

APPENDIX A

**DIOXIN AND HEXACHLOROBENZENE CONTAMINANT LEVELS IN
HERBICIDES USED DURING THE 1966/67 U.S. HERBICIDE TRIALS**

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APPENDIX A1 DIOXIN CONTAMINANT LEVELS**A1-1.0 PENTACHLOROPHENOL (PCP)**

Unpurified technical PCP contains several microcontaminants, particularly polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), of which Hx is the most relevant congener toxicologically. 2,3,7,8-TCDD has only once been confirmed in commercial PCP samples (0.25 to 1.1 µg/kg). Depending on the thermolytic conditions, thermal decomposition of PCP or sodium pentachlorophenate (Na-PCP) may yield significant production of PCDDs and PCDFs. The use and the uncontrolled incineration of technical grade PCP (Karasek and Dickson, 1987) was one of the most important sources of PCDDs and PCDFs in the environment prior to the modification of its chemical synthesis and application of strict controls for its use.

According to the U.S. military, Timbertox #10 was applied at a rate of 12 pounds per acre. The solution applied was 3 gal/acre, or, equivalently, 4 lb/gal. It is unclear from the records supplied by DND whether or not this formulation was as the water soluble sodium salt (pentachlorophenate) or as the water insoluble PCP. Since no information is available to suggest that the PCP was in an organic solvent (mineral spirits, diesel fuel, *etc.*) it could be assumed that the material used was the sodium salt or pentachlorophenate (CASRN 131-52-2). This is a water soluble form of PCP with a solubility of 33 grams/100 mL. (@ 25 °C)

Conversion: 1 lb = 0.4535924 kg and 1 gallon = 4.5461760 L.

Therefore 4 lb “active ingredient”/gal = 1.8144 kg/4.5461760 L, or 399 g/L. Since the solubility of pentachlorophenate is 33 g/100 mL (330 g/L) as the salt (non-active ingredient), then it is unlikely that the PCP was applied as the salt in aqueous solution (in excess of its solubility maximum).

PCP as Timbertox (in the 1970's) was available as a 39.5% soluble concentrate (presumably in an organic solvent) as Koppers penta wood preservative 1 to 10 concentrate or as Timbertox 40 which was 38.9% PCP and 26.8% petroleum distillates (U.S. EPA registration 453-8).

The water soluble form of PCP (pentachlorophenate salt) generally had lower concentrations of chlorinated dibenzodioxins and dibenzofurans. As seen from the table below (Table A1-1), the PCP available as a salt would have had a much lower concentration of PCCDs and PCDFs when compared to the organic soluble pentachlorophenol. This was likely because the water insoluble fraction was driven off during the process of salt formation and purification.

Table A1-1 presents data from Buser and Bosshardt (1976) who compared the concentrations of chlorinated dibenzo-*p*-dioxins and chlorinated dibenzofurans that were found in commercial preparations of PCP (both technical and analytical grade) and in the sodium salt available from Swiss suppliers after 1973. Virtually all samples PCP contained little or no TCDD (2,3,7,8-Tetrachlorodibenzo-*p*-dioxin) but all were rich in the hexa-, hepta- and octa- congeners of both PCCDs and PCDFs. It is also important to recognize that the technical grade, not the analytical grade products would have been used at CFB Gagetown in 1967. The process for preparation of PCP was changed during the period 1968 to 1973 to significantly lower the potential for formation of dioxins and furans (Young, 1980). It is not possible to accurately determine the

concentration of chlorinated dibenzo-*p*-dioxins and chlorinated dibenzofurans in the Timbertox applied to two plots in 1967.

Table A1-1 PCDDs and PCDFs in Commercially Available PCP Samples Current in 1973^c

