, that his lung cancer is a service-related injury, entitling him to ongoing disability benefits, but his claims have been repeatedly denied by Veterans Affairs Canada because of his smoking.

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Goode, right, at 15 or 16, during his time as a reservist, shortly before he joined the regular forces. (Submitted by Gary Goode)

Maine wants more testing

Since 1971, Maine National Guard members have undergone training at CFB Gagetown — and many have tried unsuccessfully to claim disability benefits, claiming their illnesses are a result of exposure to herbicides sprayed at the base.

The U.S. government denied those submissions largely because of the 2005-2007 Canadian investigation's conclusions.

But former president of Maine's state senate Troy Jackson grew up hearing veterans' stories, and he said they raised questions.

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In 2023, he launched a state commission to re-examine the report, which found the "study that they did was flawed," the former state senate president said, referring to the Canadian investigation.



A view of CFB Gagetown in the 1960s, when spraying would have taken place. (Library and Archives Canada)

In April, Maine's governor signed into law the recommendations from that commission, which include looking at whether new studies should be conducted at CFB Gagetown, something Jackson said the state would pay for if recommended.

"The evidence [the commission] gathered and the testimony it received made it more than clear that Maine and Canadian servicemen stationed at the base were exposed to levels of carcinogenic chemicals that were not only harmful, but in too many cases ultimately deadly," Jackson said in his testimony during the public hearing for the bill.

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He said he hopes renewed testing would ensure veterans receive appropriate compensation, but he also wants to make sure current military members are not harmed by any potential remaining contaminants.

When asked about the Maine commission's recommendations, DND told CBC in a statement it was "not aware of additional environmental analysis or study underway" because of the commission and that its "co-operation and support will be evaluated if/when a request is made."



Former president of the Maine senate Troy Jackson launched for a commission to look into the use of Agent Orange after veterans from the state complained of illnesses relating to alleged exposure while training at the New Brunswick base. (Office of Troy Jackson)

Previous study on these types of chemicals — and their use in Vietnam — supports the case for more testing at CFB Gagetown, said Wayne Dwernychuk, who spent more than a decade as chief scientist for Hatfield Consultants, an independent environmental consulting firm. There, he led research from 1994 to 2006 on how dioxins used in Vietnam affected humans and the environment.

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"It can last in soil for over 100 years without breaking down," he said in an interview. “Certainly additional soil studies could be done [at CFB Gagetown] just to see, in fact, whether there is a carryover from all those years to present time."

He notes, however, that though these chemicals can remain in the soil for a century, they also may have broken down over the past six decades.

Military families

Eileen Beauchamp and her family moved to military housing on base when she was five in 1962. Like many other young families, she said hers spent lots of time outdoors, especially in the woods, during their seven years on base.

“I loved Gagetown, actually,” she said. “I loved going fishing with my dad and I loved going to pick the blueberries and the picnics.”

Agent Orange continues to haunt lives of U.S. veterans trained in New Brunswick

But after she left the base, she said she was diagnosed with illnesses related to the endocrine system, including autoimmune diseases. As an adult, she was diagnosed with three types of cancer: melanoma, breast cancer and non-Hodgkin's lymphoma. Chemical exposure is a recognized risk factor in developing the latter type of cancer.

Though she believes her illnesses are linked to her time playing in the sprayed fields in Gagetown, she did not qualify for the compensation, because she was first diagnosed with cancer in 2017 — after the 2011 deadline.

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Eileen Beauchamp, seen here at six years old, in 1963 at CFB Gagetown. She believes illnesses she experienced as a child and her cancer diagnoses as an adult are linked to her time living on the base. (Submitted by Eileen Beauchamp)

And as military housing gets built over the next few years, she said she feels it's important to test for potential lingering contaminants and remediate if they are found.

"Military life is not only the soldier ... military life includes the spouse, includes the children," she said. "We're the ones who are left behind. We're the ones who can be affected by what happens on a base."

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Andrea Hoang (2026, June 18). "60 years ago, Agent Orange was sprayed at CFB Gagetown. Vets want to know: are toxins still in the soil?" *The Sunday Magazine*,

For Goode, the recent military investments feel empty.

"They think about us a lot when the cameras are on and the microphones are there — or on Remembrance Day," he said. "But we're more than just a photo prop."

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HOUSE OF COMMONS
CHAMBRE DES COMMUNES
CANADA

PETITIONS

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451-00899 (Environment)

Keywords

- Canadian Forces Base Gagetown
- Committee studies and activities
- Contaminated sites
- Herbicides
- Standing Committee on National Defence

Paper petition
Original language of petition: English

Petition details

Petition to the Government of Canada

Whereas:

Environmental health science and military experts, and the State of Maine's Commissioned Study into CFB Gagetown's Harmful Chemical Use (2023/2024) stated that the Base Gagetown Area Fact-Finding Project was seriously flawed;

Environmental health science and military experts have stated that it is highly probable that the CFB Gagetown training area is significantly contaminated with dioxins, hexachlorobenzene and heavy metals, and that some chemicals may remain in the soil for an extended period;

During the 44th Parliament, the Standing Committee on National Defence (NDDN) began a study of Department of National Defence and Canadian Armed Forces Contaminated Sites, but due to the election being called this critical study was not completed; and

Significant gaps in CFB Gagetown's Fact-Finding Project, concerns regarding the chemical industry's involvement in the Health Risk Assessment, and the impacts of hazardous exposures on veterans, families, nearby communities, military personnel, including long-term food safety - require urgent attention.

We the undersigned, citizens and residents of Canada, call upon the Government of Canada to :

Conduct a fully independent public inquiry into the history of CFB Gagetown's toxic herbicide program and the Base Gagetown and Area Fact Finding Project/Report, with the purpose of establishing an accurate account of the chemicals used and verifying findings presented in the Fact-Finding Project; and

Instruct the Standing Committee on National Defence to complete its study of the Department of National Defence and Canadian Armed Forces Contaminated Sites and provide a final report with recommendations.

Government response tabled

Response by the Minister of National Defence

Signed by Sherry Romanado

National Defence is taking concrete steps to advance whole of Government efforts towards creating a clean environment. With the responsibility to manage more than two million hectares of land, thousands of buildings, jetties, and training areas, National Defence is central to the Government’s commitment to be a responsible steward of the environment. This includes remediating sites formerly impacted by military activities and proactively mitigating the environmental impacts of its current military activities.?

National Defence has conducted extensive research since the 1980s into the use and testing of herbicides, including Agent Orange, to better understand the impact of their use at 5 Canadian Division Support Base Gagetown (CFB Gagetown). This includes detailed investigations in 2005 and 2018 into the disposal of barrels of Agent Orange at CFB Gagetown. Both investigations confirmed that no barrels of Agent Orange have been found.

Additionally, in 2005, National Defence, along with Veterans Affairs Canada, Health Canada, and various other departments and agencies, undertook a comprehensive fact-finding investigation to understand the health and environmental risks associated with the past use of registered and unregistered herbicides at CFB Gagetown. This comprehensive investigation included, among other tasks, conducting health risk assessments, tissue sampling of fish and clams from CFB Gagetown to test for dioxin concentrations, and compiling lists of individuals and units present when

herbicides were tested in 1966 and 1967. Research for this investigation was conducted by highly qualified, non-government experts, and was peer-reviewed by independent specialists in the field.?In 2013, the United States Centers for Disease Control's Agency for Toxic Substances and Disease Registry (CDC ATSDR) reviewed the Canadian report and concluded the methods to create it were consistent ATSDR's own guidelines for evaluating the public health implications of human exposure.

This investigation concluded that, aside from the two instances of testing Agent Orange, Agent Purple, Agent White, and other herbicides by the United States military in 1966 and 1967, all herbicides used at CFB Gagetown were regulated and used in accordance with all federal and provincial regulations and scientific policies at the time.?

Furthermore, human health risk assessments conducted as a part of the 2005 investigation concluded that most people who lived and worked at or near CFB Gagetown were not at risk of exposure to herbicides. Potential long-term health risks were identified as a possibility only for those individuals directly involved with the application of the herbicides or brush clearings soon after application. As compensation for possible exposure to unregistered United States herbicides between 1966 and 1967, in 2007 the Government of Canada provided eligible individuals with a one-time, tax-free ex gratia payment of $20,000.???

In January 2024, the State of Maine's Gagetown Harmful Chemical Study Commission released its final report examining potential health impacts associated with historical herbicide use at CFB Gagetown. The Commission included recommendations such as further expert review of existing studies and enhanced support for affected individuals. The Government of Canada is aware of the Commission's findings and continues to monitor related research and developments. Any new evidence will be assessed in accordance with established scientific and policy processes.

To ensure compliance with the most effective and environmentally responsible practices, National Defence will continue to work closely with relevant authorities, including the New Brunswick Department of Environment and Local Government, the New Brunswick Department of Natural Resources and Energy Development, the Canadian Forest Service, and Fisheries and Oceans Canada.

National Defence will continue to be a responsible steward of federal lands by protecting land and complying with environmental practices. Given the extensive research and investigations National Defence has already conducted on the use and testing of herbicides at CFB Gagetown, National Defence does not have any plans to conduct further inquiries at this time.

History

Presented to the House of Commons

Elizabeth May (Saanich—Gulf Islands)
April 24, 2026 (Petition No. 451-00899)

Government response tabled
June 8, 2026

Member of Parliament



Elizabeth May
Saanich—Gulf Islands
Green Party Caucus
British Columbia

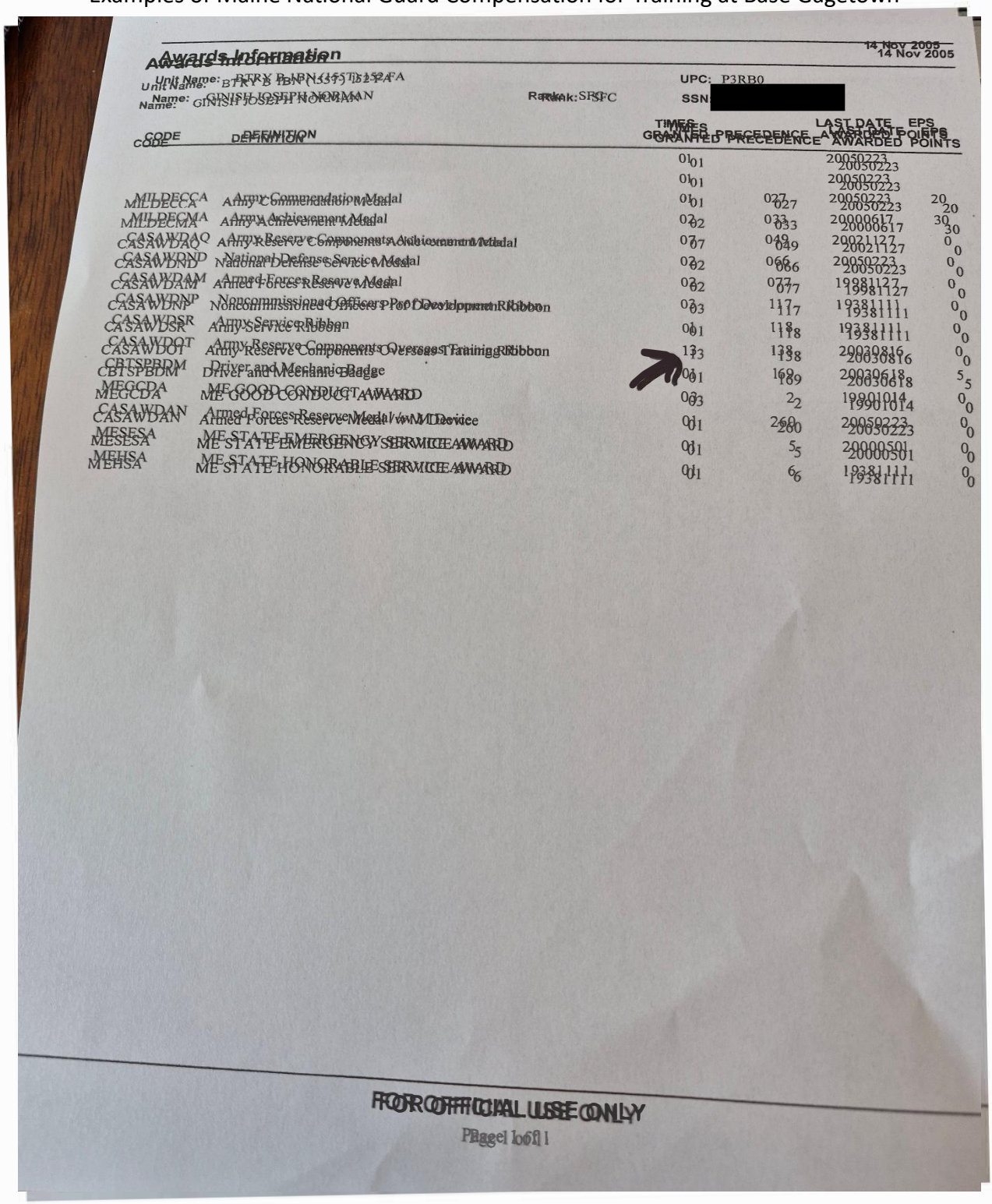
58 signatures

Only validated signatures are counted towards the total number of signatures.

