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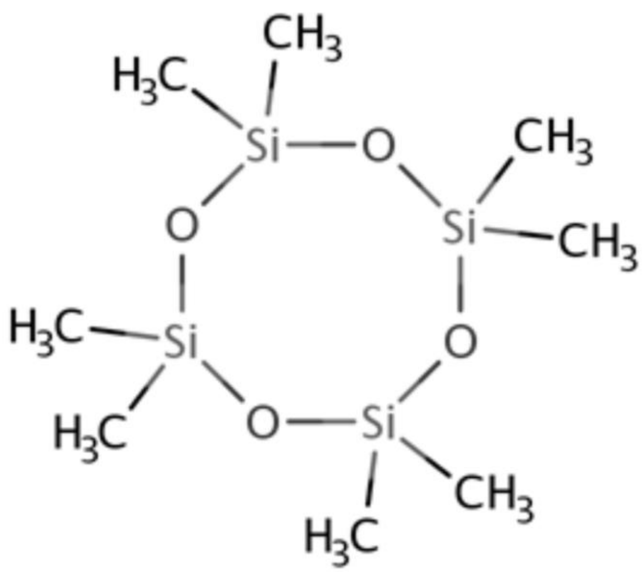
Draft Environmental Hazard Assessment for Octamethylcyclotetrasiloxane (D4)

Technical Support Document for the Draft Risk Evaluation

CASRN 556-67-2



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Abbreviations and Acronyms

AF	Assessment factor
ChV	Chronic health value
COC	Concentration(s) of concern
CDR	Chemical Data Reporting (Rule)
DMSD	dimethylsilanediol
EC50	Effect concentration at which 50 percent of test organisms exhibit an effect
ECHA	European Chemicals Agency
ECOSAR	Ecological structure-activity relationship
EPA	Environmental Protection Agency
HC05	Hazard concentration that is protective of 95 percent of the species in the sensitivity distribution
LC50	Lethal concentration at which 50 percent of test organisms die
LOAEL	Lowest-observable-adverse-effect level
LOEC	Lowest-observable-effect concentration
NOAEL	No-observed-adverse-effect level
NOEC	No-observed-effect concentration
OCSPP	Office of Chemical Safety and Pollution Prevention
OPPT	Office of Pollution Prevention and Toxics
SCHSE	Silicones Environmental health and Safety
SSD	Species sensitivity distribution
TRV	Toxicity reference value
TSCA	Toxic Substances Control Act
U.S.	United States
Web-ICE	Web-based Interspecies Correlation Estimation

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Docket

Supporting information can be found in the public docket, Docket ID EPA-HQ-OPPT-2018-0443.

Disclaimer

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Summary

EPA evaluated the reasonably available information for environmental hazard endpoints associated with D4 and dimethylsilanediol (DMSD) exposure. DMSD is the terminal degradation product of D4 and is expected to persist in the aqueous environment. The key points of the environmental hazard assessment are summarized below:

Aquatic organism hazard:

- Experimental aquatic hazard data were available from D4 studies for two fish species, one aquatic invertebrate species, three benthic invertebrate species, and one algal species.
- Experimental aquatic hazard data were available from DMSD studies for two fish species, and one aquatic invertebrate species. None of the DMSD studies showed adverse effects at the highest concentrations tested; 126,000 µg/L for rainbow trout acute exposure, 12,000 µg/L for Fathead minnow chronic exposure, 117,000 µg/L for *Daphnia magna* acute exposure, and 12,000 µg/L for *Daphnia magna* chronic exposure.
- Because there were no reported adverse effects for aquatic organisms from exposure to DMSD a hazard threshold could not be established and exposure to DMSD will not be further evaluated.
- Acute and chronic aquatic concentrations of concern (COC) were calculated from rainbow trout (2.4 µg/L) and *D. magna* (1.1 µg/L) mortality studies, respectively. Acute and chronic benthic COCs were calculated from blackworm (1.9 mg/kg), and midge species (8.8 mg/kg), respectively. The aquatic plant COC was calculated from a single green algae (0.33 µg/L) study.

Terrestrial organism hazard:

- Experimental terrestrial data were available from six human health-relevant mammal studies that contained ecologically relevant hazard data for mammalian exposure to D4 and were used to derive a mammalian toxicity reference value (TRV) of 95 mg/kg-bow/day (Figure 4-1). These studies reported reproductive, growth, and behavioral effects in rats and rabbits.
- Experimental terrestrial data were available from a single study for D4 exposure to invertebrates (earthworm) which was used to calculate the terrestrial hazard threshold of 98.7 mg/kg soil.
- Experimental terrestrial data were available from two studies for DMSD exposure to terrestrial invertebrates (earthworm) species, and 10 terrestrial plant species. None of the DMSD studies showed adverse effects at the highest concentrations tested from earthworm (3.8 mg/kg) or plant species (4.3 mg/kg).
- Because there were no reported adverse effects for terrestrial organisms from exposure to DMSD a hazard threshold could not be established and exposure to DMSD will not be further evaluated.

1 Introduction

D4 is a colorless, oily liquid with an annual total production volume in the United States, as reported in the most recent Chemical Data Reporting (CDR) in 2020, between 250 million and 500 million pounds (U.S. EPA, 2022b). D4 is primarily used to make other silicone chemicals and as an ingredient in some personal care products.

