Assessing Dioxin and Furan Risks at Contaminated Sites in Alberta



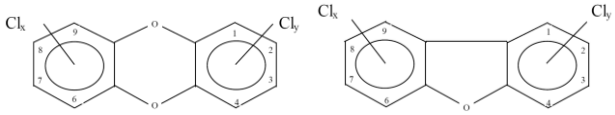
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Outline

- What are dioxins & furans (and dioxin-like PCBs), and how are they evaluated?
- Soil quality guidelines for human direct soil contact: What is Alberta's guideline? What is it based on?
- Considerations for risk assessment.

Dioxins & Furans



Source: CCME (2002)

MULTIPLE SOURCES, PERSISTENT IN ENVIRONMENT

MAY OCCUR AT HIGH CONCENTRATIONS IN SOIL

LOW CONCENTRATIONS IN PLANTS AND WATER

STORED IN FAT TISSUE IN ANIMALS

BACKGROUND EXPOSURE = 90% FROM FOOD

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Dioxin & Furan Toxic Equivalent (TEQ)

Substance	TEFs[1]
Polychlorinated Dibenzo-p-dioxins	
2,3,7,8- Tetrachlorodibenzo-p-dioxin (TCDD)	1
1,2,3,7,8- Pentachlorodibenzo-p-dioxin (PeCDD)	1
1,2,3,4,7,8- Hexachlorodibenzo-p-dioxin (HxCDD)	0.1
1,2,3,6,7,8- Hexachlorodibenzo-p-dioxin (HxCDD)	0.1
1,2,3,7,8,9- Hexachlorodibenzo-p-dioxin (HxCDD)	0.1
1,2,3,4,6,7,8- Heptachlorodibenzo-p-dioxin (HpCDD)	0.01
Octachlorodibenzo-p-dioxin (OCDD)	0.0003
Polychlorinated Dibenzofurans	
2,3,7,8- Tetrachlorodibenzofuran (TCDF)	0.1
1,2,3,7,8- Pentachlorodibenzofuran (PeCDF)	0.03
2,3,4,7,8- Pentachlorodibenzofuran (PeCDF)	0.3
1,2,3,4,7,8- Hexachlorodibenzofuran (HxCDF)	0.1
1,2,3,6,7,8- Hexachlorodibenzofuran (HxCDF)	0.1
1,2,3,7,8,9- Hexachlorodibenzofuran (HxCDF	0.1
2,3,4,6,7,8- Hexachlorodibenzofuran (HxCDF)	0.1
1,2,3,4,6,7,8- Heptachlorodibenzofuran (HpCDF)	0.01
1,2,3,4,7,8,9- Heptachlorodibenzofuran (HpCDF)	0.01
Octachlorodibenzofuran (OCDF)	0.0003
Non-ortho Substituted PCB Congeners	
PCB 77	0.0001
PCB 81	0.0003
PCB 126	0.1
PCB 169	0.03
Mono-ortho Substituted PCB Congeners	
PCB 105	0.00003
PCB 114	0.00003
PCB 118	0.00003
PCB 123	0.00003
PCB 156	0.00003
PCB 157	0.00003
PCB 167	0.00003
PCB 189	0.00003

Notes:

[1] 2005 World Health Organization's toxic equivalency factors (TEFs) (Van den Berg et al., 2006) summarized in Table 4 from Health Canada (2021a).

Source: Alberta EPA (2024)

$$TEQ = \sum_{i=1}^{n} C_i \times TEF_i$$

$$TEQ = \\ (2,3,7,8\text{-}TCDD \times 1) + \\ (1,2,3,7,8\text{-}PeCDD \times 1) + \\ (1,2,3,4,7,8\text{-}HxCDD \times 0.1) + \ldots \\ (PCB\ 189 \times 0.00003)$$

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Health Effects

What health effects are associated with exposure to dioxins and furans?

- Effects on the developing nervous system
- Liver and skin issues
- Immune, endocrine and reproductive effects
- Certain types of cancer

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Human Direct Soil Quality Guidelines