Disclaimer regarding petitions

Gagetown Harmful Chemical Study Commission

Examples of Maine National Guard Compensation for Training at Base Gagetown



Awards Information

14 Nov 2005
14 Nov 2005

Unit Name: HHBN (537) 152FA
Name: GINISH JOSEPH NORMAN
Rank: SFC
UPC: P3RB0
SSN: [redacted]

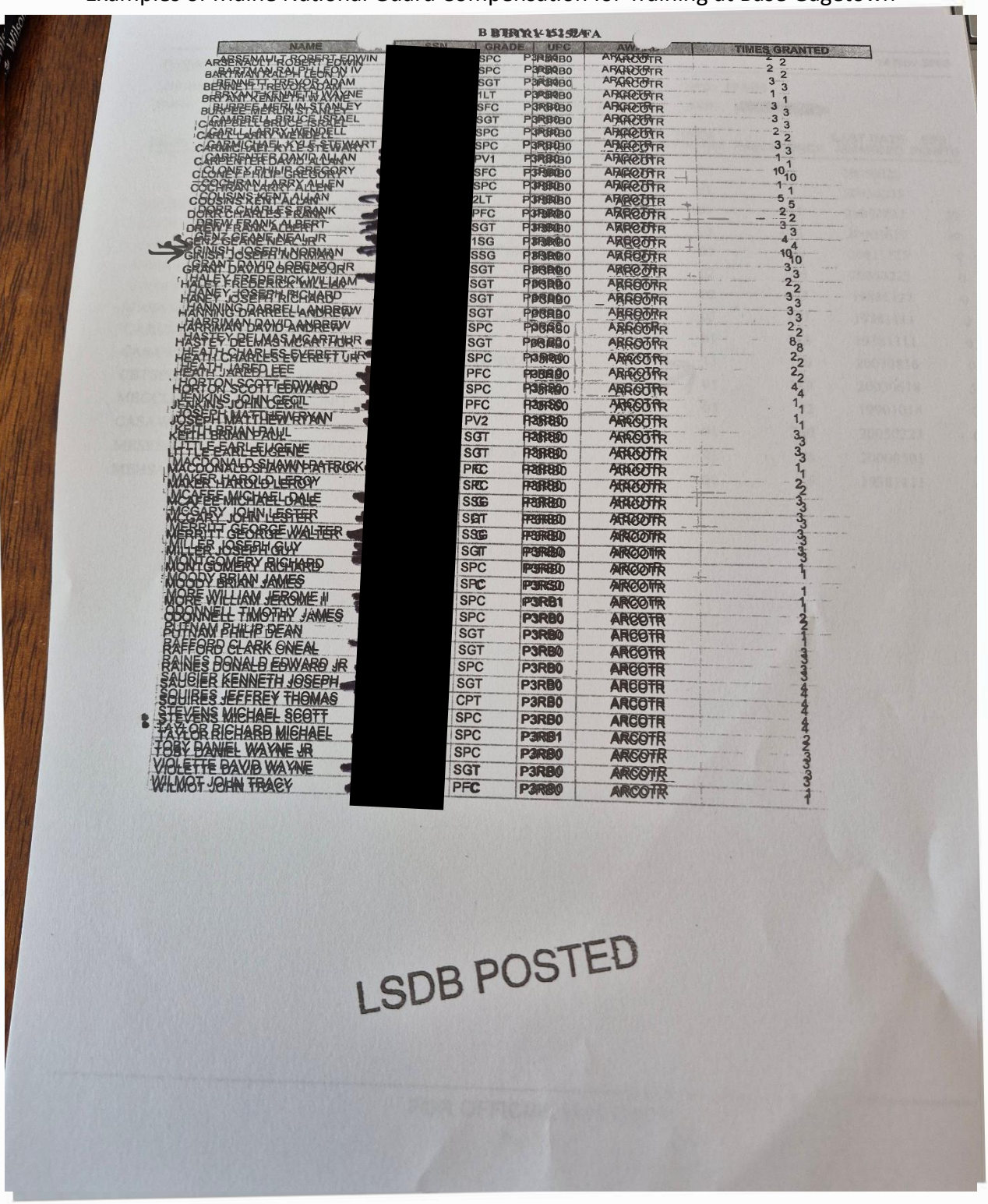
CODE	DEFINITION	TIMES GRANTED	PRECEDENCE	LAST DATE AWARDED	EPS POINTS
		01		20050223	
		01		20050223	
MILDECCA	Army Commendation Medal	01	027	20050223	20
MILDECMA	Army Achievement Medal	02	033	20000617	30
CASAWDAQ	Army Reserve Components Achievement Medal	07	049	20021127	0
CASAWDND	National Defense Service Medal	02	066	20050223	0
CASAWDAM	Armed Forces Reserve Medal	02	077	19981127	0
CASAWDNP	Noncommissioned Officers Prof Development Ribbon	03	117	19381111	0
CASAWDSR	Army Service Ribbon	01	118	19381111	0
CASAWDOT	Army Reserve Components Overseas Training Ribbon	13	138	20030816	0
CBTSPBDM	Driver and Mechanic Badge	01	168	20030618	5
MEGCDA	ME GOOD CONDUCT AWARD	03	2	19901014	0
CASAWDAN	Armed Forces Reserve Medal w/ M Device	01	260	20050223	0
MESESA	ME STATE EMERGENCY SERVICE AWARD	01	5	20000501	0
MEHSA	ME STATE HONORABLE SERVICE AWARD	01	6	19381111	0

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Page 1 of 1

Gagetown Harmful Chemical Study Commission

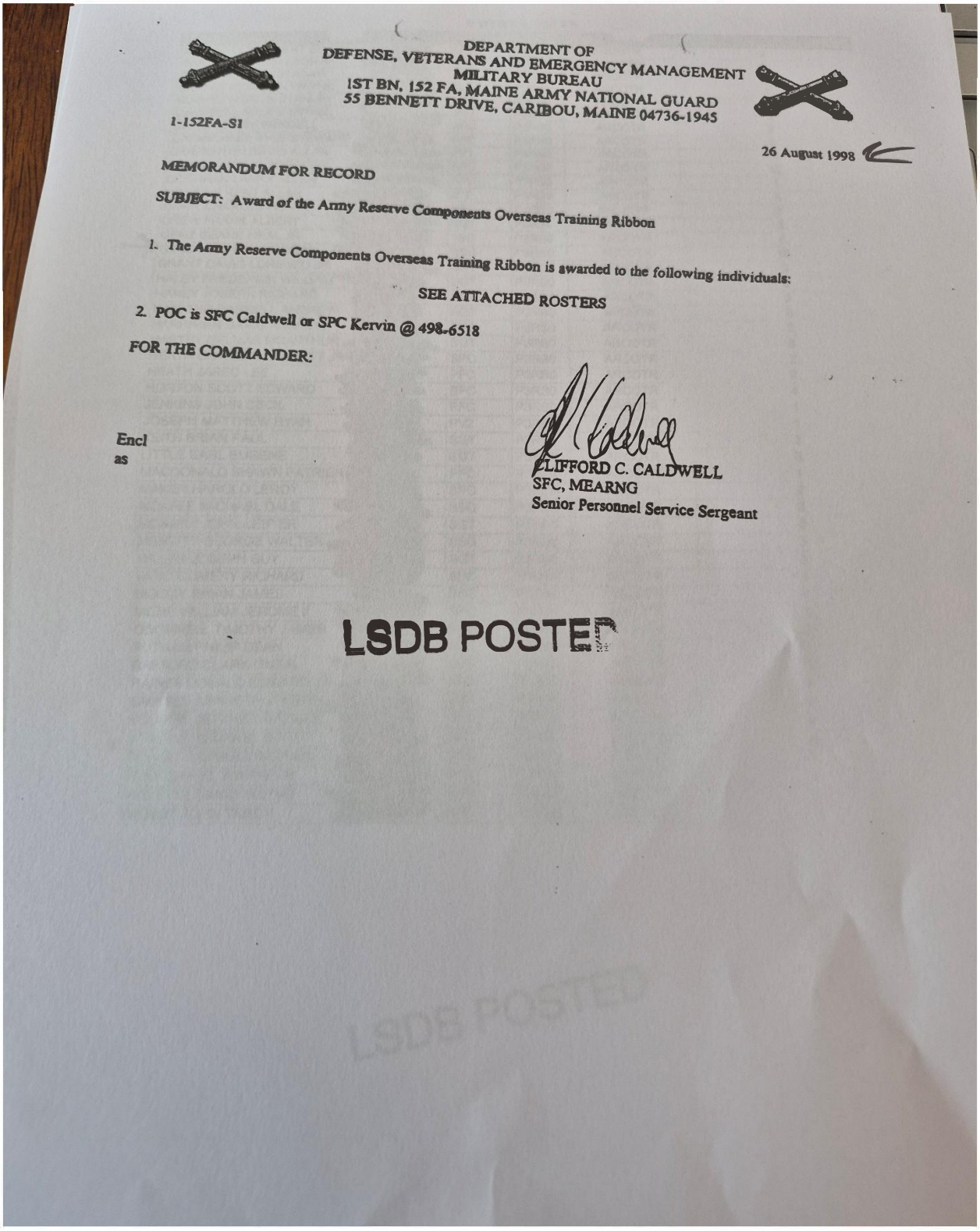
Examples of Maine National Guard Compensation for Training at Base Gagetown



NAME	SSN	GRADE	UIC	AW	TIMES GRANTED
ARSENAULT ROBERT EDWIN	[redacted]	SPC	P3RB0	ARCOTR	2
ARSENAULT ROBERT EDWIN IV		SPC	P3RB0	ARCOTR	2
BARTMAN RALPH LEON IV		SGT	P3RB0	ARCOTR	3
BENNETT TREVOR ADAM		1LT	P3RB0	ARCOTR	3
BRAYAN JEANNETTE WAYNE		SFC	P3RB0	ARCOTR	1
BURGESS NEIL N STANLEY		SGT	P3RB0	ARCOTR	3
CAMPBELL BRUCE ISRAEL		SPC	P3RB0	ARCOTR	3
CARLL LARRY WENDELL		SPC	P3RB0	ARCOTR	2
CARMICHAEL KYLE STEWART		SPC	P3RB0	ARCOTR	2
CARPENTER DAVID ALAN		PV1	P3RB0	ARCOTR	3
CARPENTER DAVID ALAN		SFC	P3RB0	ARCOTR	1
CLOUGH PHILIP GREGORY		SPC	P3RB0	ARCOTR	10
COCHRAN LARRY ALLEN		2LT	P3RB0	ARCOTR	1
COLLINS KENT ALLAN		PFC	P3RB0	ARCOTR	5
CORR CHARLES FRANK		SGT	P3RB0	ARCOTR	2
DREW FRANK ALBERT		1SG	P3RB0	ARCOTR	3
DREW FRANK ALBERT JR		SSG	P3RB0	ARCOTR	4
GENTZEL NEAL JR		SGT	P3RB0	ARCOTR	10
GINISH JOSEPH NORMAN		SGT	P3RB0	ARCOTR	3
GRANT DAVID LORENZO JR		SGT	P3RB0	ARCOTR	2
HALEY FREDERICK WILLIAM		SGT	P3RB0	ARCOTR	3
HANEY JOSEPH RICHARD		SGT	P3RB0	ARCOTR	3
HANNING DARRELL ANDREW		SPC	P3RB0	ARCOTR	2
HARRIMAN DAVID ANDREW		SGT	P3RB0	ARCOTR	8
HASTEY DELMAS MCARTHUR JR		SPC	P3RB0	ARCOTR	2
HEATH CHARLES EVERETT JR		PFC	P3RB0	ARCOTR	2
HEATH JARED LEE		SPC	P3RB0	ARCOTR	4
HORTON SCOTT EDWARD		PFC	P3RB0	ARCOTR	1
JENKINS JOHN CECIL		PV2	P3RB0	ARCOTR	1
JOSEPH MATTHEW RYAN		SGT	P3RB0	ARCOTR	3
KEITH BRIAN PAUL		SGT	P3RB0	ARCOTR	3
LITTLE EARL EUGENE		SPC	P3RB0	ARCOTR	1
MACDONALD SHAWN PATRICK		SPC	P3RB0	ARCOTR	2
MAKER HAROLD LEROY		SSG	P3RB0	ARCOTR	3
MCAFEE MICHAEL DALE		SGT	P3RB0	ARCOTR	3
MCGARY JOHN LESTER		SSG	P3RB0	ARCOTR	3
MERRITT GEORGE WALTER		SGT	P3RB0	ARCOTR	3
MILLER JOSEPH GUY		SPC	P3RB0	ARCOTR	1
MONTGOMERY RICHARD		SPC	P3RB0	ARCOTR	1
MOODY BRIAN JAMES		SPC	P3RB1	ARCOTR	1
MORE WILLIAM JEROME II		SPC	P3RB0	ARCOTR	2
ODONNELL TIMOTHY JAMES		SGT	P3RB0	ARCOTR	2
PUTNAM PHILIP DEAN		SGT	P3RB0	ARCOTR	3
RAFFORD CLARK ONEAL		SPC	P3RB0	ARCOTR	3
RAINES DONALD EDWARD JR		SGT	P3RB0	ARCOTR	4
SAUCIER KENNETH JOSEPH		CPT	P3RB0	ARCOTR	4
SQUIRES JEFFREY THOMAS		SPC	P3RB0	ARCOTR	4
STEVENS MICHAEL SCOTT		SPC	P3RB1	ARCOTR	2
TAYLOR RICHARD MICHAEL		SPC	P3RB0	ARCOTR	3
TOBY DANIEL WAYNE JR		SGT	P3RB0	ARCOTR	3
VIOLETTE DAVID WAYNE		PFC	P3RB0	ARCOTR	1
WILMOT JOHN TRACY					

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Provided by commission member Karen St. Peter



DEPARTMENT OF
DEFENSE, VETERANS AND EMERGENCY MANAGEMENT
MILITARY BUREAU
1ST BN, 152 FA, MAINE ARMY NATIONAL GUARD
55 BENNETT DRIVE, CARIBOU, MAINE 04736-1945