D4 does not undergo biodegradation in water under aerobic conditions and is expected to volatilize from surface water due to its high vapor pressure (0.9338 mmHg at 25 °C) and Henry's Law constant (11.8 $atm \cdot m^3/mol$ at 21.7 °C). D4 is expected to undergo rapid hydrolysis in aquatic environments with DMSD as its final product and DMSD is expected to persist in the aqueous environment. However, D4's hydrolysis rate is highly dependent on pH and temperature. In addition, D4 is not expected to undergo photolysis in aquatic environments under environmentally relevant conditions since it does not absorb wavelengths greater than 290 nm. Additionally, D4 can be transported to sediments from overlying surface water via advection, dispersion, and sorption to suspended solids that can settle out from the water column. Due to its high log K_{OC} (4.19 and 4.22 at 24.4 – 24.8 °C) and log K_{OW} (6.488 at 25.1 °C) values, D4 will have a strong affinity for organic carbon in sediment.

D4 is expected to be released to terrestrial environments via land application of biosolids and disposal of solid waste to landfills. With measured log K_{OC} values of 4.19 and 4.22 (Kozerski et al., 2014; Miller and Kozerski, 2007) and a low water solubility, D4 will have a strong affinity for organic matter in terrestrial environments and leaching is not expected to occur. When D4 is released to soil, approximately 90.5 percent of the mass fraction is estimated to volatize from soil and partition to air. A small percentage (9.5 percent) will remain partitioned to soil associated with solids and undergo abiotic degradation processes. The relative contribution of hydrolytic and volatilization processes to D4 dissipation from soil depends on the mineralogy of the soil and the percentage of relative humidity (soil moisture) (Xu, 2007; Xu and Chandra, 1999). D4 volatilization was observed to be predominant in moist soils, while acidic, drier, and clay heavy soils have shown to have greater hydrolysis rates (Xu and Chandra, 1999).

2 Approach and Methodology

EPA reviewed the potential environmental hazards associated with D4 during scoping and identified 44 references in Figure 2-9, and can be viewed in the interactive literature inventory tree in HAWC, from *Final Scope of the Risk Evaluation for octamethylcyclotetrasiloxane (Cyclotetrasiloxane, 2,2,4,4,6,6,8,8-octamethyl-) (D4) CASRN 556-67-2* (U.S. EPA, 2022b). EPA also reviewed D4 risk assessments from Silicones Environmental health and Safety (SEHSC), European Chemicals Agency (ECHA), and Environment Canada risk assessments to provide awareness of previous hazard thresholds and approaches used within ecological risk assessments (Table_Apx A-2).

EPA reviewed the environmental hazard data in referenced studies using the data quality evaluation metrics and criteria described in the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (U.S. EPA, 2021). Studies were assigned an overall quality determination of high, medium, or uninformative. No studies received a low data quality determination. The high and medium quality studies were moved forward for further evaluation.

EPA assigned data quality ratings to aquatic toxicity studies that included 23 high and five medium quality determinations and six terrestrial toxicology studies that included four high and two medium quality determinations for exposure to D4. In addition, EPA assigned high data quality determinations to four aquatic toxicity studies and two terrestrial toxicology studies for exposure to DMSD. There were 16 aquatic studies and six terrestrial study that present relevant hazard data from exposure for D4 to fishes, aquatic and benthic invertebrates, algae, terrestrial mammals, and terrestrial invertebrates (Table 3-1, Table 3-3, Table 3-4, Table 3-6, Table 4-1 and Table 4-2). All other studies did not result in estimates of population-level effects (*e.g.*, mortality, development, growth) up to the highest concentration tested. None of the DMSD studies showed population-level effects. However, the DMSD studies are presented to show the relative toxicity of aquatic and terrestrial organisms exposed to DMSD compared to D4 exposure (Table 3-2, Table 3-5, Table 4-3, and Table 4-4). An ecological structure-activity relationship (ECOSAR) analysis was also used for comparison to empirical hazard endpoints.

3 Aquatic Species Hazard

EPA assigned an overall quality level of high or medium to 32 aquatic toxicity studies, for D4 and DMSD including three studies submitted as “substantial risk” notifications under section 8(e). These studies contained relevant aquatic toxicity data for rainbow trout (*Oncorhynchus mykiss*), sheepshead minnow (*Cyprinodon variegatus*), waterflea *(D. magna)*, midge (*Chironomus tentans* and *Chironomus riparius*), and blackworm (*Lumbriculus variegatus*) for exposure to D4, and rainbow trout, fathead minnow (*Pimphales promelas*), and waterflea for exposure to DMSD. EPA identified 20 aquatic toxicity studies as the most relevant for the risk assessment based on adverse population-level effects (*e.g.*, mortality, development, growth), including the four DMSD studies that did not have adverse effects, but were included to demonstrate the relative toxicity compared to D4 exposure.

3.1 Aquatic Vertebrates

Fish: EPA assigned an overall quality determination of high to six studies with relevant acute toxicity data from D4 exposure and two studies had chronic exposures data from D4 to rainbow trout (Table 3-1). In addition, EPA assigned an overall quality determination of high to two studies with relevant toxicity data of DMSD acute exposure to rainbow trout and chronic exposure to fathead minnow (Table 3-2).