Sample	PCDD (ppm, m:m)					PCDF (ppm, m:m)				
	Tetra-	Penta-	Hexa-	Hepta-	Octa-	Tetra-	Penta-	Hexa-	Hepta-	Octa-
Technical Grade										
PCP # T1	<0.02	<0.03	9.5	125	160	<0.02	0.05	15	95	105
PCP # T2	<0.02	<0.03	7.2	150	200	<0.02	0.05	19	110	120
PCP # T3	<0.02	<0.03	9.1	180	280	0.05	0.25	36	320	210
PCP # T4	<0.02	<0.03	9.0	240	250	0.05	0.20	39	280	230
PCP # T5	<0.02	<0.03	10.0	130	210	0.20	0.20	13	70	55
PCP # T6	<0.02	<0.03	5.4	130	370	0.07	0.20	9.1	60	65
PCP # T7	<0.02	<0.03	5.2	95	280	0.02	0.40	28	200	230
PCP # T8	<0.02	<0.03	3.3	27	90	<0.02	0.25	12	65	75
PCP # T9	<0.02	<0.03	3.1	50	135	0.04	0.65	23	140	150
PCP # T10	<0.02	<0.03	4.2	54	210	<0.02	0.10	23	160	140
PCP # T11	<0.02	<0.03	3.1	54	170	<0.02	0.05	23	180	250
PCP # T12	<0.02	<0.03	3.8	90	290	0.02	0.35	30	200	300
PCP HC ^d	<0.10	<0.10	8	520	1380	4	40	90	400	260
PCP-Na # T1 ^a	0.05	<0.03	3.4	40	115	<0.02	0.05	11	50	24
PCP-Na # T1 ^b	0.05	<0.03	3.4	36	105	<0.02	0.03	11	44	29
PCP-Na # T2	0.06	0.03	0.40	4.2	11	0.02	0.08	1.2	3.6	3.9
PCP-Na # T3	0.25	0.08	0.03	0.4	1.5	<0.02	0.03	0.75	2.3	4.1
PCP-Na # T4	0.12	0.03	<0.03	0.3	1.5	<0.02	0.03	0.70	1.3	2.1
PCP-Na # T5	0.08	0.03	0.25	2.8	5.1	0.02	0.13	4.1	13	8.6
PCP-Na # T6 ^a	0.16	0.03	<0.03	0.3	1.2	<0.02	<0.03	0.20	1.2	3.0
PCP-Na # T6 ^b	0.23	0.03	<0.03	0.3	1.2	<0.02	<0.03	0.10	1.0	2.5
Analytical Grade										
PCP # A1 ^a	<0.01	<0.03	<0.03	1.0	3.2	<0.02	<0.03	0.15	1.7	1.3
PCP # A1 ^b	<0.01	<0.03	<0.03	1.1	2.8	<0.02	<0.03	0.10	1.4	1.2

^{a,b} Represents replicate assays

^c Adapted from Buser and Bosshardt, 1976

^d Data from Health Canada, 1988 (American product)

PCDD data in samples of PCP from other authors who published less comprehensive concentration information for contaminants in PCP than Buser and Bosshardt (1976) around the same time are shown in Table A1-2. These reports all agree that in technical grade organic PCP the lower substituted congeners (tetra- and penta-PCDDs) were below the limit of detection, while hexa-, hepta and octa-PCDDs were detected. It can not be assumed that absolutely no TCDD was generated during the manufacture of PCP. Among the data presented by Buser and Bosshardt (1976) all samples of technical grade sodium pentachlorophenate did contain detectable levels of both TCDD and pentachlorodibenzo-*p*-dioxins (Table A1-1). These unexpected results were later found to be an unusual 1,2,3,4-substituted isomer (Rappe *et al.*, 1978).

Table A1-2 PCDDs in Technical Grade Commercially Available PCP Samples Current in 1973 to 1976

Sample	PCDD (ppm, m:m)				
	Tetra-	Penta-	Hexa-	Hepta-	Octa-
PCP 1 ^a	-	-	18	-	1550
PCP 2 ^a	-	-	9	-	1250
PCP 3 ^a	-	-	27	-	575
PCP 4 ^a	-	-	19	-	1980
PCP 5 ^b	-	-	42.00	24.07	10.78
PCP 6 ^c	-	-	17	108	144

^a Adapted from Blaser *et al.*, 1976

^b Adapted from Villanueva *et al.*, 1974

^c Adapted from Plimmer *et al.*, 1973

For calculation of the TCDD toxic equivalency quotients (TEQ) for PCP to be used in the risk assessment only values for PCDD/F that had been determined in samples of the organic solvent soluble form of PCP was used. As discussed above it was uncertain whether the sodium chloropentaphenate salt or the organic form of PCP was used in the 1967 trials so the use of this approach was thought to be the most conservative. Table A1-3 provides the mean of values reported for each congener (Vilanueva *et al.*, 1974; Plimmer *et al.*, 1973; Balser *et al.*, 1976; Buser and Bosshardt, 1976; Health Canada, 1988) as well as the maximum and minimum reported values.