1-152FA-S1

26 August 1998

MEMORANDUM FOR RECORD

SUBJECT: Award of the Army Reserve Components Overseas Training Ribbon

1. The Army Reserve Components Overseas Training Ribbon is awarded to the following individuals:

SEE ATTACHED ROSTERS

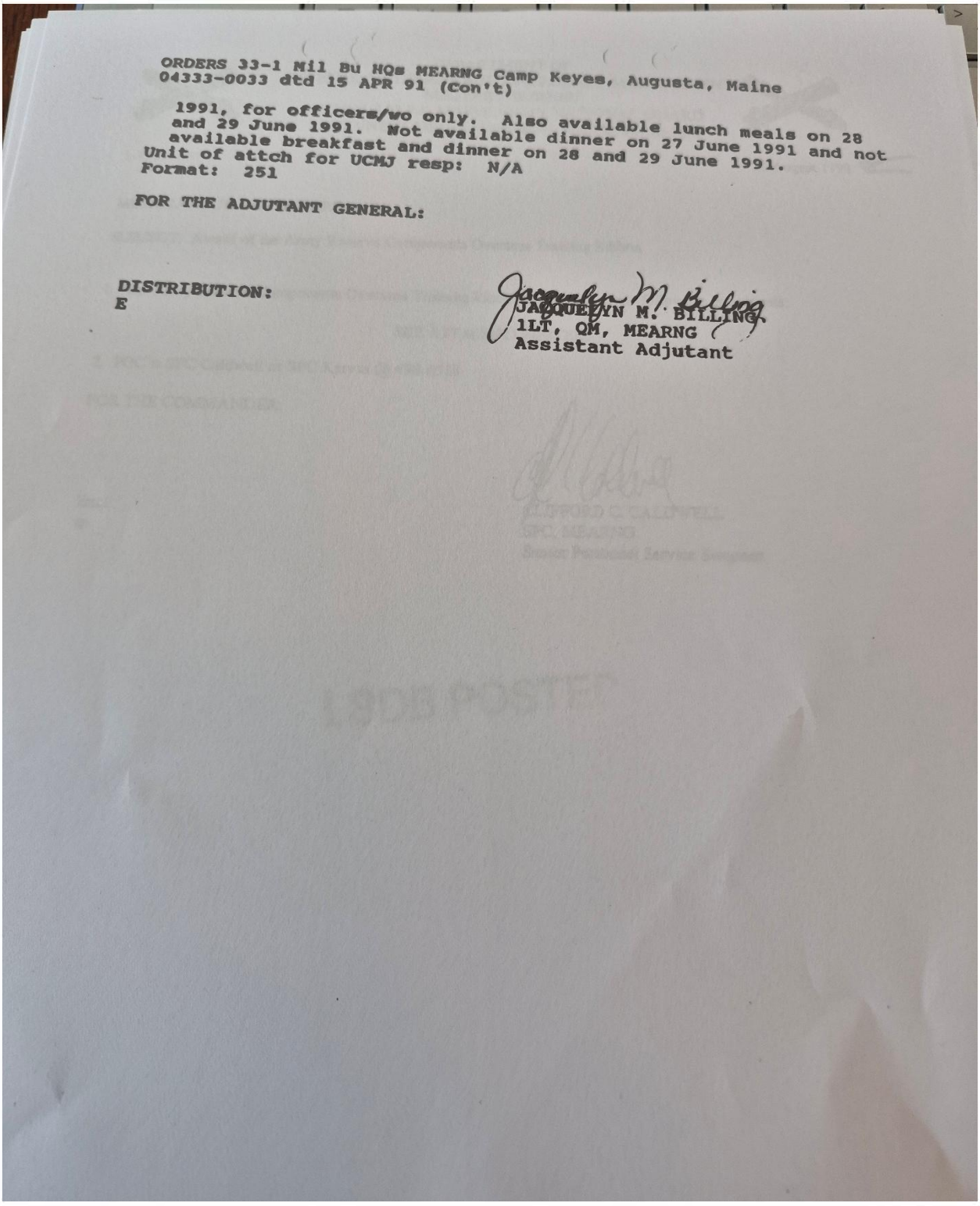
2. POC is SFC Caldwell or SPC Kervin @ 498-6518

FOR THE COMMANDER:

Encl
as

CLIFFORD C. CALDWELL
SFC, MEARNG
Senior Personnel Service Sergeant

LSDB POSTED



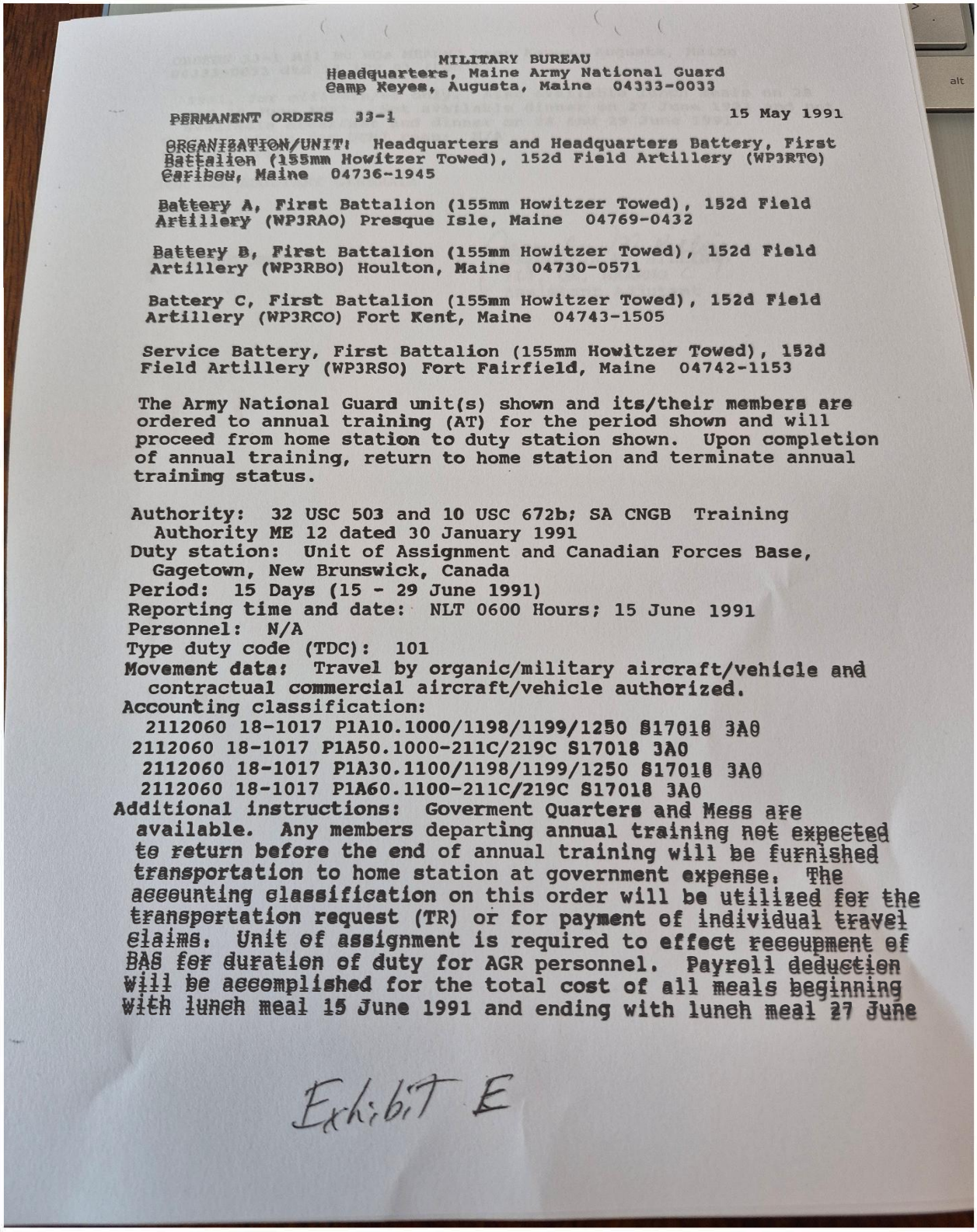
ORDERS 33-1 Mil Bu HQs MEARNG Camp Keyes, Augusta, Maine
04333-0033 dtd 15 APR 91 (Con't)

1991, for officers/wo only. Also available lunch meals on 28 and 29 June 1991. Not available dinner on 27 June 1991 and not available breakfast and dinner on 28 and 29 June 1991.
Unit of attch for UCMJ resp: N/A
Format: 251

FOR THE ADJUTANT GENERAL:

DISTRIBUTION:
E

JACQUELYN M. BILLING
1LT, QM, MEARNG
Assistant Adjutant



MILITARY BUREAU
Headquarters, Maine Army National Guard
Camp Keyes, Augusta, Maine 04333-0033

PERMANENT ORDERS 33-1 15 May 1991

ORGANIZATION/UNIT: Headquarters and Headquarters Battery, First Battalion (155mm Howitzer Towed), 152d Field Artillery (WP3RTO) Caribou, Maine 04736-1945

Battery A, First Battalion (155mm Howitzer Towed), 152d Field Artillery (WP3RAO) Presque Isle, Maine 04769-0432

Battery B, First Battalion (155mm Howitzer Towed), 152d Field Artillery (WP3RBO) Houlton, Maine 04730-0571

Battery C, First Battalion (155mm Howitzer Towed), 152d Field Artillery (WP3RCO) Fort Kent, Maine 04743-1505

Service Battery, First Battalion (155mm Howitzer Towed), 152d Field Artillery (WP3RSO) Fort Fairfield, Maine 04742-1153

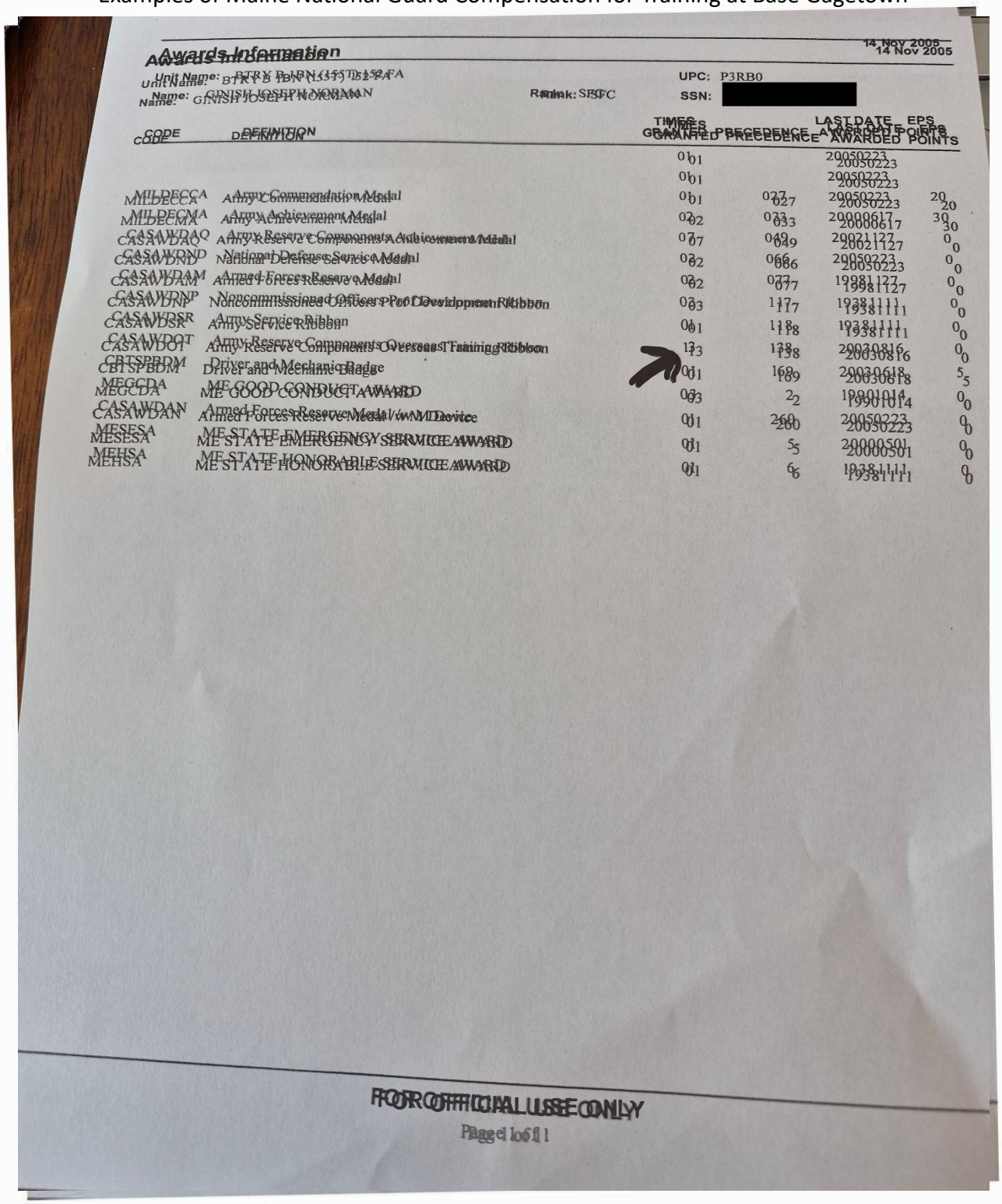
The Army National Guard unit(s) shown and its/their members are ordered to annual training (AT) for the period shown and will proceed from home station to duty station shown. Upon completion of annual training, return to home station and terminate annual training status.