Acute studies are designated for study exposure durations which are less than 10 percent of an organism's lifespan. Three acute fish studies for juvenile (Drottar, 2008; Springborn Laboratories, 1990a) and larvae (Sousa et al., 1995) rainbow trout included 14-day lethal concentration at which 50 percent of test organisms die (LC50), with a geometric mean of the early life stage LC50s = 11.9 µg/L. For the adult life stage rainbow trout study, Bayer AG (1991) found the no-observed-effect concentration (NOEC) = 34.2 µg/L, lowest-observable-effect concentration (LOEC) = 51.7 µg/L, and LC50 >51.7 µg/L. These data suggest that early life stages are more sensitive to D4 exposure than the adult life stage in rainbow trout. In agreement that earlier life stages are more sensitive to D4 exposure Dow Corning (1992) found fish weighing 1 g to have 80% mortality at 23.2 µg/L and fish weighing 5 g to have no mortalities at 31 µg/L in an 18-day rainbow trout study. A chronic toxicity test was performed for embryo (33- and 93-day exposures) and larvae (60- and 93-day exposures) rainbow trout (Sousa et al., 1995; Springborn Laboratories, 1991b) with no adverse effects reported for exposures to D4 at the highest concentration tested (NOEC > 4.4 µg/L) (Table 3-1).

For DMSD, the 96-hour acute study for rainbow trout had a NOEC > 126,000 µg/L for mortality and behavioral endpoints (Dow Corning, 2009a). The 32-day chronic study for fathead minnow had a NOEC > 12,000 µg/L for mortality, growth/development, and behavioral endpoints (Smithers, 2021a). Although there were no adverse effects from acute or chronic exposures to DMSD up to the highest experimental concentration tested, the data suggest that fish are less sensitive to DMSD exposure than D4 (Table 3-1 and Table 3-2).

Table 3-1. Aquatic Vertebrate Environmental Hazard Studies Used for D4

Duration	Test Organism (Species)	Endpoint	Hazard Values (µg/L)	Geometric Mean[a] (µg/L)	Effect	Citation (Data Evaluation Rating)	Data Evaluation Rating
Aquatic vertebrates							
Acute	Rainbow trout (*Oncorhynchus mykiss*)	14-day NOEC/LOEC	4.4/6.9	5.51	Mortality (juvenile)	(Springborn Laboratories, 1990a)	High
		14-day LC50	10 (8.5-13)[b]				
	Rainbow trout (*Oncorhynchus mykiss*)	14-day NOEC/LOEC	34.2/51.7	42.05	Mortality	(Bayer AG, 1991)	High
		14-day LC50	>51.7				
		14-day NOEC/LOEC	16.9/34.2	34.04	Behavior		
	Rainbow trout (*Oncorhynchus mykiss*)	18-day LC80	23.2		Mortality (1g fish)	(Dow Corning, 1992)	High
		18-day LC0	31		Mortality (5g fish)		
		14-day NOEC/LOEC	4.4/6.9	5.51	Mortality (larvae)	(Sousa et al., 1995)	High
		14-day LC50	10 (8.5-13)[b]				
	Sheepshead minnow (Cyprinodon variegatus)	14-day NOEC	>6.3		Mortality		
	Rainbow trout (*Oncorhynchus mykiss*)	14-day NOEC/LOEC	6.8/13	9.4	Mortality (juvenile)	(Drottar, 2008)	High
		14-day LC50	17 (14-21)[b]				

Duration	**Test Organism (Species)**	**Endpoint**	**Hazard Values (µg/L)**	**Geometric Mean[a] (µg/L)**	**Effect**	**Citation (Data Evaluation Rating)**	**Data Evaluation Rating**
		14-day NOEC	>29		Developmental/ growth (juvenile)		
	Rainbow trout (*Oncorhynchus mykiss*)	LC50 at day 5 and LC100 at day 9	33.2		Mortality at 12 C (juvenile 100 - 300 mg)	(Dow Corning, 1990b)	High
		LC100 at day 5	19.1		Mortality at 17 C (juvenile 100 - 300 mg)		
Chronic	Rainbow trout (*Oncorhynchus mykiss*)	33-day NOEC	>4.4		Mortality (embryo)	(Springborn Laboratories, 1991b)	High
		33-day NOEC	>4.4		Reproduction (embryo)		
		60-day NOEC	>4.4		Mortality (larvae)		
		60-day NOEC	>4.4		Growth/ development (larvae)		
	Rainbow trout (*Oncorhynchus mykiss*)	93-day NOEC	>4.4		Mortality (embryo)	(Sousa et al., 1995)	High
		93-day NOEC	>4.4		Growth/ development (larvae)		

[a] Geometric mean of definitive values only.
[b] 95% confidence interval

Table 3-2. Aquatic Vertebrate Environmental Hazard Studies Used for DMSD

Duration	Test Organism (Species)	Endpoint	Hazard Values (µg/L)	Geometric Mean[a] (µg/L)	Effect	Citation	Data Evaluation Rating
Aquatic vertebrates							
Acute	Rainbow trout (*Oncorhynchus mykiss*)	96-hour NOEC	>126,000		Mortality	(Dow Corning, 2009a)	High
		96-hour NOEC	>126,000		Behavior		
Chronic	Fathead minnow (*Pimphales promelas*)	32-day NOEC	>12,000		Mortality (embryo/larvae)	(Smithers, 2021a)	High
		32-day NOEC	>12,000		Growth/ Development (embryo/larvae)		
		32-day NOEC	>12,000		Behavior (embryo/larvae)		

[a] Geometric mean of definitive values only.