Table A1-3 Calculation of TEQ Equivalents for use with PCP Exposure Based on Tables A1-1 and A1-2

	PCDD (ppm, m:m)					PCDF (ppm, m:m)				
	Tetra-	Penta-	Hexa-	Hepta-	Octa-	Tetra-	Penta- ^a	Hexa-	Hepta-	Octa-
Mean values	0.030	0.040	11.21	131.80	501.83	0.56	3.29	27.70	175.38	168.46
Range max	0.100	0.100	42.00	520.00	1980.00	4.00	40.00	90.00	400.00	300.00
min	0.020	0.030	3.10	24.07	10.78	0.02	0.05	9.10	60.00	55.00
TEF (WHO)	1	1	0.1	0.01	0.001	0.1	0.5	0.1	0.01	0.001
TEQ value for PCP by congener										
[Mean]	0.026	0.035	1.121	1.318	0.502	0.056	1.644	2.770	1.754	0.017
[Maximum]	0.100	0.100	4.200	5.200	1.980	0.400	20.000	9.000	4.000	0.030
[Minimum]	0.020	0.030	0.310	0.241	0.011	0.002	0.025	0.910	0.600	0.006
Σ ppm by WHO-TEF ^b	Mean: 9.242 [Range: 45.010 (max) to 2.154 (min)]									

^a Since no congener breakout was available for the PCP data prepared in 1976, all PeCDFs have been assigned the higher value of 0.5 TEF.

^b Total ppm (TEQ) = Σ tetra- to octa-PCDD plus tetra- to octa PCDFs

Therefore, the TEF equivalent for use with PCP exposure in the risk assessment was 9.2 $\mu\text{g/g}$ (ppm, m:m) with a range of 2.2 to 45 $\mu\text{g/g}$ (ppm, m:m) TCDD (TEQ_{WHO}).

A1-2.0 2,4,5-TRICHLOROPHENOXYACETIC ACID (2,4,5-T)

2,4,5-Triphenoxyacetic acid was produced as a commercial herbicide in 1944 *via* the reaction of trichlorophenol with acetic acid.

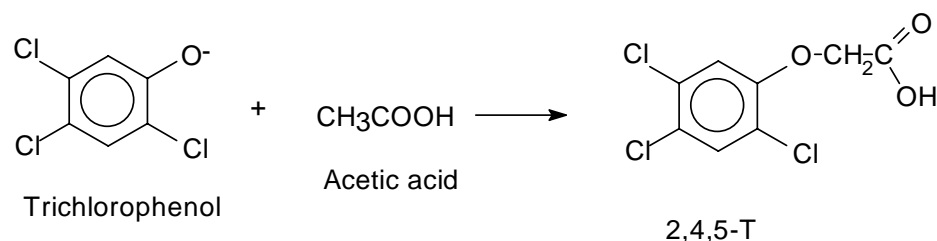


Figure A1-1 Synthesis of 2,4,5-T

2,3,7,8-Tetrachlorodibenzo-*p*-dioxin (TCDD) was the dioxin formed during the production of the herbicide 2,4,5-T. If during production of 2,4,5-trichlorophenol from tetrachlorobenzene the temperature exceeded 160 °C it has been established that TCDD was produced as a contaminant. Under excess temperature conditions, hexa-, hepta and/or octachlorodibenzo-*p*-dioxins may be formed (Woolson *et al.*, 1972). Industrial synthesis of 2,4,5-T started with 2,4,5-trichlorophenol which in turn was a product of the reaction of tetrachlorobenzene with NaOH. In a side reaction, two trichlorophenoxy anions react with each other, eliminate two chlorines and produced tetrachlorodibenzo-*p*-dioxin.

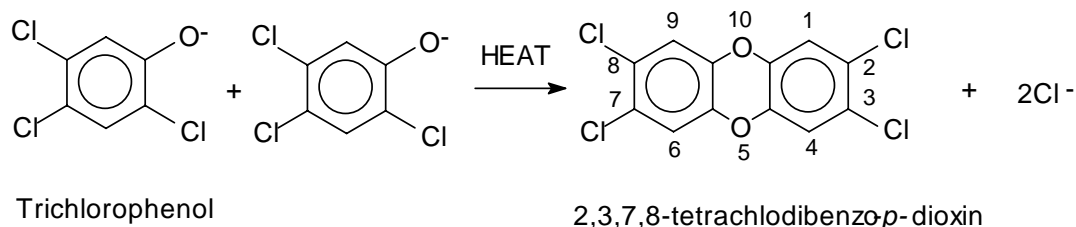


Figure A1-2 Synthesis of contaminant TCDD during production of 2,4,5-T

Since the starting material for synthesis of 2,4,5-T was the trichlorophenol, it is very unlikely that higher congeners of dioxins or dibenzofurans were contaminants of technical grade herbicide (Young, 1980).