Authority: 32 USC 503 and 10 USC 672b; SA CNGB Training Authority ME 12 dated 30 January 1991
Duty station: Unit of Assignment and Canadian Forces Base, Gagetown, New Brunswick, Canada
Period: 15 Days (15 - 29 June 1991)
Reporting time and date: NLT 0600 Hours; 15 June 1991
Personnel: N/A
Type duty code (TDC): 101
Movement data: Travel by organic/military aircraft/vehicle and contractual commercial aircraft/vehicle authorized.
Accounting classification:
2112060 18-1017 P1A10.1000/1198/1199/1250 S17018 3A0
2112060 18-1017 P1A50.1000-211C/219C S17018 3A0
2112060 18-1017 P1A30.1100/1198/1199/1250 S17018 3A0
2112060 18-1017 P1A60.1100-211C/219C S17018 3A0
Additional instructions: Goverment Quarters and Mess are available. Any members departing annual training not expected to return before the end of annual training will be furnished transportation to home station at government expense. The accounting classification on this order will be utilized for the transportation request (TR) or for payment of individual travel claims. Unit of assignment is required to effect recoupment of BAS for duration of duty for AGR personnel. Payroll deduction will be accomplished for the total cost of all meals beginning with lunch meal 15 June 1991 and ending with lunch meal 27 June

Exhibit E

Gagetown Harmful Chemical Study Commission

Examples of Maine National Guard Compensation for Training at Base Gagetown



Awards Information

14 Nov 2005
14 Nov 2005

Unit Name: BTRY B, 1BN (155T), 152FA
Name: GINISH, JOSEPH NORMAN
Rank: SFC
UPC: P3RB0
SSN: [redacted]

CODE	DEFINITION	TIMES GRANTED	PRECEDENCE	LAST DATE AWARDED	EPS POINTS
		01		20050223	
		01		20050223	
MILDECCA	Army Commendation Medal	01	027	20050223	20
MILDECMA	Army Achievement Medal	02	033	20000617	30
CASAWDAO	Army Reserve Components Achievement Medal	07	049	20021127	0
CASAWDND	National Defense Service Medal	02	066	20050223	0
CASAWDAM	Armed Forces Reserve Medal	02	077	19981127	0
CASAWDNP	Noncommissioned Officers Prof Development Ribbon	03	117	19381111	0
CASAWDSR	Army Service Ribbon	01	118	19381111	0
CASAWDOT	Army Reserve Components Overseas Training Ribbon	13	138	20030816	0
CBTSPBDM	Driver and Mechanic Badge	01	168	20030618	5
MEGCDA	ME GOOD CONDUCT AWARD	03	2	19901014	0
CASAWDAN	Armed Forces Reserve Medal w/ M Device	01	260	20050223	0
MESESA	ME STATE EMERGENCY SERVICE AWARD	01	5	20000501	0
MEHSA	ME STATE HONORABLE SERVICE AWARD	01	6	19381111	0

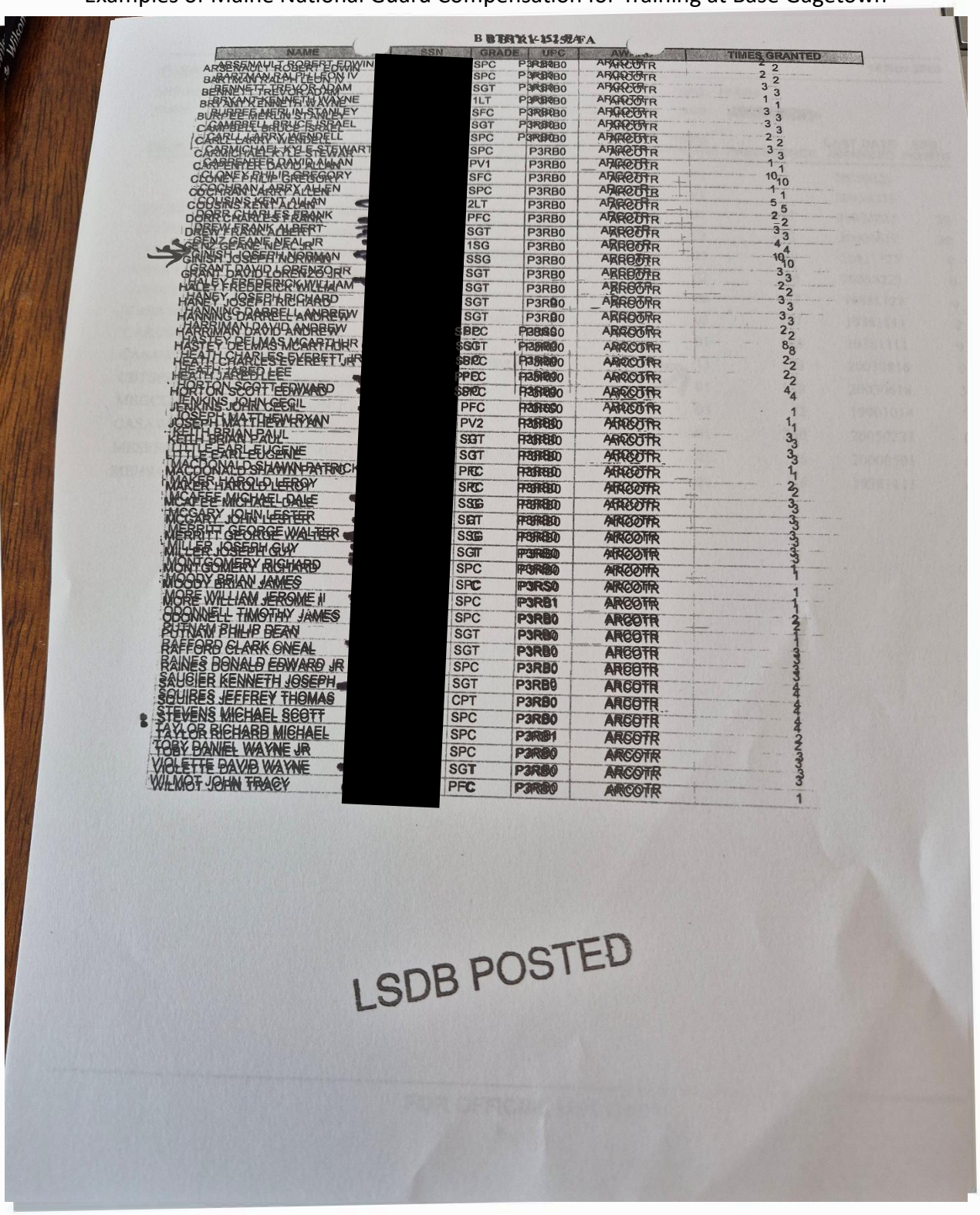
FOR OFFICIAL USE ONLY

Page 1 of 1

Provided by commission member Karen St. Peter

Gagetown Harmful Chemical Study Commission

Examples of Maine National Guard Compensation for Training at Base Gagetown



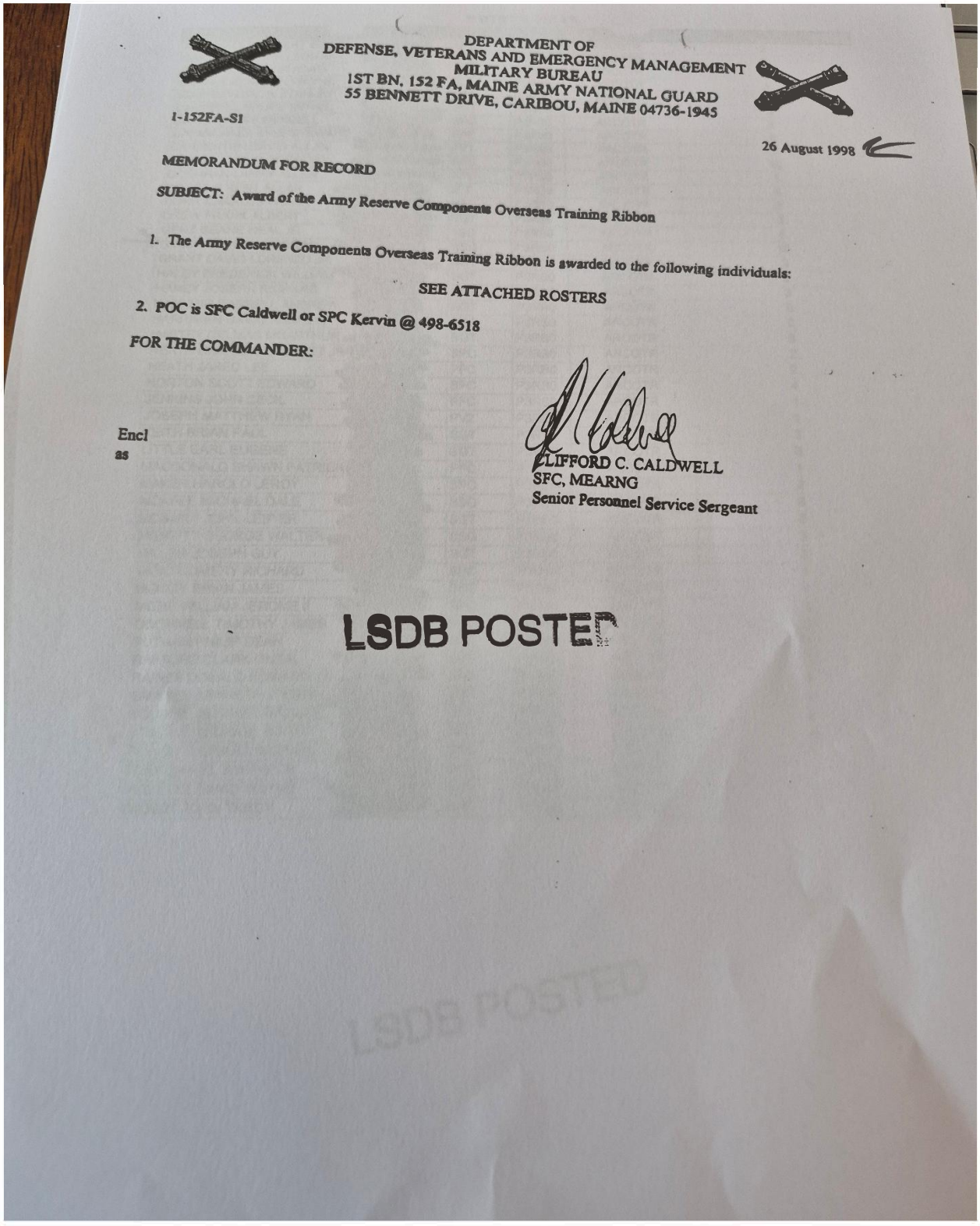
NAME	SSN	GRADE	UPC	AW...	TIMES GRANTED
ARSENAULT, ROBERT EDWIN	[redacted]	SPC	P3RB0	ARCOTR	2
BARTMAN, RALPH LEON IV		SPC	P3RB0	ARCOTR	2
BENNETT, TREVOR ADAM		SGT	P3RB0	ARCOTR	3
BRYANT, KENNETH WAYNE		1LT	P3RB0	ARCOTR	1
BURNETT, MERLIN STANLEY		SFC	P3RB0	ARCOTR	3
CAMPBELL, BRUCE ISRAEL		SGT	P3RB0	ARCOTR	3
CARL, LARRY WENDELL		SPC	P3RB0	ARCOTR	2
CARPENTER, DAVID ALAN		SPC	P3RB0	ARCOTR	3
CLONEY, PHILIP GREGORY		PV1	P3RB0	ARCOTR	1
COCHRAN, LARRY ALLEN		SFC	P3RB0	ARCOTR	10
COUSINS, KENT ALLAN		SPC	P3RB0	ARCOTR	1
DORR, CHARLES FRANK		2LT	P3RB0	ARCOTR	5
DREW, FRANK ALBERT		PFC	P3RB0	ARCOTR	2
GENZ, GEANE NEAL JR		SGT	P3RB0	ARCOTR	3
GINISH, JOSEPH NORMAN		1SG	P3RB0	ARCOTR	4
GRAN, DOUGLAS GREGOR		SSG	P3RB0	ARCOTR	10
HALEY, FREDERICK WILLIAM		SGT	P3RB0	ARCOTR	3
HANEY, JOSEPH RICHARD		SGT	P3RB0	ARCOTR	2
HANNING, DARREL ANDREW		SGT	P3RB0	ARCOTR	3
HARRIMAN, DAVID ANDREW		SGT	P3RB0	ARCOTR	3
HASTEY, DELMAS MCARTHUR		SPC	P3RB0	ARCOTR	2
HEATH, CHARLES EVERETT JR		SGT	P3RB0	ARCOTR	8
HEATH, JARED LEE		SPC	P3RB0	ARCOTR	2
HORTON, SCOTT EDWARD		PFC	P3RB0	ARCOTR	2
JENKINS, JOHN CECIL		SPC	P3RB0	ARCOTR	4
JOSEPH, MATTHEW RYAN		PFC	P3RB0	ARCOTR	4
KEITH, BRIAN PAUL		PV2	P3RB0	ARCOTR	1
LITTLE, EARL EUGENE		SGT	P3RB0	ARCOTR	1
MACDONALD, SHAWN PATRICK		SGT	P3RB0	ARCOTR	3
MAKER, HAROLD LEROY		PFC	P3RB0	ARCOTR	3
MCAFEE, MICHAEL DALE		SPC	P3RB0	ARCOTR	1
MCGARY, JOHN LESTER		SSG	P3RB0	ARCOTR	2
MERRITT, GEORGE WALTER		SGT	P3RB0	ARCOTR	3
MILLER, JOSEPH GUY		SSG	P3RB0	ARCOTR	3
MONTGOMERY, RICHARD		SGT	P3RB0	ARCOTR	3
MOODY, BRIAN JAMES		SPC	P3RB0	ARCOTR	3
MORE, WILLIAM JEROME II		SPC	P3RB0	ARCOTR	1
ODONNELL, TIMOTHY JAMES		SPC	P3RB1	ARCOTR	1
PUTNAM, PHILIP DEAN		SPC	P3RB0	ARCOTR	1
RAFFORD, CLARK ONEAL		SGT	P3RB0	ARCOTR	2
RAINES, DONALD EDWARD JR		SGT	P3RB0	ARCOTR	1
SAUCIER, KENNETH JOSEPH		SPC	P3RB0	ARCOTR	3
SQUIRES, JEFFREY THOMAS		SGT	P3RB0	ARCOTR	3
STEVENS, MICHAEL SCOTT		CPT	P3RB0	ARCOTR	4
TAYLOR, RICHARD MICHAEL		SPC	P3RB0	ARCOTR	4
TOBY, DANIEL WAYNE JR		SPC	P3RB1	ARCOTR	4
VIOLETTE, DAVID WAYNE		SPC	P3RB0	ARCOTR	2
WILMOT, JOHN TRACY		SGT	P3RB0	ARCOTR	3
		PFC	P3RB0	ARCOTR	3
					1