3.2 Aquatic Invertebrates

EPA assigned an overall quality determination of medium or high to three studies with relevant mortality, development, or reproductive toxicity effects from D4 exposure (Table 3-3). The studies included a single study representing acute exposures and two studies representing chronic exposure of D4 to aquatic invertebrates. For benthic aquatic invertebrates, EPA assigned an overall quality determination of high to six studies with relevant mortality, development, growth, or reproductive toxicity effects from D4 exposure (Table 3-4). These studies include two studies representing acute exposures and four studies representing chronic exposure of D4. EPA assigned an overall quality determination of high to two studies with relevant mortality, growth, or reproductive toxicity data from DMSD exposure (Table 3-5). The studies included a single study representing acute exposures and a single study representing chronic exposure of DMSD to aquatic invertebrates. There were no reasonably available toxicity studies of DMSD exposure to benthic aquatic invertebrates.

For aquatic invertebrates living in the water column, the acute and chronic toxicity data were for *D. magna*, a freshwater invertebrate. For acute toxicity, 72-hour exposure to D4 for mortality show the LC10 = 1,850 µg/L; LC50 = 23,440 µg/L; and LC90 = 297,740 µg/L (Dow Chemical, 1982). The 21-day exposure toxicity data were the same for both chronic studies with a NOEC = 7.9 µg/L, LOEC = 15 µg/L, and a chronic health value (ChV) = 11 µg/L (Springborn Smithers Laboratories, 2018; Sousa et al., 1995). The acute study by Dow Chemical (1982) was of medium quality and the endpoint concentrations were well above the limit of solubility (56 µg/L). The study did not report the use of solvents to increase solubility and was lacking detail on the environmental test conditions. Because of the unexpected high toxicity value in the acute daphnia study, EPA's Ecological Structure Activity Relationships (ECOSAR) model was used to help validate the empirical data. ECOSAR predictions for daphnid had a 48-hour LC50 of 11 µg/L which were consistent with chronic *D. magna* data as well other empirical toxicity data for aquatic and terrestrial organisms except for the acute *D. magna* data which had a 72-hour LC50 of 23,440 µg/L (U.S. EPA, 2022a). Because of these inconsistencies with endpoint toxicity and test concentrations that are not expected to occur in the environment, EPA has reduced confidence in the acute daphnia data from Dow Chemical (1982) and it will not be further evaluated. Therefore, acute hazard thresholds for determining aquatic COCs will be based on toxicity studies for aquatic fish and benthic invertebrates.

For acute exposures (less than 10 percent of the organism's lifespan) of D4 to benthic invertebrates, there were two relevant 28-day acute exposure toxicity studies for blackworm. Krueger et al. (2009) results show a LOEC = 0.73 mg/kg, and an effect concentration at which 50 percent of test organisms exhibit an effect (EC50) = 9.32 mg/kg for survival/reproduction. The author reports that because it was not possible to differentiate between adult and young worms, and worms can reproduce within the study duration, survival and reproduction were considered a single endpoint (Krueger et al., 2009). Whereas in Springborn Smithers Laboratories (2009), the authors artificially segmented the worms 14 days prior to test initiation to synchronize worm life stage. The segmented worms were then acclimated to the test conditions for 13 days as new heads were regenerated. By synchronizing the life stage of worms, regeneration and reproduction were controlled to limit variation in test results. The results show a NOEC = 13 mg/kg and LOEC = 19 mg/kg for the reproduction endpoint and a NOEC > 32 mg/kg for the growth endpoint in the definitive study.

For chronic exposures of D4 to benthic invertebrates, three relevant 14-day exposure toxicity studies with midge (*C. tentans*) larvae (Kent et al., 1994; Springborn Laboratories, 1991a, c), and one 28-day exposure toxicity study with midge (*C. riparius*) larvae (Wildlife International Ltd, 2008) were evaluated for the hazard assessment. Chronic 14-day mortality and growth effects from midge larvae exposure to D4 are shown in Table 3-4. There were no adverse effects to midges at the maximum tested concentration in the benthic pore water (Kent et al., 1994; Springborn Laboratories, 1991a). Midge larvae were also tested for 14-day mortality and growth effects under low and high organic carbon conditions in the sediment. For low organic carbon sediment, the most sensitive endpoint was growth (NOEC = 65 mg/kg; LOEC = 130 mg/kg; ChV = 92 mg/kg). For high organic carbon sediment, mortality and growth endpoints in Kent et al. (1994) both had a NOEC = 54 mg/kg; LOEC = 170 mg/kg; and a ChV = 95.8 mg/kg, whereas Springborn Laboratories (1991c) had a NOEC = 54 mg/kg; LOEC = 170 mg/kg; and a ChV = 95.8 mg/kg for mortality, but not growth. In Springborn Laboratories (1991a), there were significant mortalities under high organic carbon conditions for all concentrations (LOEC = 16 mg/kg; LC50 = 130 mg/kg) (Springborn Laboratories, 1991a). As a result, a dose response was not observed. For chronic 28-day exposure to D4, midge (*C. riparius*) were evaluated for mortality, development, and emergence. Mortality and emergence were the most sensitive endpoints with a NOEC = 44 mg/kg; LOEC = 131 mg/kg; and a ChV = 73.3 mg/kg (Wildlife International Ltd, 2008).