Analyses of samples of 2,4,5-T undertaken after application of Agent Orange in 1966 to 1967

In 1970, 2,4,5-T was implicated as a potential teratogen in pregnant rats by Courtney *et al.* (1970). Chemical analysis of technical grade samples of 2,4,5-T supplied by Dow Chemical (lot # 120499) are given below. These analyses carried out in approximately 1970 showed the following contaminants present in 2,4,5-T (Courtney and Moore, 1971):

- | | |
|---|---------|
| • TCDD in 2,4,5-T | 0.5 ppm |
| • 2,4-Dichlorophenoxy acetic acid in 2,4,5-T | 0.05% |
| • 2,5-Dichlorophenoxy acetic acid in 2,4,5-T | 0.42% |
| • 2,6-Dichlorophenoxy acetic acid in 2,4,5-T | <0.02% |
| • 2,3,6-Trichlorophenoxy acetic acid in 2,4,5-T | 0.55% |

- 2,4,6- Trichlorophenoxy acetic acid in 2,4,5-T <0.01%
- 2,4,5 Trichlorophenol in 2,4,5-T <0.1%
- Bis(2,4,5-trichlorophenoxy)acetic acid in 2,4,5-T 0.4%
- 3 Isomers of dichloromethoxyphenoxyacetic acid in 2,4,5-T 2.9%

Elvidge (1971) cited a study carried out by Bionetics Research Laboratories that showed one sample of 2,4,5-T contained about 0.27 ppm 2,3,7,8-tetrachlorodibenzo-*p*-dioxin. In a Gas chromatography procedure developed to determine TCDD in samples from four manufacturers a detection limit of 0.05 ppm was reported. Concentrations of TCDD determined in 2,4,5-T are shown below:

Table A1-4 TCDD in 2,4,5-T and Formulations from Various Manufacturers in 1970^a

Sample	Duplicate analyses TCDD in ppm
2,4,5-T A ₁	0.30, 0.27
2,4,5-T A ₂	0.17, 0.12
2,4,5-T A ₃	0.50, 0.42
2,4,5-T B	0.29, 0.31
2,4,5-T C	0.27, 0.28
2,4,5-T D	<0.05, <0.05
2,4,5-T ethylhexyl ester A	0.26, 0.28
2,4,5-T ethylhexyl ester	0.27, 0.24
2,4,5-T ester	0.19, 0.17
2,4,5-T ester	0.09, 0.13

^a Adapted Elvidge, 1971

Woolson *et al.* (1972) selected seventeen pesticides from the U.S. Department of Agriculture laboratories for analysis of contamination by TCDD and other chlorinated dibenzo-*p*-dioxins. Each was selected on the basis of their use of chlorophenols in their manufacture. The methods developed at this early stage of the evaluation of dioxin contamination in phenoxy herbicides utilized gas chromatography exclusively with a specified detection limit of less than 0.5 ppm.

A total of forty-two samples of 2,4,5-T were examined and 23 showed evidence of contamination. Among those, 7 had less than 10 ppm of tetrachlorodibenzo-*p*-dioxin and thirteen had concentrations in excess of 10 ppm but less than 100 ppm tetrachlorodibenzo-*p*-dioxin. Four samples were contaminated with detectable levels of hexachlorodibenzo-*p*-dioxin. None of the samples showed any evidence of contamination with hepta- or octachlorinated dioxins (Woolson *et al.*, 1972). Ten of eleven sampled of PCP were contaminated with PCDDs but none of these showed any evidence of TCDD (Woolson *et al.*, 1972).

By 1974, Buser and Bosshardt (1974) reported that a technique that combined gas chromatography with mass spectrometry (GC-MS) was able to detect selected chlorinated dioxins in the parts per billion range (ppb). TCDD in technical grade 2,4,5-T and its alkyl ester (used in Agent Orange and Agent Purple) was reported for samples prepared by European manufacturers between 1967 to 1973 (Table A1-5). Samples of the basic chemical starting material 2,4,5-trichlorophenol for production of 2,4,5-T (see Figure A1-1) supplied by Dow Chemical (Dowicide 2) contained less than 3 ppb of TCDD.