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Provided by commission member Karen St. Peter

Gagetown Harmful Chemical Study Commission

Examples of Maine National Guard Compensation for Training at Base Gagetown



DEPARTMENT OF
DEFENSE, VETERANS AND EMERGENCY MANAGEMENT
MILITARY BUREAU
1ST BN, 152 FA, MAINE ARMY NATIONAL GUARD
55 BENNETT DRIVE, CARIBOU, MAINE 04736-1945

1-152FA-S1

26 August 1998

MEMORANDUM FOR RECORD

SUBJECT: Award of the Army Reserve Components Overseas Training Ribbon

1. The Army Reserve Components Overseas Training Ribbon is awarded to the following individuals:

SEE ATTACHED ROSTERS

2. POC is SFC Caldwell or SPC Kervin @ 498-6518

FOR THE COMMANDER:

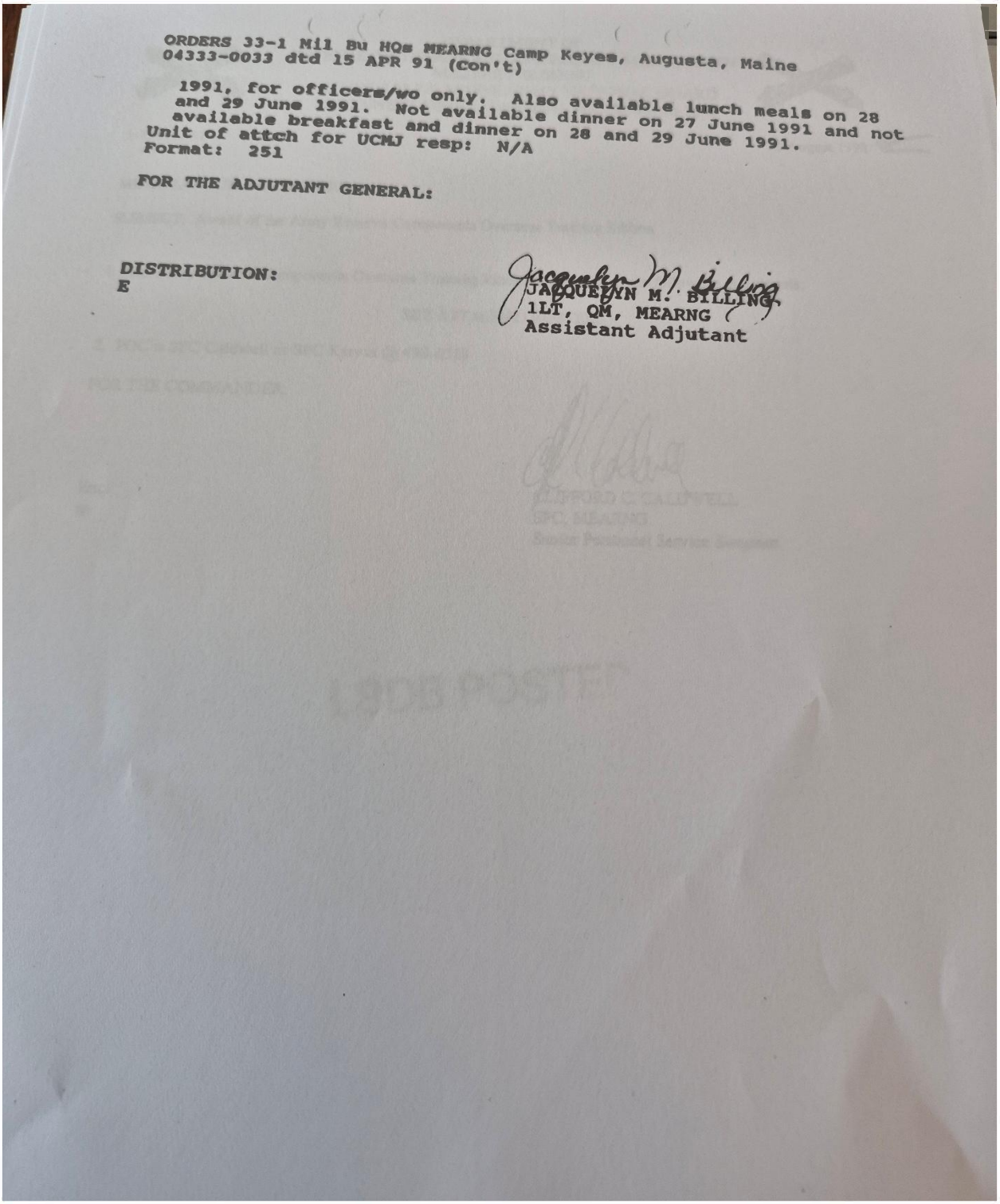
Encl
as

CLIFFORD C. CALDWELL
SFC, MEARNG
Senior Personnel Service Sergeant

LSDB POSTED

Gagetown Harmful Chemical Study Commission

Examples of Maine National Guard Compensation for Training at Base Gagetown



ORDERS 33-1 Mil Bu HQs MEARNG Camp Keyes, Augusta, Maine
04333-0033 dtd 15 APR 91 (Con't)

1991, for officers/wo only. Also available lunch meals on 28 and 29 June 1991. Not available dinner on 27 June 1991 and not available breakfast and dinner on 28 and 29 June 1991.
Unit of attch for UCMJ resp: N/A
Format: 251

FOR THE ADJUTANT GENERAL:

DISTRIBUTION:
E

JACQUELYN M. BILLING
1LT, QM, MEARNG
Assistant Adjutant

APPENDIX B

LIMITATIONS OF THE FURLONG REPORT AND TASK 3A-TIER 1 RISK ASSESSMENT

[From Lisa Laird, Pensions Advocate Pensions Advocate for Bureau of Pensions Advocates, Veterans Affairs Canada]

A. Degree of exposure of any individual was indeterminable

In Dr. Furlong's covering letter to the Minister, he sets out "some salient information" in bullet points. Arguably, these points contain, in Dr. Furlong's opinion, the most important facts the Minister needs to know. The very first point in the list is that "*the degree of exposure of an individual to any chemical sprayed was indeterminable*."

This fact bears highlighting in the context of claims adjudication because the approach taken to date by the Department and the Board requires that each individual prove the degree of his or her exposure. The information required to do so was not available to Dr. Furlong in 2006 with all the resources of the fact-finding study available to him, which included many public meetings, personal interviews, and a "vet net" coordinated by two Veteran volunteers (pp. 4-11). It is an impossible standard for an individual Veteran to meet in 2020. **Imposing such an impossible evidentiary burden on claimants forecloses the possibility of favourable decisions for genuine and deserving claims and thus defeats the purpose of the legislation**.

B. Military Trainee category applies only to those exposed *one year after* testing

The conclusions of the Task 3A-1 Risk Assessment with respect to the category of Military Trainees apply only to service members who began training in or near the sprayed areas one year after the spraying took place (pp. 44, 104-105). **These conclusions do not apply to individuals whose claims are based on exposure during 1966 and/or 1967**. The Military Trainee section of the Task 3A-1 begins at p. 44 with the following assertion and assumption:

> ***Historical records indicate that lands affected by herbicide applications may have been used for training military personnel***. … The 1966 spray campaign was completed between June 14th and June 16th. ***It was assumed that military training operations commenced the following year*** on the exact plot locations of the 1966 spray campaign…."

Provided by commission member Jan McColm from Lisa Laird, Pensions Advocate for Bureau of Pensions Advocates, Veterans Affairs Canada, Government of Canada

The assumption is not as clearly spelled out for 1967, but as the same paragraph on page 44 discusses both 1966 and 1967 spray campaigns, and as that page also records that the concentrations of PCDD and HCB in the surface soil were predicted "at each plot one year after the initial spray campaigns" it is reasonable to infer that the same assumption of a one-year delay in use was applied to both the 1966 and 1967 test sites.

It must be noted that the "Problem Formulation" section of the Task 3A-1 (pp. v, 18) states that "it was assumed that training exercises occurred in direct proximity to the spray areas during the time of spraying." The basis for this assumption is not given, nor is "direct proximity" defined. The discrepancy between the descriptions of the Military Trainee category in the problem formulation and results sections of the report is not explained.

Importantly, the Risk Assessment and Conclusions sections for long-term or chronic risk estimates for exposure to both dioxins and HCB for Military Trainees repeat the defining characteristic of those who may have trained in the 1966-67 spray areas more than a year following the spray applications. **Accordingly, these conclusions cannot reasonably be applied to claims from individuals who may have trained in or near the spray areas anytime between June 14, 1966, and June 1968 – during and up to one year after the spray tests**.

C. Some evidence that training in spray areas may have occurred

The excerpt from page 44 set out above provides further support within the Furlong report's source documents for the Federal Court's conclusion in the *McAllister* case that training may indeed have occurred in the sprayed areas.

The reference to "historical records" indicating use of the areas for training is repeated on page 25 of the Task 3A-1 report. Unfortunately, neither the Furlong nor the Task 3A-1 reports provide references to their source documents for such statements. **It is nevertheless clear that there were historical records of some form indicating the use of these areas for training during and/or sometime after the spray campaigns.**

At page 12 of the Furlong report, Dr. Furlong states that he was "*informed by the Base that the specific areas used by the Americans for testing in 1966 and 1967 have not been used since for formal training by the Base.*" Although this has often been repeated in unfavourable claims decisions, **the reliability of this statement is not known and cannot be tested:** no information is given about who at the Base provided the information or what records he or she had available to come to this conclusion.

However, if the statement is to be taken as fact, it must be considered in conjunction with the historical records referred to on pages 25 and 44 of the Task 3A-1 report. Only two conclusions are then possible:

(1) the spray area *may indeed have been used for training in 1966 and 1967*; and

(2) the area *may have been used for informal training or other purposes* after the spraying in 1966 and 1967.

Either conclusion is a reasonable inference based on the evidence. As such, pursuant to s. 39 of the VRAB Act, either (or both) inferences must be drawn if it favours the claimant's case.

D. Some evidence of uncertainty about spray areas

Despite significant details about the US tests and test areas**, the Furlong report uses tentative language suggestive of some doubt about whether Agent Orange, White or Purple may have also been sprayed elsewhere.**

For example, at the bottom of page 21, the Furlong report states, "***It appears that*** Agent Orange, Agent Purple, and Agent White were only applied on the USDoA test plots." At page 24, the report refers to category 1 being "***areas where Agent Orange is suspected to have been applied*** at CFB Gagetown."

This language contrasts sharply with the description only one sentence later of category 2: "all areas at CFB Gagetown, other than Category 1 areas, where Priority 1 chemicals have been applied.

There is therefore at least some textual evidence of a level of uncertainty about precisely where these chemicals may have been sprayed. Combined with a failure to identify the source material from which the boundaries of the test sites were identified, this introduces a level of uncertainty in the evidence that is worthy of consideration.

E. "Critical inputs" are not defined or provided

It should be noted that at page 20, the Task 3A-1 report indicates that *contact with chemicals in non-designated spray areas was not considered as part of the risk assessment* because of information from a spray drift model, but that areas "*immediately adjacent* to the spray plots were considered as part of the actual spray

plots." Task 3A-1 distinguishes between direct and indirect exposure in the following terms:

> **Direct exposure** would result when an individual is ***within the general vicinity*** of the application area during a spray event as illustrated in Figure 4-2.
>
> **Indirect exposure** might occur as a result of an individual coming into contact with various environmental media that have been impacted by previous spraying events. **Defining on- and off-site areas which may have been either directly affected by historical spray events and/or as a result of spray drift is a *critical input* to the historical reconstruction of exposure**.

Despite identifying this as a "critical input", the Task 3A-1 report does not define what it means by "within the general vicinity", "direct proximity", or "immediately adjacent to" the spray plots.

F. Key records were incomplete and contradictory

On page 21 of his report, Dr. Furlong notes in the first bullet of a 10-bullet point list:

> It should be noted that the annual herbicide files that were supplied to Jacques Whitford [the expert retained for the study] **were, more often than not, incomplete** and information frequently **had to be pieced together** from several different documents within the same file or from different files, and in some cases, the documents contained in any given file **contradicted one another**. Furthermore, the details found in the applicator and monitor records were often **sparse**, and in more recent years, **when applications were closely monitored, inconsistencies were still observed**. (Emphasis added)

While this describes the annual spray program and not the USDoA tests in 1966 and 1967, it demonstrates the potential problems with historical and documentary evidence – even for more recent, "closely monitored" applications. None of the incomplete, inconsistent, or contradictory records that the Furlong Report and its underlying studies relied upon are identified. Nor is it clear what conclusions may be questionable because their factual foundations were merely "pieced together". **In light of this acknowledgement of inadequate record-keeping, there is no justification for treating the Furlong Report as inherently reliable.**

G. The description of the 1966-67 tests is unreliable and inaccurate

The Furlong report states: "*The testing, according to the records, was conducted in an area of the Base that was difficult to access, under strictly controlled conditions, ensuring minimal spray drift.*" (p. 12)

1. **Dr. Furlong does not identify which records provided this information**, nor does he provide any details about their creation, maintenance, and comprehensiveness from which the reliability of the information could be determined. Task 3A-1 contains many details about the test parameters and a map of the 1966 and 1967 test sites in relation to the base as a whole; however, once again, the source of this information is, for the most part, not given.