For DMSD exposures to aquatic invertebrates living in the water column, the acute and chronic toxicity data were for *D. magna*. For acute toxicity, a 48-hour exposure of DMSD for mortality show the NOEC > 117,000 µg/L (Dow Corning, 2009b). The 21-day chronic toxicity data show a NOEC > 12,000 µg/L (Dow Chemical, 2017). Although there were no adverse effects from acute or chronic exposures to DMSD up to the highest experimental concentration tested, as with fish, the data suggests that invertebrates are less sensitive to DMSD exposure than D4.

Table 3-3. Aquatic Invertebrate Hazard Studies Used for D4

Duration	Test Organism (Species)	Endpoint	Hazard Values (µg/L)	Geometric Mean[a] (µg/L)	Effect	Citation	Data Evaluation Rating
Aquatic Invertebrates							
Acute	Water flea (*D. magna*)	72- hour LC10	1,850 (650-3,680)[b]		Mortality	(Dow Chemical, 1982)	Medium
		72- hour LC50	23,440 (14,530-35,730)[b]				
		72- hour LC90	297,740 (171,630-657,200)[b]				
Chronic	Water flea (*D. magna*)	21-day NOEC/LOEC	7.9/15	11	Mortality	(Springborn Smithers Laboratories, 2018)	High
		21-day NOEC	>15		Developmental		
	Water flea (*D. magna*)	21-day NOEC/LOEC	7.9/15	11	Mortality (juvenile)	(Sousa et al., 1995)	High
		21-day EC50	>15				
		21-day NOEC/LOEC	7.9/15	11	Reproduction (juvenile)		

[a] Geometric mean of definitive values only.
[b] 95% confidence interval

Table 3-4. Aquatic Benthic Invertebrate Hazard Studies Used for D4

Duration	Test Organism (Species)	Endpoint	Hazard Values (mg/kg)	Geometric Mean[a] (mg/kg)	Effect	Citation	Data Evaluation Rating
Aquatic Invertebrates (Benthic)							
Acute	Blackworm (*Lumbriculus variegatus*)	28-day LOEC	0.73		Survival/ reproduction (adult)	(Krueger et al., 2009)	High
		28-day EC50	9.32 (4.38-25.4)[b]				
	Blackworm (*Lumbriculus variegatus*)	28-day NOEC	32		Growth/biomass (adult)	(Springborn Smithers Laboratories, 2009)	High
		28-day NOEC/LOEC	13/19	15.7	Reproduction (adult)		
Chronic	Midge (*Chironomus tentans*)	14-day NOEC (Aqueous)	>15 µg/L		Mortality (larvae)	(Kent et al., 1994)	High
		14-day NOEC (Aqueous)	>15 µg/L		Growth (larvae)		
		14-day NOEC (low organic carbon sediment)	>130		Mortality (larvae)		
		14-day NOEC/LOEC (low organic carbon sediment)	65/130	92	Growth (larvae)	(Kent et al., 1994)	High
		14-day NOEC/LOEC (high organic carbon sediment)	54/170	95.8	Mortality (larvae)	(Kent et al., 1994)	High
		14-day LC50 (high organic carbon sediment)	>170				
		14-day NOEC/LOEC (high organic carbon sediment)	54/170	95.8	Growth (larvae)		
	Midge (*Chironomus tentans*)	14-day NOEC (Aqueous)	>15 µg/L		Mortality (larvae)		High

Duration	Test Organism (Species)	Endpoint	Hazard Values (mg/kg)	Geometric Mean[a] (mg/kg)	Effect	Citation	Data Evaluation Rating
		14-day NOEC (Aqueous)	>15 µg/L		Growth (larvae)	(Springborn Laboratories, 1991a)	
		14-day LC50 (low organic carbon sediment)	130		Mortality (larvae)		
		14-day NOEC/LOEC (low organic carbon sediment)	65/130	92	Growth (larvae)		
		14-day LOEC (high organic carbon sediment)	16		Mortality (larvae)		
	Midge (*Chironomus tentans*)	14-day NOEC/LOEC (high organic carbon sediment)	54/170	95.8	Mortality (larvae)	(Springborn Laboratories, 1991c)	High
		14-day LC50 (high organic carbon sediment)	>170		Mortality (larvae)		
		14-day NOEC (high organic carbon sediment)	>54		Growth (larvae)		
	Midge (*Chironomus riparius*)	28-day NOEC/LOEC	44/131	73.3	Mortality (larvae)	(Wildlife International Ltd, 2008)	High
		28-day LC50	114 (96-136)[b]		Mortality (larvae)		
		28-day NOEC/LOEC	131/355	215.7	Developmental (larvae)		
		28-day NOEC/LOEC	44/131	73.3	Emergence (larvae)		