Table A1-5 TCDD Content in Samples of 2,4,5-T (German source) Between 1967 and 1973

Year	TCDD in parts per million	TCDD in parts per billion
1967	0.24	240
1970 (a)	0.52	520
1970 (b)	1.95	1950
1970 (c)	0.58, 0.64	580, 640
1970 (d)	0.06	60
1971	0.06, 0.07	60, 70
1972	0.04	40
1973	0.08	80

^a Adapted Buser and Bosshardt, 1974

These data are not relevant to the herbicide application at CFB Gagetown other than to acknowledge that there was a recognition of a problem of contamination among manufacturers world-wide, and that 2,4,5-T was produced after 1970 with substantially reduced levels of contamination by TCDD (Buser and Bosshardt, 1974).

2,4,5-T used in formulations (as alkyl esters or amine salts) still showed evidence of significant contamination by TCDD in 1973. Samples from several manufacturers ranged from 10 ppb to 70 ppb TCDD attributable to the 2,4,5-T content in herbicides (Buser and Bosshardt, 1974).

Similar results were reported by Rappe *et al.* (1978) when GC-MS analyses of several archived samples of Agent Orange as well as alkyl esters of 2,4,5-T were reported. Alkyl esters from 1962 contained 950 ppb (0.95 ppm) TCDD, but four similar esters manufactured between 1966 and 1967 exhibited levels ranging from non-detectable to 220 ppb (0.22 ppm). Three samples of Agent Orange (of undetermined date of manufacture) contained 5.1 ppm, 1.1 ppm and 0.12 ppm of TCDD. Some smaller amounts of other PCDDs were also detected in these samples (Rappe *et al.*, 1978).

A large number of samples of 2,4,5-T butyl- and octyl-alkyl esters from the late 1960s and early 1970s were evaluated in 1973 (Edmond *et al.*, 1973.). Twenty-five of eighty samples were determined to have TCDD below the detection limit of 0.05 ppm. Fifty-five samples revealed various levels of contamination. A mean concentration TCDD in all samples (contaminated and uncontaminated together) was reported by Young (1980) as 0.31 ppm (detection limit 0.05 ppm). No range for these samples was reported.

A1-2.1 Agent Purple

A single archived sample of Herbicide Purple produced between 1962 and 1964 contained 45 ppm of TCDD (Young, 1980; Young *et al.*, 1978). In addition, according to the reports from Detrick and from published information by Young *et al.* (2004) the 2,4,5-T that was used in Agent Purple contained 45 ppm of dioxin. Stellman *et al.* (2003) have discussed the range of reported values for Agent Purple, and have suggested that up to four samples in the U.S. Military stockpile could have been Agent Purple, “redrummed” as Agent Orange. Young *et al.* (1988) reported some samples of herbicide that may have been Agent Purple (Stellman *et al.*, 2003) with values for TCDD of 17, 22, 33 and 47 ppm. NAS estimated an average TCDD level for Agent Purple of 32.8 ppm (NAS, 2005). A range of 17 to 45 ppm (average 32.8 ppm) has been assumed.

A1-2.2 Agent Orange

Young *et al.* (1978) reported the results of analysis of 492 samples of surplus Herbicide Orange (Agent Orange). The levels of TCDD detected ranged from <0.02 to 15 ppm in herbicide produced between the period 1965 to 1968. The weighted mean concentration of TCDD in the Herbicide Orange samples was 1.98 ppm.

A1-2.3 Other products containing 2,4,5-T phenoxy acetic acid

It should be assumed that all other products containing 2,4,5,-T as the phenoxyacetic acid had an average TCDD level of contamination of 2 ppm (range 0.02 to 15 ppm).

A1-3.0 2,4-D

Herbicides contaminated with dioxin that were applied in 1966 include Herbicide (Agent) Orange and Herbicide (Agent) Purple. There is no evidence that 2,4-D used at that time was contaminated with polychlorinated dibenzo-*p*-dioxins (PCDDs). Therefore products that included 2,4-D (*e.g.*, Tordon 101) have not been included as a source of PCDD contamination.

In 1983, the manufacturing process for 2,4-D was modified, and a production limit of “not detectable at 1 ppb” was established for 2,3,7,8-tetrachlordibenzo-*p*-dioxin (2,3,7,8-TCDD). Based on the current manufacturing process, the precursor phenol (2,4,5-trichlorophenol) that forms 2,3,7,8-substituted isomers was not used to manufacture 2,4-D. Furthermore, as a result of the review in 1981, improved methods of synthesis have been employed to lower the levels of non-2,3,7,8-substituted dioxins in 2,4-D. Thus, with refined manufacturing processes, contamination of 2,4-D with dioxins and furans is not seen, nor is it expected (PMRA, 2005).