2. **The assessment that the conditions were "strictly controlled" is attributed to unidentified "records" and appears to be mere opinion from an unknown source.** No details are provided to indicate what measures were taken that were considered to have been indicative of "strict control".

3. The report itself contradicts the description of the test sites as "remote" and "difficult to access". **In fact, both test sites were accessible by road, within walking/hiking distance of a populated area** for most able-bodied individuals (< 5-10kms).

   At p. 12, Dr. Furlong states that the 1966 tests were located *between two roads* (the Broad Rd and the Blissville Road) *only 4.5 kilometers from the nearest populated area*. He describes the 1967 test site as "located *along the Ripon Road*, east of the Broad Road", *8.5 kilometers from the nearest populated area*.

   Some of the information relied on by Dr. Furlong may have been two Technical Memoranda ("TM") published by the US Department of the Army in October 1968:
   - **TM 145 confirms that the 1967 test plots were *"laid out on both sides of Rippon Road."***
   - **TM 141 confirms the 1966 test site was *between Broad Road and Blissville Road*.**
   - The map provided at Figure 1 and the map at p. 32 of the Furlong report clearly indicate that both test sites **begin *right at* the Broad Road** and shows their proximity to the Blissville Airstrip and the Enniskillen range complex.
   - Moreover, Demaree and Creager confirm that **the 1966 test plots were marked off along an existing, partially-vehicle-accessible trail** (p. 3). At p. 7, they provide more detail: *"At first, wheeled vehicles such as jeeps and ¾-ton trucks were able to traverse the swampy areas along the trail, but eventually only tracked vehicles could navigate through the mud and mire."*

- At p. 13 of TM 141 (1966 test), Demaree and Creager confirm: "*Plots were evaluated at monthly intervals from time of application to the end of September 1966. … Certain plots, those that were sprayed at 3 and 4 gallons per acre and with high concentration of material, were evaluated by **walking into the sprayed area** and recording effects of various species."*

See: Technical Memorandum 141, "Defoliation tests in 1966 at Base Gagetown, New Brunswick Canada" K. Demaree and R. Creager, October 1968.
Technical Memorandum 145, "Chemical Defoliation of Northern Tree Species" K. Demaree and A. Haws, October 1968

4. There is no information in the Furlong report or its underlying studies to support the conclusion that there was "minimal spray drift"

(i) Wind conditions are known only for 1966; 1967 had "unfavourable weather"

Many summary reports and claims decisions rely on the fact that the Agent Orange tests were carried out when there was "little to no wind." However, p. 7 of Task 3A-1 indicates that this data was for 1966 only. For the 1967 dates, "Demaree and Haws (1968) reported **unfavourable weather conditions during spraying**; however, no details were provided." It is therefore not known what the wind conditions were during the 1967 tests.

Dr. Furlong erroneously applied the data from 1966 to the 1967 tests at page 12 of his report, where he wrote: "Records indicate that spraying was conducted when there was very little wind." **This example of inaccurately summarizing source material necessarily undermines the reliability of other unattributed statements within the report and of the report as a whole**.

Importantly, the inaccurate statement about wind conditions appears in the same paragraph as the statement cited above, attributed only to "the records", about the testing having been done in an area that was difficult to access and under strictly controlled conditions. The absence of source references for these and other critical statements in his report makes fact-checking impossible and further undermines the reliability and probative value of the report and its conclusions.

(ii) Missing critical facts and inconsistent spray drift distances:

Although both the Furlong and Task 3A-1 reports mention spray drift modelling that estimated a possible exposure limit away from the flight path, the two reports appear to give different figures:

Dr. Furlong states at page 15: “Spray drift modeling has demonstrated that the spray could only drift 800 meters under normal conditions.” What constitutes “normal conditions” is not defined. **Nor is there any information about whether the conditions that existed during the test days in 1966 and 1967 were, in fact, the “normal conditions” used as inputs for the modelling exercise**.

The Task 3A-1 report at page 20 refers to information provided by REMSpC (2006) regarding spray drift that “indicates that **virtually** all of the herbicide product would have deposited on the foliage and/or ground within 500 ft (152 m) of the flight line.” For this reason, drift to non-designated spray areas was not considered in Task 3A-1. “Virtually all” is not given any definition or context. **It is clear that not all of the herbicide was deposited within the flight line and 500 ft margin.**

Neither of these reports provide the facts or assumptions that were used to create the spray drift model. **It is unknown whether the error about the wind conditions in 1967 may have affected the outcome of the modeling exercise**.

(iii) The peer review of the spray drift model demonstrated important limitations:

The peer reviewers of the spray drift model commented, among other concerns, that “*it does not appear that the model has the capability to predict spray drift in a scenario with a capping inversion, a condition that is generally believed to be a worst case condition for spray drift with small droplets.*”

The fact that Agent Orange was apparently sprayed with a very small droplet size has been cited in unfavourable claims decisions (although the source of this information is not given so we cannot determine its reliability)

After reviewing REMSpC’s response to the peer review comments, the best endorsement the peer reviewers were able to give was: “*Despite the comments given above, the AGDISP model, **with all of its limitations**, is probably the best tool that is currently available.”*

It is clear that the spray drift model had significant limitations and may have failed to predict spray drift for Agent Orange with a sufficient or reasonable degree of accuracy to allow its conclusions to be considered reliable.

H. The Risk Assessment is based on many unproven assumptions

Unfavourable claims decisions often refer to the fact that Task 3A-1 was completed by non-governmental experts with the specific goal of assessing potential exposures and resulting human health risks. However, the fact that the experts arrived at a set of conclusions does not mean that this goal was successfully met or that the conclusions can be reliably applied to individual claims determinations.

First and foremost, the Task 3A-1 report itself states clearly that "the risk assessment does not evaluate risks to particular people" (p. iv). Nor was there sufficient information in the historical records to be able to determine the magnitude of exposure to particular groups of people. Rather, **the exposure assessment was completed on the basis of a series of estimates and predictions based on incomplete information and, in some circumstances, using data from wholly different situations and time periods**.

In addition, certain exposure pathways were eliminated from the study (pp. v-vi). **Exposure through drinking water from streams or other sources in the area was not considered**. **Pathways related to brush clearing and burning were also not considered** based on information that brush clearing was not conducted manually in either 1966 or 1967. Unfortunately, no source is given for that information, so once again its reliability cannot be ascertained.

Because of gaps in available information and the passage of several decades, Cantox Environmental was **forced to rely on a number of assumptions** in order to complete its risk assessment. As a result, **the evidentiary foundation, and thus the probative value, of Task 3A-1's conclusions are questionable** and must be carefully weighed if the report is to be used in an adjudicative context.

The Task 3A-1 report itself acknowledges that "variability and uncertainty in the input parameters or risk model result in variability and uncertainty in the estimate of risk". The report lists **5 ½ pages of uncertainties** in its assessment (pp. 98-103). Some of these include "conservative assumptions" designed to ensure that risks are not underestimated. Others, however, do not appear to meet that criteria. A few items of note are the following:

1. **The level of contamination** in Agent Orange and Agent Purple was not known but only **assumed** for the purposes of the risk assessment (p. 9)

2. **Only two contaminants in the herbicides were assessed** in the Tier 1 risk assessment of the 1966-67 tests: PCDD/PCDF and HCB. (p. 17) **The rate of exposure to these chemicals of concern was not known**, but was predicted "using a series of conservative assumptions" (p. 11) However, **essential data about**

historical exposures was missing and substitutions for this data had to be found. The report states at page 17 that:

Depending on the extent of data and historical records available, the reconstruction of historical exposures ranged from **a qualitative discussion** of potential exposures of individuals **(based upon reviews of quantitative studies conducted elsewhere**) to a detailed quantitative assessment of historical exposure estimates based on detailed herbicide application data.

3. The estimate of site-related exposure is contrasted with the historical estimated daily intake (EDI) value of "background exposure" from normal activities unrelated to herbicide use at CFB Gagetown. However, with respect to dioxin, the report indicates that "historical EDI rates for the Canadian population are **difficult to estimate for years prior to the 1980s due to a paucity of data**." (p. 26) Instead, Task 3A-1 used a value derived from **a single study** from 2002 that **estimated** that EDIs in the 1960s and 1970s were "**as high as** 6.0 pg TEQ/kg bw/day". There is no discussion of what a reasonable low-end estimate of EDI may have been for that time period. **As a result of using high-end values for background exposure**, only the accident scenarios and routine flagging activities were found to exceed these background exposure estimates. **This fed directly into the conclusion that exposure for most individuals at CFB Gagetown was not greater than that of the general population in that time period.**

4. **The concentrations of chemicals of concern in the soil one year after spraying were not known but merely predicted** using a range of forest canopy intercept fractions and estimated application rates of PCDD or HCB (p. 44-45).

5. The uncertainty that estimation introduced is **compounded** by the fact that the "incidental soil ingestion rate" used to characterize the soil intake of a military trainee in the area one year after spraying also had to be estimated. As no data was available, the Task 3A-1 authors **substituted the rate reported in 2004 for construction workers.** (p. 45) It is readily apparent that construction workers in 2004 were engaged ***in very different activities, with different clothing, and different access to washing-up facilities***, than military trainees on exercise for days at a time belly-crawling around in the bush in 1966, digging "foxholes" and latrines, stripping branches and pulling up plants to camouflage their locations, drinking water from streams, eating berries, rolling in the dirt and sleeping on the ground with no access to showers, washing their clothes in streams if at all etc.

6. For the accident scenario, the liquid herbicide mixture was assumed to be in contact with the skin for *approximately 20 minutes*, which affected the proportion of the applied dermal dose that could have been absorbed. **No reason is given for choosing this amount of time**. **No consideration appears to have been given to limited washing facilities or opportunities for members on field exercises.**

7. ***I was unable to find an estimated duration of dermal contact for the flagger, field scout, or trainee scenarios despite the acknowledgment in the report that the duration of time the chemical is in contact with the skin has a direct impact on the absorbed dose***. *It is therefore impossible to evaluate whether a realistic duration was applied to generate the risk assessment conclusions and to determine whether and to what extent that assumed duration is applicable to an individual applicant's circumstances.*

8. At page 42, the rate of dislodgeable residue and rate of transfer to the skin for the field scout was estimated using **US Forest Service estimates from 2003**. It is reasonable to infer that these estimates were derived from chemical residue of approved and/or registered herbicides with which US Forestry workers would come into contact in 2003. **No evidence is available to explain how or why those estimates are applicable to the unregistered, contaminated chemicals in Agents Orange, Purple, and White**.

9. Also on page 42, the exposure rate for the field scout category was based on one 12-hour shift of **walking through** all 45 plots. No consideration appears to have been given to the **very different activities engaged in by military trainees on exercise** in defoliated areas: see above, belly-crawling, camouflaging, digging in, sleeping on the ground, etc.

10. Dr. Furlong refers to a 24-hour time limit for hazardous concentrations of chemicals sprayed (p. 16). **He does not provide a reference for this information**. **The Task 3A-1 report does not refer to this timeframe.** I have not yet found the source of the 24-hour limit. However, from other *summary* reports available on the VAC website, it appears that this timeframe may be related in some part to the rate at which Agent Orange degrades in sunlight. **The 24-hour timeframe has been relied on in some claims decisions without any consideration of the reliability of this unsourced information, its applicability to the weather conditions in Gagetown on the relevant days in 1966 and 1967, or the potential effect of a lack of direct sunlight, rain, or shade from the "densely forested" area and "heavy canopy."**

The uncertainties introduced in the risk assessment due to the lack of data, substitution of data from unrelated dissimilar sources and time periods, and reliance on unproven assumptions supports the Federal Court's findings that these reports cannot be considered the best evidence of what occurred at CFB Gagetown in 1966-67.

The risk assessment itself acknowledges that its results **"*must be put into context*"** as ***"the level of uncertainty resulting from the recreation of activities, some of which occurred more than 50 years ago, coupled with the uncertainties inherent in standard forward-looking risk assessment is very large."*** (Furlong report p. 43)

Logically, this "very large" level of uncertainty undermines the probative value of the report's conclusions when applied to individual disability claims adjudication.

All of which is respectfully submitted.

Lisa Laird
Pensions Advocate

SAMPLE OF ARGUMENTS FREQUENTLY PRESENTED TO VRAB

(Details of specific individuals have been removed)

Presumption of service-relationship for environmental exposure:

With respect to the liberal interpretation of the presumption mandated by the legislation itself and affirmed through Federal Court jurisprudence, the Applicant relies on the statutory interpretation analysis set out in Appendix A: Interpreting the Environmental Hazard Presumption, page 26.

The Applicant submits that the presumption in s. 50(g) of the *VWBR* applies when the evidence reasonably establishes: (1) he was exposed to an environmental hazard in the course of his duties; (2) a causal association between that hazard and the claimed condition is reasonably *possible*; and (3) there is insufficient "evidence to the contrary" to establish on a balance of probabilities that his service exposures were inconsequential to the development of his disease.

Reasonable evidence of exposure:

Training for CAF members involved in field exercises in the Gagetown Range and Training Area ("RTA") necessitated close contact with the soil, vegetation, and water in the area.

Training involved bivouacking within the RTA for extended periods of time, sleeping in tents in the field or sometimes in the open without a tent, and drinking from area streams. Mess tins and utensils were washed with

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ground water from the area. Food was often prepared with this same ground water. (evidence from individual veterans, witness statements, and testimony given in previous decisions)

Some members have testified that standing orders were to “take your ponchos with you because aerial spraying was going on.”