[a] Geometric mean of definitive values only.
[b] 95% confidence interval

335 **Table 3-5. Aquatic Invertebrate Hazard Studies Used for DMSD**

Duration	Test Organism (Species)	Endpoint	Hazard Values (µg/L)	Geometric Mean[a] (µg/L)	Effect	Citation	Data Evaluation Rating
Aquatic Invertebrates							
Acute	Water flea (*D. magna*)	48-hour NOEC	>117,000		Mortality (juvenile)	(Dow Corning, 2009b)	High
		48-hour NOEC	>117,000		Immobilization (juvenile)		
		48-hour NOEC	>117,000		Behavioral (Juvenile)		
Chronic	Water flea (*D. magna*)	21-day NOEC	>12,000		Mortality (juvenile)	(Dow Chemical, 2017)	High
		21-day NOEC	>12,000		Growth (juvenile)		
		21-day NOEC	>12,000		Reproduction (juvenile)		

[a] Geometric mean of definitive values only.
[b] 95% confidence interval

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3.3 Aquatic Plants

EPA assigned an overall quality determination of high to a single study with relevant toxicity data of D4 exposure to fresh water green algae (*Selenastrum capricornutum*). Springborn Laboratories (1990c) show a 96-hour LOEC = 3.29 µg/L for the growth endpoint from a single concentration (Table 3-6). For this study a closed system was used because exposure concentrations of D4 could not be maintained in an open system. The closed system was expected to have reduced growth rates due to lack of gas exchange. Growth of algae based on cell density at 96 hours exposure was significantly (Student's t-test) less than the control group. However, the LOEC concentration was below the EC50 and the authors did not consider this level of reduction in cell density to be representative of an adverse effect. Because durations normally considered acute for other species (*e.g.*, up to 96 hours) can encompass several generations of algae, algae are assessed separately and not incorporated into acute or chronic COCs.

Table 3-6. Aquatic Plant Environmental Hazard Studies Used for D4

Test Organism (Species)	Endpoint	Hazard Values (µg/L)	Effect	Citation	Data Evaluation Rating
Aquatic plants					
Freshwater green algae, (*Selenastrum capricornutum*)	96-hour LOEC	3.29	Growth	(Springborn Laboratories, 1990c)	High

4 Terrestrial Species Hazard

EPA assigned an overall quality level of medium and high to nine terrestrial toxicity studies. No studies received a low data quality determination. There were no studies submitted as "substantial risk" notifications under section 8(e). The rat (*Rattus norvegicus*), rabbit (*Oryctolagus cuniculus*), and earthworm (*Eisenia fetida*) studies contained relevant toxicity data for exposure to D4, and DMSD. The cabbage (*Brassica oleracea*), corn (*Zea mays*), cucumber (*Cucumis sativus*), oat (*Avena sativa*), onion (*Allium cepa*), perennial rye grass (*Lolium perenne*), radish (*Raphanus sativus*), soybean (*Glycine max*), sunflower (*Helianthus annuus*), and tomato (*Lycopersicon esculentum*) study contained relevant toxicity data for exposure to DMSD.

4.1 Terrestrial Vertebrates

No terrestrial vertebrate studies in bird or mammalian wildlife species were available to assess potential hazards from D4 or DMSD exposure. Therefore, EPA considered ecologically relevant hazard data from studies conducted on mammals routinely used to inform human health hazard (*e.g.*, rats, mice, rabbits, etc.). These data were used to derive a hazard threshold for terrestrial mammals, called a TRV (see, Table 4-1, Figure 4-1, and Section 6). EPA calculated a TRV of 95 mg/kg-bw/day using methods published in EPA's Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs) (U.S. EPA, 2003). Eco-SSL defines a TRV as a dose above which ecologically relevant effects might occur to wildlife species following chronic dietary exposure and below which it is reasonably expected that such effects will not occur.

Mammals

Six studies contained ecologically relevant hazard data for mammalian exposure to D4 and were used to derive a mammalian TRV for D4 (Table 4 1). These studies reported reproductive, growth, and behavioral effects in rats and rabbits from exposure to D4 via the oral exposure route by gavage (Table 4-1). Two studies found significant reproductive effects in mammals exposed to D4 (Falany and Li, 2005; IRDC, 1993). IRDC (1993) reported decreased maternal body weight in a 13-day study at no-observed-adverse-effect level (NOAEL) = 51.3 mg/kg-bw/day and lowest-observable-adverse-effect level (LOAEL) = 101.4 mg/kg-bw/day, and increased frequency of spontaneous abortions at NOAEL = 101.4 mg/kg-bw/day and LOAEL = 489 mg/kg-bw/day for New Zealand white rabbits. Measured doses (mg/kg-bw/day) are based on average measured concentrations (mg/L) in dosage mixtures multiplied by dosing volume (3 mL/kg). In Falany and Li (2005), D4 was administered to pregnant Sprague-Dawley rats in a 4-day study to test if D4 could diffuse to and affect fetal liver. Liver microsomal cytochrome P450 expression was observed in both the dam and fetus liver. Fetal body weights decreased at NOAEL = 20 mg/kg-bw/day and LOAEL = 100 mg/kg-bw/day group for Sprague-Dawley rats. Body weights and ingestion rates were not reported for the dams.