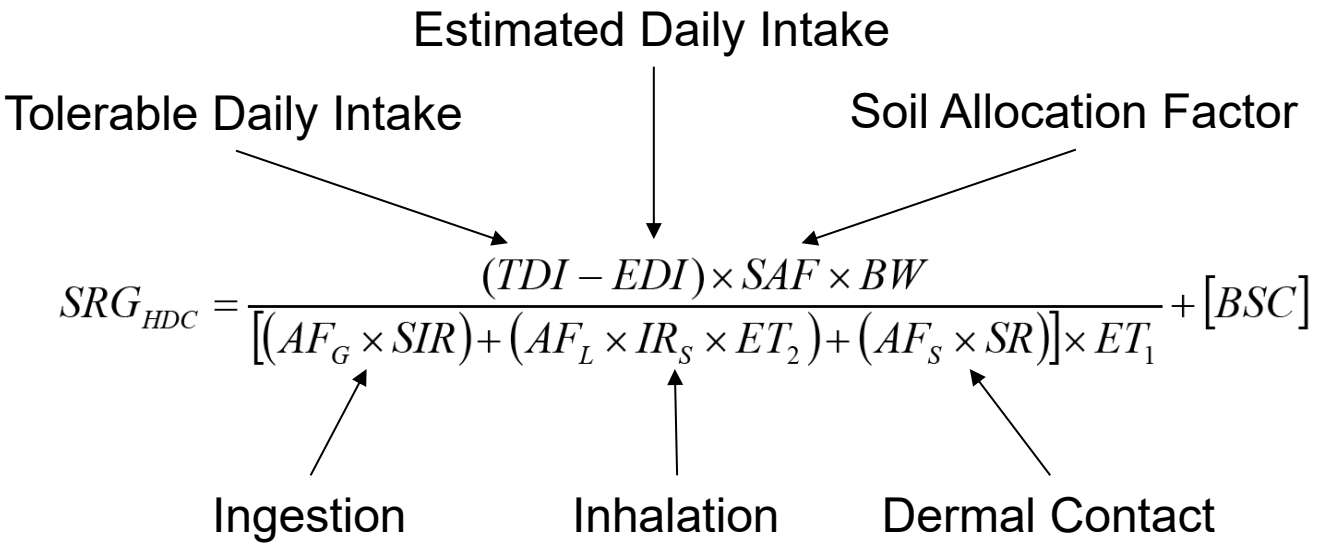
- CCME (2002)
  - Based on background levels of dioxins and furans in Canadian soils → **4 ng TEQ/kg**

- Alberta (2024)
  - Health-based guideline → **54 ng TEQ/kg**
    (residential/agricultural)

Land Use	Natural Area	Agricultural	Residential/ Parkland	Commercial	Industrial
Unit (unless otherwise indicated)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Dioxins & Furans	0.00025	0.000054	0.000054	0.000080	0.000118

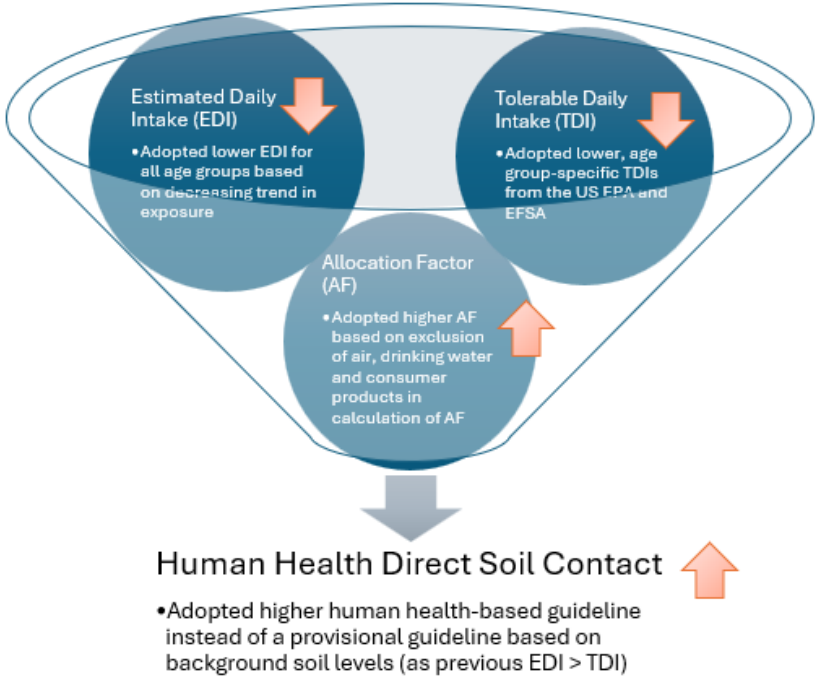
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Soil Quality Guideline Calculation



2024 Alberta Guideline

Basis of Guideline Changes



TDI	2.0 pg/kg-day	→	0.7 pg/kg-day
EDI	7.1 pg/kg-day (toddler) 1.3 pg/kg-day (adult)	→	0.2 pg/kg-day
AF	0.25 (unitless)	→	0.5 (unitless)
TEF	WHO (1998)	→	WHO (2005)

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Alberta EPA Guideline – TDIs

- Most sensitive endpoint is reproductive and developmental effects.