USDoA tests in 1966 & 1967:

These chemicals “are known to be persistent as defined by CEPA”, the *Canadian Environmental Protection Act*. (EA-Ex-D1: Furlong Report, p. 27) This means that they “…take a very long time to break down in the environment - sometimes many years. These substances can affect the environment for a long period of time….” (EA-Ex-D9: Environment and Climate Change Canada definitions of Persistent and Bioaccumulative)

There is no evidence to support the often-cited contention in past cases that the USDoA testing grounds remained “unused” during or after the tests were completed or that they were “remote” and “difficult to access”. The *McAllister (2014)* and *Blount* Federal Court decisions found that the Furlong Report did not support such a conclusion. Indeed, the Furlong Report contradicts its own use of these descriptions by providing facts demonstrating that both test areas were <u>accessible by road and an established trail</u> and were <u>within walking/hiking distance of a populated area for most able-bodied individuals</u> (only 4.5 kms in 1966 and 8.5 kms in 1967) (EA-Ex-D1: Furlong Report, pp. 12, 32 (map)).

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CFS/DND Trials in 1966 & 1967:

In addition to the American army tests, trials of unregistered herbicides involving the same chemicals as Agent Orange were conducted by the Canadian Forestry Service and the Department of National Defence in both 1966 and 1967. The tests are reported to have included spraying in an area north of Enniskillen Road in the Medium Machine Gun Field Firing Area near the Enniskillen Range Complex. (EA-Ex-D1: Furlong Report, p. 23; EA-Ex-D2: Task 2A Final Report, p. 25)

There is no evidence of any restrictions on use or accessibility of the CFS/DND unregistered herbicide test sites in 1966 and 1967 or thereafter.

CFB Annual Spray Program:

The Furlong Report also confirms that CFB Gagetown used chemical defoliants containing the same chemicals of concern studied in the IOM research in "many areas" "throughout the RTA".

What was sprayed:

The list of chemical compounds and their active ingredients that were confirmed to have been used by CFB Gagetown and the years in which they were confirmed to have been used can be found in Exhibit 2: Task 2A Final Report, pp. 21-23, Tables 2 & 3)

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Additionally, the Furlong researchers admit: "It is possible that a limited number of other products may have been applied in the RTA given the level of documentation provided in the earlier years of the herbicide application program." The products and dates reflected in the tables created by the HHRA researchers include only those products that "were confirmed to have been applied by DND at the RTA" despite incomplete and contradictory records. (EA-Ex-D1: Furlong Report, pp. iii, 21).

Although many summary reports, briefing notes, and past decisions stress the fact that the chemical herbicides applied as part of the annual spray program were understood to be "commercial" and/or "regulated", the Furlong research was unable to confirm that fact. The report states: "For the purpose of the current assessment, all herbicide products applied at the base were assumed to be products registered for use in Canada. As such, contaminant levels have been assumed to fall within levels deemed acceptable through the pesticide registration process." (EA-Ex-D1: Furlong Report, p. 39) As can be seen from the peer review comments on the Task 2A report, there is no consistent, comprehensive evidence to confirm those assumptions.

On the contrary, in addition to the confirmed evidence of the CFS/DND and USDoA trials of unregistered products in 1966 and 1967, there is reference within the Task 2A report to evidence indicating "the potential use by applicators of unregistered herbicide products" as part of the annual spray program. (EA-Ex-D2: Task 2A Final Report, pp. iii, 38, Appendix F)

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Furthermore, regulatory approval in the 1960s and 1970s, when health effects were unknown, does not establish that the herbicides in question were not capable of causing serious illness. For example, 2,4,5-T (one-half of the active ingredient in Agent Orange and a common component of the annual spray program in early years) was the subject of extensive investigations beginning in the 1970s but was not ultimately withdrawn from North American commercial registrations until 1985. It was found to have been contaminated with harmful dioxins. (EA-Ex-D5: Briefing Note dated 7 December 2005, p. 3).

Where annual spraying took place:

Unfortunately, insufficient evidence now exists to reliably identify all of the chemicals used and all of the areas that were sprayed in each year of the annual spray program. The records kept by the CAF and DND about the use of herbicides at CFB Gagetown are admitted to be "more often than not incomplete," contradictory, sparsely detailed, and inconsistent, particularly in the early years but even in more recent years when applications were supposedly "closely monitored." (EA-Ex-D1: Furlong Report, p. 21; EA-Ex-D2: Task 2A Final Report, p. iii)

What is known is that "many areas" of the RTA were sprayed occasionally, while some were sprayed repeatedly. At least seven areas within the RTA were confirmed to have been sprayed on five or more years. These included troop training areas such as Unit Training Area #1 and the

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General Manoeuvre Areas as well as the Tank Driving and Manoeuvre Area and several Impact Ranges. (EA-Ex-D1: Furlong Report, p. 24)

Further, recorded spray drift incidents demonstrate that the active chemicals from such spray events can deposit in "high concentrations" several kilometers beyond the target zones depending on the method of application, the time of day, and the weather at the time of application. (EA-Ex-D2: Task 2A Final Report, p. 38; EA-Ex-D6: Email correspondence dated 26 April 2007; EA-Ex-D7: Table of Spray Incidents; EA-Ex-D8: "Spray drift incidents")

A report dated 2 August 1966 outlining US participation in vegetation control at CFB Gagetown suggests that the CAF was specifically advised as early as 1964 to adjust its spray program by means of changes that would have significantly increased the risk of such spray drift: They were told that "factors which may have contributed to a degree of lack of success in the past" included, among other things, "droplet sizes too large", "sub-lethal deposits only"; and "sprays delivered under *other than inversion conditions.*" However, a 2007 email on the subject of spray drift confirms that spraying during inversions is "a worst case condition for spray drift with small droplets." (EA-Ex-D10: Report dated August 1966; EA-Ex-D6: Email correspondence dated 26 April 2007; EA-Ex-D8: "Spray drift incidents", emphasis added.)

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A 1964 spray drift incident that damaged market crops as much as six kilometers away from the target zone was thought to be the result of spraying during inversion conditions. This evidence demonstrates that atmospheric conditions conducive to significant spray drift do occur at CFB Gagetown in the summer months *and* suggests that the advice given by US technical advisors was likely followed. Although there is some evidence that DND undertook measures to try to correct the drift problem, another spray drift incident in 1972 demonstrates that these measures had limited success. (EA-Ex-D2: Task 2A Final Report, p. 38).

Additionally, a damage claim from 1988 indicates that harmful levels of active ingredients may also spread outside the target zones through “vapor drift (vs. spray drift) where fine particles of the herbicide are given off the treated area after the application has taken place.” In the 1988 incident, 65 damage claims were paid out to homeowners and commercial growers adjacent to the Gagetown training area for damage caused by vapor drift. (EA-Ex-D7: Table of Spray Incidents)

As far as can be determined, the CAF has not released evidence of how far within the RTA borders the target area lay such that the distance covered by vapor drift cannot be established. Nor is it possible to determine, 60 years later, how often vapor drift and/or spray drift affected areas outside the target zones. Again as far as can be determined, CFB Gagetown did not maintain records of drift damage that occurred within CFB borders as such incidents did not result in the payment of damage awards.

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The Appellant submits that the evidence of vapor drift, in addition to spray drift, is nevertheless sufficient for the Panel to draw a reasonable inference that areas outside the target zones were likely affected by these chemicals.

That inference is further supported by the fact that the chemicals of concern "are persistent as defined by CEPA." (EA-Ex-D1: Furlong Report, p. 27) As noted above, persistence under the *Canadian Environmental Protection Act* means:

> … chemical substances that take a very long time to break down in the environment - sometimes many years. These substances can affect the environment for a long period of time. Because they last for so long, they can travel long distances and pollute a much wider area than those that break down quickly. (EA-Ex-D9: Environment and Climate Change Canada definitions of Persistent and Bioaccumulative)

We submit therefore that the totality of the evidence permits a reasonable inference to be drawn that Veterans were likely exposed to these toxic chemicals in the performance of their duties training in the field in the RTA in the 1960s, whether or not the veteran was in one of the target zones at the time the spraying occurred.

Exposure likely occurred through dermal contact with vegetation, soil, and water that had been sprayed or contaminated by spray and vapor drift;

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through inhalation of particles from spray drift, vapor drift, and contaminated dust; and through ingestion from drinking ground water and from eating foods contaminated with herbicide residue from mess kits washed in ground water and/or contaminated by dust due to eating in or after moving through affected areas without the ability to wash properly or at all.

The Appellant submits that this inference is reasonable given the objective evidence of repeated spraying in unit training areas, general manoeuvre areas, and gun ranges; the nature of military field exercises; the absence of any evidence that troops were kept out of sprayed areas at the time spraying occurred or afterwards; and the evidence in respect of spray drift, vapor drift, and environmental persistence.

VRAB Jurisprudence supporting a reasonable inference of exposure

The Appellant relies on several recent VRAB decisions that have found that evidence of field work in the Gagetown RTA at a time when toxic herbicides were being sprayed there is sufficient for favourable inferences of exposure to be drawn.

The Federal Court has confirmed that such environmental exposures fall within the scope of the presumption of service-relationship: Proof of direct exposure is not necessary to benefit from the presumption. (EA-Attach-D1: *McAllister v Canada (Attorney General),* 2014 FC 991 [*McAllister*])

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On the contrary, the Board has ruled that "a broad and generous interpretation of what constitutes exposure" is required in keeping with the purpose of the presumption." This approach is consistent with the liberal interpretation mandated by s. 2.1 of the *Veterans Well-being Act* and s. 39 of the *Veterans Review and Appeal Board Act* ("*VRAB Act*"). (EA-Atttach-D6: VRAB Decision 100003602362, p. 20; EA-Attach-D7 VRAB Decision 100003683802, p. 11)

Thus, while mere presence at CFB Gagetown in 1966 and 1967 is not sufficient to establish exposure, the Board has found that evidence of field work in the RTA at a time when toxic herbicides were sprayed "throughout" the area is sufficient for favourable inferences of exposure to be drawn.

In both Decisions 100003602362 and 100003683802, the Board found that Veterans who had trained in the RTA over a period of years "would have come into contact with soil, vegetation and water, that had been subjected to herbicide spraying, and therefore [were] likely to have been, at minimum, exposed to these substances." The Board found this was "sufficient to trigger the presumption". (EA-Attach-D6: VRAB Decision 100003602362, p. 20; EA-Attach-D7: VRAB Decision 100003683802, p. 11)

In Decision 100003729377, the Appellant served four years at CFB Gagetown from 1963 – 1967, with much time spent travelling throughout the RTA. The Board concluded: "The Panel finds it unreasonable that this Appellant would not have been exposed to particulates from the spraying of

Provided by commission member Jan McColm from Lisa Laird, Pensions Advocate for Bureau of Pensions Advocates, Veterans Affairs Canada, Government of Canada

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Agent Orange, even if the Appellant cannot prove he was in the spray zone." (EA-Attach-D8)

In Decision 100004647676, the Board concluded that a reasonable inference of exposure could be drawn for a Veteran who started his training at CFB Gagetown in the fall of 1967, had exposure to foliage and water within the RTA, and was diagnosed with diabetes in 2016. (EA-Attach-D9: VRAB Decision 100004647676)

Similarly, in Decision 100003933765, the Board granted full entitlement for diabetes to a fellow artilleryman based on his training within the RTA in 1966 and 1967, which the Board found would reasonably have resulted in environmental exposure to Agent Orange. (EA-Attach-D10: VRAB Decision 100003933765)

Reasonably possible causal association:

Pursuant to long-established policy, Veterans Affairs Canada recognizes a specified list of illnesses as being associated with exposure to Agent Orange and other herbicides for disability benefits purposes. (VAC Policy: Exposure to Agent Orange and Other Unregistered US Military Herbicides)

This list adopts the research published by the U.S. Institute of Medicine ("IOM"). (EA-Ex-D4: Excerpt from Veterans and Agent Orange: Update 11 (2018)).

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The Board has accepted that in practical terms, this means that entitlement is warranted where the "Veteran has a claimed condition which is recognized by both the IOM and the Department, and his evidence regarding the nature of his duties is supportive of exposure." (EA-Attach-D6: VRAB Decision 100003602362; EA-Attach-D7: VRAB Decision 100003683802)

As explained in recent VRAB jurisprudence:

> The 50(g) presumption explicitly sets out a causal connection standard in exposure cases which differs from other cases. The test is different from other entitlement cases.
>
> …
>
> In the Panel's view, paragraph 50(g) … instructs decision-makers to accept a causal connection standard that will facilitate, rather than impede, the awarding of compensation to Veterans who may have been disabled or may have died as a result of military service. **This provision applies to environmental hazard claims where a cause and effect relationship is not clearly and readily discernible**, and permits the presumption of a service relationship in those cases where the possibility of such relationship meets the test formulated as "might reasonably" …. (EA-Attach-D7: VRAB Decision 100003542993; EA-Attach-D8: VRAB Decision 100004098605)

Because the purpose of the rebuttable presumption is to lessen the Veteran's burden of proof, the Veteran is not required to prove that

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environmental hazards were a *significant cause* of his claimed condition. With the benefit of the presumption, the Veteran need only establish that the hazards were a *reasonably possible* cause of Diabetes.

Consistent with the structure of a rebuttable presumption of law, the onus is then transferred to Veterans Affairs to provide affirmative evidence establishing that the hazards were not a significant cause of the Veteran's disease before entitlement may be denied. (EA-Attach-D3: *Léonelli v. Canada (A.G.),* 2003 FC 1374, para. 52)

Absence of "evidence to the contrary"

In the present case, there is no medical opinion or other medical evidence in the record capable of establishing that the Applicant's service-related exposures to environmental hazards were *insignificant* in the development of his disease.

Furlong Report:

The Furlong Report has been discredited and is "no longer used as a vehicle to deny entitlement to disability pensions." (EA-Attach-D8: VRAB Decision 100003729377).