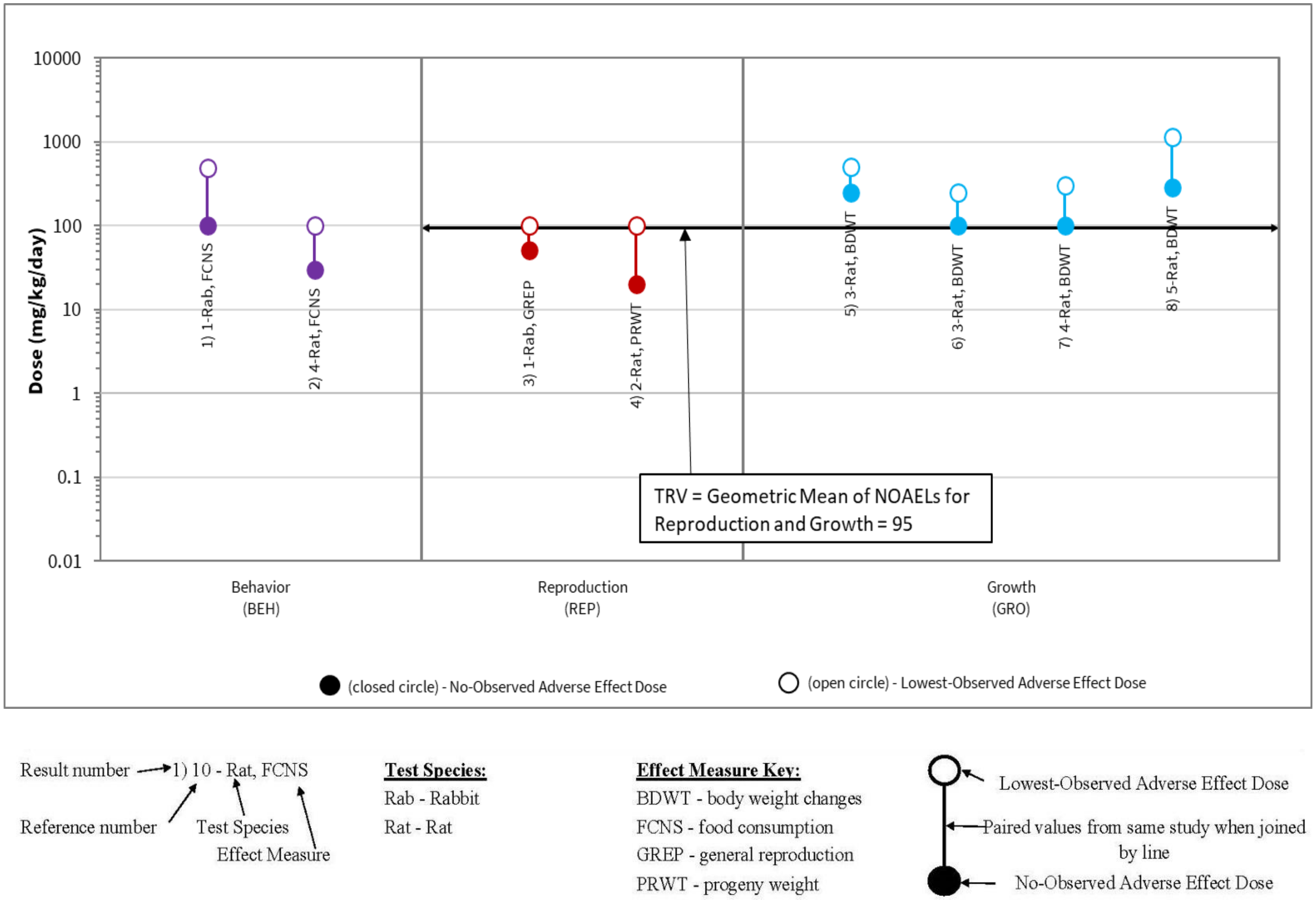
Four studies observed significant changes in growth in mammals exposed to D4 (Mckim et al., 2001; MPI Research, 1999; Virginia Commonwealth University, 1997; Dow Corning, 1990a). Virginia Commonwealth University (1997) observed decreased body weight in a 28-day study at NOAEL = 100 mg/kg-bw/day and LOAEL = 300 mg/kg-bw/day for Fischer 344 rats. MPI Research (1999) and Mckim et al. (2001) in a 7-day study reported decreased body weight gain at NOAEL = 100 mg/kg-bw/day and LOAEL = 250 mg/kg-bw/day in Fischer 344 rats, and at NOAEL = 250 mg/kg-bw/day and LOAEL = 500 mg/kg-bw/day in Sprague-Dawley rats. Dow Corning (1990a) in a 14-day study reported decreased body weight in male and female at NOAEL = 400 mg/kg-bw/day and LOAEL = 1600 mg/kg-bw/day groups of Sprague-Dawley rats.