2.0 pg/kg-day	→	0.7 pg/kg-day

- Adopted **two** separate TDIs:
  1. 0.7 pg/kg-day (US EPA 2012) for the protection of children less than 10 years of age. → Toddler
  2. 0.25 pg/kg-day (EFSA 2018) for anyone 10+ years of age. → Adult

Alberta EPA Guideline – EDIs & AF

- Estimated Daily Intakes

7.1 pg/kg-day (toddler) 1.3 pg/kg-day (adult)	→	0.2 pg/kg-day

  - Decreasing trend in exposure over time
  - Suggests that the EDIs from the 1990s overstate current Canadian exposure
- Allocation Factors

0.25 (unitless)	→	0.5 (unitless)

  - Previously included four pathways (i.e., soil, food, drinking water, consumer products)
  - Now based on soil and food alone
  - Factor of 0.5 now applied

Alberta EPA Guideline – TEFs

- Toxic Equivalency Factors

WHO 1998 TEFs → WHO 2005 TEFs

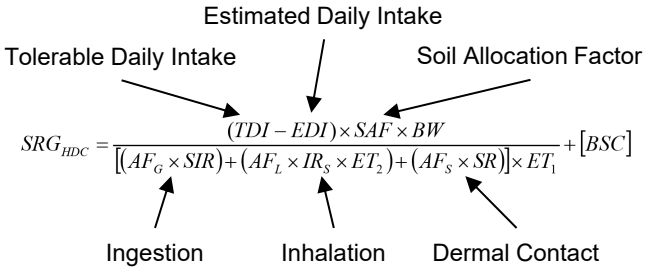
  - Internationally established factors for consistency in assessing dioxins & furans.
  - The WHO re-evaluates the key assumptions underlying these values and has established several iterations over time.
  - The WHO 2005 TEFs were adopted in place of 1998 values.

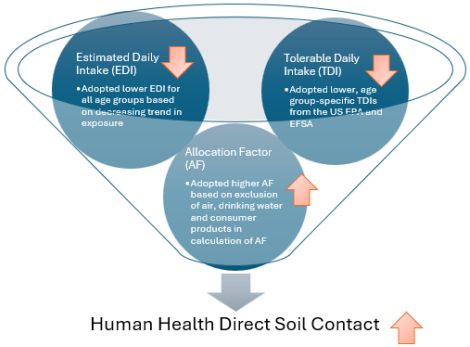
2024 Alberta Guidelines

Alberta moved towards dioxin and furan guidelines that are:

- Health-based
- Land-use-specific

Natural Area	Agricultural	Residential/ Parkland	Commercial	Industrial
(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
0.00025	0.000054	0.000054	0.000080	0.000118





Risk Assessment Considerations

- Know your COPC
  - When and where to look for dioxins and furans
- Know your data
  - TEFs have changed over time
  - Non-detects:
    upper and lower bound TEQs

Analyte	1998 WHO TEF	2005 WHO TEF	2022 WHO TEF
2,3,7,8-TCDD	1	1	1
1,2,3,7,8-PeCDD	1	1	0.4
1,2,3,4,7,8-HxCDD	0.1	0.1	0.09
1,2,3,6,7,8-HxCDD	0.1	0.1	0.07
1,2,3,7,8,9-HxCDD	0.1	0.1	0.05
1,2,3,4,6,7,8-HpCDD	0.01	0.01	0.05
OCDD	0.0001	0.0003	0.001
2,3,7,8-TCDF	0.1	0.1	0.07
1,2,3,7,8-PeCDF	0.05	0.03	0.01
2,3,4,7,8-PeCDF	0.5	0.3	0.1
1,2,3,4,7,8-HxCDF	0.1	0.1	0.3
1,2,3,6,7,8-HxCDF	0.1	0.1	0.09
1,2,3,7,8,9-HxCDF	0.1	0.1	0.2
2,3,4,6,7,8-HxCDF	0.1	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.01	0.01	0.02
1,2,3,4,7,8,9-HpCDF	0.01	0.01	0.1
OCDF	0.0001	0.0003	0.002

Risk Assessment Considerations

- Know your receptors
  - 0.7 pg/kg-day (US EPA 2012)
    for the protection of children less than 10 years of age.
  - 0.25 pg/kg-day (EFSA 2018)
    for anyone 10+ years of age.
  - Alternate reference values may be appropriate
- Know your pathways
  - Soil? Groundwater? Food?

Risk Assessment Considerations

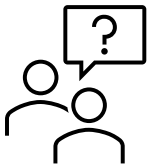
- EPA (2024):
  Ingestion of produce, milk, and meat produced on the site is not included in Tier 1 human exposure estimates because of its site-specific nature.

  Where a significant portion of an individual's diet is obtained from areas contaminated by substances that bioconcentrate, this exposure pathway must be evaluated with the Tier 2 approach.

Land Use	Natural Area	Agricultural	Residential/ Parkland	Commercial	Industrial
Unit (unless otherwise indicated)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Dioxins & Furans	0.00025	0.000054	0.000054	0.000080	0.000118

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Questions?



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