This is because, first, the *Human Health Risk Assessment* ("HHRA") research study from which the conclusions of the Furlong Report are drawn did not include an assessment of "health risks associated with historical exposures via the consumption of water or fish". Thus, an entire exposure

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pathway to which Veterans, including the Appellant, were subjected was not studied and forms no part of the Furlong conclusions. (EA-Ex-D1: Furlong Report, p. 60)

Second, and more generally, the available historical data for the exposure pathways that *were* studied had so many gaps, uncertainties, and contradictions within it that the study's peer reviewers concluded it was simply inadequate to allow for "meaningful environmental and human health risk assessment." The Furlong conclusions were found to be so "fraught with uncertainty" that they were not considered scientifically credible. The lack of reliable data was so significant that the peer reviewers questioned "the validity and the ultimate utility of the report for its intended purpose." (EA-Ex-D2: Task 2A Report, Appendix F)

Notably, the limited value of the report to individual claims adjudication is openly recognized not only in the response to the peer review but also within the report itself. Dr. Furlong and the authors of the research studies caution repeatedly throughout the report that the conclusions of the HHRA are merely "*predictions*" subject to "*very large*" uncertainty. The following paragraph appears many times:

> The results of the HHRA must be put into context. The level of uncertainty resulting from the recreation of activities, some of which occurred more than 50 years ago, coupled with the uncertainties inherent in standard forward-looking risk assessment, is very large. As a result, the expectations regarding the level of precision that

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this risk assessment exercise can produce should be limited. (EA-Ex-D1: Furlong Report, p. 61 and p. 43, among others, emphasis added)

Latency

Although the Appellant was not diagnosed with diabetes until 2010 (SOC 69), no medical evidence has been presented in support of a temporal cut-off point after which environmental exposures to toxic herbicides could reasonably be found to be insignificant. On the contrary, the latency period between exposure to the chemicals of concern and the onset of several of the diseases on the IOM list is unknown. (EA-Ex-D4: Excerpt from Veterans and Agent Orange: Update 11 (2018), p. 9)

Of particular importance in respect of the latency issue is the fact that 2,4-D; 2-4-5-T; Picloram; HCB, and TCDD "are known to bioaccumulate", meaning that they are stored in the body. This means that a person "may continue to experience 'internal exposure' for years even if exposure from the environment has ceased." (EA-Ex-D1: Furlong Report, p. 27; EA-Ex-D4: Excerpt from Veterans and Agent Orange: Update 11 (2018))

Accordingly, the available evidence does not support any negative finding regarding causal significance based merely on the passage of time between the Veteran's exposure and ultimate diagnosis.

Other risk factors

Provided by commission member Jan McColm from Lisa Laird, Pensions Advocate for Bureau of Pensions Advocates, Veterans Affairs Canada, Government of Canada

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We submit that when evidence of other risk factors is being considered, the ruling of the Federal Court of Appeal must be applied: entitlement for a multifactorial condition is warranted even if personal factors have a larger causal connection to the claimed condition than the service-related factors. A claim cannot be denied simply because a Veteran has been shown to have other significant risk factors for the condition at issue. (EA-Attach-D11: *Cole v. Canada (A.G.),* 2015 FCA 119, paras. 78-80)

In the context of a rebuttable presumption, this ruling applies with even greater force because the existence of one or even several other recognized risk factors does nothing to disprove a significant causal contribution from service-related exposures. Accordingly, such evidence is insufficient to displace the presumption of service relationship in s. 50(g).

In worker's compensation cases, the Court has held that a similar presumption must hold unless there is evidence of "sufficient weight to show the presumption wrong." This requires "affirmative evidence of an alternative cause ***and*** evidence that the employment was *not* contributory" (EA-Attach-D4: *MacLaren*, emphasis added; EA-Attach-D5: *Alberta WCAC*, para. 37)

Importantly, an absence of medical evidence establishing that the exposure *was* significant cannot reasonably defeat a presumption designed to lessen the burden of proof on Veterans. To allow such reasoning would mean that to obtain entitlement, the Veteran would have to produce proof of

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significant cause, which is exactly the same burden of proof he would have to meet to gain entitlement without the benefit of the presumption.

The problem with treating an absence of positive data as "evidence to the contrary" is explained as follows:

> In practice, this statutory presumption has commonly been ignored, and it has even been replaced by contrary presumptions in the process of adjudication. For example, a Board doctor may render an opinion that the injury was not caused by the employment. That opinion may rest on nothing except the absence of any positive data about employment etiology. **When that happens, the statutory presumption is, in effect, reversed. The opinion imports a presumption of the negative while the Act prescribes a presumption of the affirmative.** Yet the opinion may be applied by the adjudicator as evidence rebutting the presumption of employment causation. **To reach conclusions in that way is clearly illegal.** (Ison, *Worker's Compensation in Canada,* 2nd ed. Butterworths, 1989, at p. 208, as cited in EA-Attach-D5: *Alberta WCAC,* para. 37)

Professor Ison's comments were relied on by the Alberta Worker's Compensation Appeals Commission in examining rebuttal medical evidence suggesting non-employment causes for a worker's illness in the context of a very similar legal presumption of employment-relatedness. The Appeals Commission found as follows:

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> The evidence to rebut is weighed on the balance of probabilities, and must do more than just raise a reasonable doubt that the accident *arose out of* the worker's employment. Medical evidence, specifically, must do more than merely offer an opinion that it is not likely the injury was related to work. The medical evidence must be based on some positive data about employment etiology, and not just an assertion that it is not likely or not probable that the injury was the result of a work accident. In effect, once the presumption has been triggered, the claim for compensation is acceptable unless there is specific evidence of adequate weight to *disprove* that the accident *arose out of* the worker's employment. (para. 40, emphasis added.)
>
> … providing evidence that merely suggests that alternate causes might exist, or even might be likely, is not adequate to displace the presumption. (para. 45, emphasis added)

In the Appellant's case, given the substantial frailties of the Furlong Report's conclusions, there is no affirmative evidence in the record capable of establishing that the Appellant's service-related exposure to toxic chemicals did not significantly contribute to the development of his disease.

In the result, there is no "evidence to the contrary" that is sufficient to displace the legal presumption that the claimed condition is a service-related disease, being a disease that "arose out of" the Veteran's service in accordance with the provisions of the *Veterans Well-Being Act.*

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CONCLUSION

The Veteran is entitled to the benefit of the legal presumptions Parliament created to assist him in discharging his burden of proof. The preponderance of the evidence in the Veteran's case establishes his environmental exposure to toxic chemicals, particularly when "a broad and generous interpretation of what constitutes exposure" is applied in keeping with the purpose of the presumption. The IOM research discloses a reasonably possible causal relationship between those chemicals and diabetes that is not only sufficient to meet the lesser standard of causation demanded by the presumption but that VAC has long deemed sufficient for disability benefits purposes. The Veteran has therefore established presumptive entitlement.

The available evidence to the contrary, including the Furlong Report and the Veteran's personal medical risk factors for the disease, is insufficient to establish that the Veteran's exposures were *insignificant* and that his condition therefore did *not* arise out of his service. Accordingly, it is insufficient to displace presumptive entitlement.

All of which is respectfully submitted.

Lisa Laird
Pension Advocate

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Exhibits frequently filed with the Veterans Review and Appeal Board:

Ex 1: CFB Gagetown Herbicide Spray Programs 1952-2004 Fact Finders' Report, by Dr. Dennis Furlong (the "Furlong Report") including Peer Review at Appendix F finding conclusions to be not scientifically credible.

Ex. 2: Final Report Task 2A: The History and Science of Herbicide Use at CFB Gagetown from 1952 to Present (excerpts)

Ex. 3: Task 3A Final Report (excerpts)

Ex. 4: Veterans and Agent Orange: Update 11 (2018), (excerpts)

Ex. 5: Draft Briefing Note dated 7 December 2005

Ex. 6: Email correspondence dated 26 April 2007

Ex. 7: Table of Spray Incidents.

Ex. 8: "Spray drift incidents"

Ex. 9: CEPA definitions of Persistence and Bioaccumulative

Appendix to submission: Limitations of the Furlong Report and Task 3A-Tier 1 Report (written by Lisa Laird, LLB, Bureau of Pensions Advocates)

Provided by commission member Jan McColm from Lisa Laird, Pensions Advocate for Bureau of Pensions Advocates, Veterans Affairs Canada, Government of Canada

Politics

Ex-soldier says he watched barrels of Agent Orange being buried at Gagetown base

Did the Canadian military actually track down all of its stocks of the dangerous defoliant?

Murray Brewster · CBC News · Posted: May 23, 2018 4:00 AM EDT | Last Updated: May 23, 2018

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Former military police officer Al White says he watched barrels of Agent Orange being buried at CFB Gagetown in 1985. (CBC News)

comments

It is a 33-year-old mystery that has gnawed at retired sergeant Al White's conscience.

The now-former military police officer told CBC News that, before sunrise on a clear morning in the late spring of 1985, he was ordered to escort a Department of National Defence flatbed truck along an empty road at CFB Gagetown in New Brunswick. The journey took just minutes and ended in shadows just off the road, where an excavator had dug a wide, fresh pit in the spongy soil.

On the flatbed were over 40 full or semi-full barrels in various conditions. Some were solid, others were dented, rusted or in various

states of decay. Almost all of them were wrapped with an orange stripe.

"At the time, I didn't think much of it," White told CBC News. "I just did the task and it wasn't until some time later that it really, really hit home to me."

Very few words were exchanged between White, the truck driver and the operator of the excavator. The barrels were dumped into the pit and covered over.

What Al White said he witnessed that morning three decades back was the burial of leftover Agent Orange, the notorious chemical defoliant linked to various types of cancer that was used in secret spraying experiments by the U.S. at the Gagetown military base in New Brunswick — something which would blow up into a major public policy issue 20 years later.

An eyewitness account

White said he was told at the time what the barrels contained. Experts and activists who have followed the case — and who fought the federal government for compensation for military personnel and civilians affected by defoliant spraying at Gagetown — said White's statement is the first eyewitness account they've heard of the base disposing of stocks of Agent Orange.

"This is quite an interesting development from my perspective," said Wayne Dwernychuk, a expert who spent over 15 years studying Agent Orange contamination and its effects on combatants during the war in Vietnam.

Much of the public controversy in New Brunswick over a dozen years ago related to the secret spraying program. Agent Orange was sprayed at CFB Gagetown in 1966 and 1967 by the U.S. military, with permission from Canada.

It's now known that exposure can lead to skin disorders, liver problems and certain types of cancers. The Canadian government set aside almost $100 million in 2007 for Canadians harmed by defoliants at the base. In 2011, Ottawa also reversed a decision to reject compensation for dozens of soldiers and their families exposed to the defoliant who later became ill.

What makes White's account remarkable, Dwernychuk said, is that it's the first hint of an answer to a nagging question about the Gagetown spraying program: do we know what happened to all of the leftover defoliant?



Al White in uniform in the mid-1980s. "I just felt ... enough about hiding stuff. Bring it out into the public." (Submitted photo)

There are references to disposal in some of the public reports on the program — in both an independent engineering report and the public health study conducted by Dr. Dennis Furlong, which cites one instance of empty barrels being dug up near what is known as the Shirley Road dump.

White said that is roughly the area where he witnessed the burial.

There are, however, significant discrepancies between the Department of National Defence's timeline and White's account of the burial.

At least 10 sites on the base were the subject of study — and the department said it found barrels at only one.

White said he is willing to show defence officials where he saw the barrels buried; CBC News asked to accompany him. National Defence refused to allow access to the base and a spokesman said the issue has been studied exhaustively.

Veterans say Ottawa's planned PTSD research centre falls short of what was promised

Plan to give service dogs to PTSD veterans rocked by federal agency's decision to pull out

AUDIO

Agent Orange compensation: victim claims payout 'not human'

"DND/CAF has done extensive research into the use and testing of herbicides at CFB Gagetown and has left no stone unturned," said Daniel LeBouthillier.

LeBouthillier pointed to independent research conducted by Jacques Whitford Engineering and the community outreach the department did between 2005 and 2007.

"The Department of National Defence has been open and transparent about its work regarding this file and the science indicates that the base is safe today."

LeBouthillier did, however, invite White to contact the department directly.

Dwernychuk said the federal government needs to investigate further.

"It behooves whoever is in charge of the area, the ministry of defence, to find out what is actually in that particular region, particularly if there is a witness to the burying," he said.

The department claims it conducted remediation at the site where it found barrels. Dwernychuk said it should still look at taking deep core samples at that site, given that a brook runs through the area.

Rumours of buried toxins

Both he and Carol Brown Parker, of the Agent Orange Association of Canada — which still lobbies for more disclosure on the Agent Orange program and its aftermath — said they are amazed that White kept silent all these years.

The rumour that barrels of the defoliant had been secretly buried on the base has been rife in nearby communities for decades.

"I absolutely believe Al," said Brown-Parker, who recalled hearing as a child her teachers talking about the late night transport of barrels through the area. "It was well known they did that, but everybody kept quiet."

White said he recently lost three friends — all former soldiers — to cancer. They all suffered lingering, painful deaths, he said.

"I just felt ... enough about hiding stuff. Bring it out into the public that this did occur," White said. "Perhaps I should have brought it forth years ago after I was released from the military and I didn't, and I'm probably wrong for not doing that."

He said he would like clear, definitive answers from National Defence about the site "so that people can be at rest."

Dwernychuk said it's a bitter disappointment to hear now about what White said he saw decades past, given that he didn't come forward when the battle for recognition and federal compensation for those

exposed to Agent Orange at Gagetown was being fought a dozen years ago.

"I would speculate that the government would have taken it more seriously if he had come forward earlier," he said.

"There is always going to be the question of, 'Why did you wait so long?'"