It may be concluded that during the period of interest (1966 to 1967) 2,4-D used in Agent Orange and Agent Purple might have had TCDD present but no verifiable estimates of this or any other contaminants were identified in this review. Analyses carried out at approximately the time of herbicide application at CFB Gagetown suggest contamination of 2,4-D by PCDD/Fs was low (Woolson *et al.*, 1972).

A1-4.0 CONCLUSION

For the purposes of the current assessment all Agent Purple was assumed to be contaminated at a level ranging from 17 to 45 µg 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 µg 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 µg TEQ/g PCP (mean value of 9.2 µg TEQ/g PCP).

A1-5.0 REFERENCES

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APPENDIX A2**HEXACHLOROBENZENE CONTAMINANT LEVELS****A2-1.0 HEXACHLOROBENZENE CONTAMINANT LEVELS**

Technical grade picloram used in the 1966 and 1967 U.S. trials contained hexachlorobenzene (HCB) as a contaminant. Villanueva *et al.* (1974) reported that some but not all samples of HCB examined included impurities of chlorinated dibenzo-*p*-dioxin and chlorodibenzofurans. These were octa-CDD, hepta-CDF or octa-CDF. Levels were not quantified, and no TCDD or other PCDDs or PDDFs were reported. Since the toxic equivalency factors (TEFs) for the contaminants of HCB that were identified are 0.0001, 0.01 and 0.0001 respectively (CFIA, 2006; Van den Berg *et al.*, 1998), it is unlikely that at concentrations of HCB in the region of 200 ppm could have significant toxicity due to co-contamination with dibenzofurans.

Manufactured picloram contains an impurity, HCB, a persistent organic pollutant according to the Stockholm Convention (FAO, 2005). At a meeting of the Food and Agriculture Organization (FAO) in 2005, a peer validated method was described for the determination of HCB, based on capillary GCMS, over a range of 0.5 to 3.0 ppm. In tests of multiple production batches recovery of HCB in the range 0.5 to 3.0 ppm in picloram (acid equivalent) was 80 to 100%. The FAO proposed a specification limit for HCB in technical picloram of 50 ppm (*i.e.*, 0.05 g/kg or 0.005%), expressed on the basis of picloram acid (FAO, 2005).

A Registration Standard for picloram was established by the United States Environmental Protection Agency (U.S. EPA) in 1995. The Standard required:

- Precautionary label statements advising against the use of picloram in very permeable soils such as karst limestone and loamy sands;
- A groundwater monitoring study;
- Retention of Restricted Use classification ;
- Additional wildlife testing on the technical;
- A field monitoring study to determine concentrations of picloram in runoff water and sediment, leachate, groundwater, and in water and sediment of receiving aquifers to complete a hazard evaluation of wildlife;
- Development of analytical methods for metabolite residues in plant and animal samples;
- Storage stability data;
- Additional oncogenicity data; 9) limiting the level of hexachlorobenzene (HCB) in the technical to a maximum of 200 parts per million (ppm);
- Nontarget area phytotoxicity data on the technical; and,
- Testing for nitrosamines and certification that the upper limit of nitrosamines occurring in the technical is not greater than 1 ppm (U.S. EPA, 1995).

In 1995 the U.S. EPA completed a review of information submitted to the Agency and concluded that DowElanco complied with these requirements set out in 1995. These included evidence that no nitrosoamines were detected in picloram products (<1 ppm) and the level of HCB was certified to be less than 100 ppm (0.10 g/kg or 0.010%).

Current picloram formulations contain very low levels of HCB in compliance with U.S. EPA and Pest Management Regulatory Agency (PMRA) regulations. However, historical contamination of picloram with HCB was significant as shown in the toxicity study conducted in 1986. Landry

et al. (1986) reported results of a 2 year chronic toxicity/carcinogenicity feeding study that used technical grade picloram (93% containing 197 ppm hexachlorobenzene as an impurity) conducted in the F344 rat. A chronic toxicity LOEL was identified at 60 mg/kg/day based on evidence of altered size and colour of centrilobular hepatocytes and increased absolute and/or relative liver weights in both sexes. The NOEL was 20 mg/kg/day. The study was negative for carcinogenicity, but may not have achieved a maximum tolerated dose (MTD) for picloram (U.S. EPA, 1995).

Therefore, a contamination level of 197 ppm HCB in picloram is representative of the levels of contamination in the herbicide applied during the 1966/67 U.S. trials.

A2-2.0 REFERENCES

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