Two studies found significant changes in behavior in mammals exposed to D4 (Virginia Commonwealth University, 1997; IRDC, 1993). IRDC (1993) observed decreased food consumption in a 13-day study at NOAEL = 101.4 mg/kg-bw/day and LOAEL = 489 mg/kg-bw/day groups for New Zealand white rabbits during the exposure period. The NOAEL and LOAEL for food consumption correlates with the observed increased frequency of spontaneous abortions. The dose was by gavage and not added directly to the feed. Again, measured doses (mg/kg-bw/d) are based on average measured concentrations (mg/L) in dosage mixtures multiplied by dosing volume (3 mL/kg). Virginia Commonwealth University (1997) in a 28-day study reported decreased food consumption rate at NOAEL = 30 mg/kg-bw/day and LOAEL = 100 mg/kg-bw/day groups for Fischer 344 rats. The decrease in food consumption correlates with the observed decreased body weight.

Figure 4-1 outlines how these data were used to derive the TRV of 95 mg/kg-bw/day using ECO-SSL methods. The TRV derivation process follows four steps. First, EPA determined that there was enough data to derive a TRV as there were at least three results available for two test species for growth, reproduction, or survival. Because there were two reproductive effects from the same study, only the most sensitive effect measure was used for calculating the TRV (IRDC, 1993). Second, there were at least three NOAELs available for growth or reproduction to calculate a geometric mean. Third, the geometric mean of the NOAEL values for growth and reproduction (95 mg/kg-bw/day) was lower than the lowest bounded LOAEL of 100 mg/kg-bw/day for reproduction, growth, or survival. Fourth, when the mechanism of toxicity is addressed by the effects measure in growth and reproductive effects, the TRV is equal to the geometric mean of the NOAEL values for growth and reproductive effects. Because the mechanism of toxicity reported by Falany and Li (2005) show D4 exposure resulted in liver microsomal cytochrome P450 expression in both the dam and fetus liver, and the effects on fetal body weights was addressed by the effect measures in growth and reproductive effects, the TRV was the geometric mean of the NOAELs for growth and reproductive effects.

Table 4-1. Terrestrial Mammal Hazard Studies for D4 Used for TRV Derivation

Test Organism	Endpoint	Hazard Value (mg/kg-bw/day)	Effect	Citation	Data Evaluation Rating
New Zealand white rabbit (*Oryctolagus cuniculus*)	13-day NOAEL/LOAEL	51.3/101.4	Reproduction (gestation body weight)	(IRDC, 1993)	High
		101.4/489	Reproduction (spontaneous abortion)		
Sprague-Dawley rat (*Rattus norvegicus*)	4-day NOAEL/LOAEL	20/100	Reproduction (fetal weight)	(Falany and Li, 2005)	Medium
Fischer 344 rat (*Rattus norvegicus*)	28-day NOAEL/LOAEL	100/300	Growth (body weight)	(Virginia Commonwealth University, 1997)	High
Sprague-Dawley rat (*Rattus norvegicus*)	7-day NOAEL/LOAEL	250/500	Growth (body weight)	(MPI Research, 1999)	High
Fischer 344 rat (*Rattus norvegicus*)	7-day NOAEL/LOAEL	100/250	Growth (body weight)	(Mckim et al., 2001)	High
Sprague-Dawley rat (*Rattus norvegicus*)	14-day NOAEL/LOAEL	400/1,600	Growth (body weight)	(Dow Corning, 1990a)	Medium
New Zealand white rabbit (*Oryctolagus cuniculus*)	13-day NOAEL/LOAEL	101.4/489	Behavior (food consumption)	(IRDC, 1993)	High
Fischer 344 rat (*Rattus norvegicus*)	28-day NOAEL/LOAEL	30/100	Behavior (food consumption)	(Virginia Commonwealth University, 1997)	High



Wildlife TRV Derivation Process

1) There are at least three results available for two test species within the growth, reproduction, and survival effect groups. There are enough data to derive a TRV.

2) There are at least three NOAEL results available in the growth and reproduction effect groups for calculation of a geometric mean.

3) The geometric mean of the NOAEL values for growth and reproductive effects equals 95 mg Octamethylcyclotetrasiloxane/kg BW/day, which is lower than the lowest bounded LOAEL of 100 mg Octamethylcyclotetrasiloxane/kg BW/day for reproduction, growth or survival.

4) As the mechanism of toxicity is addressed by the effect measures in the growth and reproductive effect groups, the TRV is equal to the geometric mean of the NOAEL values for growth and reproductive effects.

Figure 4-1. Terrestrial Mammal Hazard TRV Derivation for D4 from Studies Presented in Table 4-1

4.2 Terrestrial Invertebrates

For terrestrial invertebrates, EPA assigned an overall quality determination of high to a single study with relevant acute toxicity data for D4 and DMSD exposure to earthworms (Table 4-2, and Table 4-3). For exposure to D4, toxicity for 28-day exposure had no adverse effects at the highest concentration of 130 mg/kg for the mortality and growth endpoints. For the 56-day exposure to D4 the NOEC = 75 mg/kg, and the LOEC = 130 kg/mg for the reproductive endpoint (Smithers, 2022b). For exposure to DMSD, toxicity data for earthworms had no adverse effects up to the highest concentration tested (NOEC > 3.8 mg/kg) at 28-days for mortality and growth endpoints. There were also no adverse effects at the highest concentration tested for the 56-day exposure to DMSD with a NOEC > 3.8 mg/kg (Smithers, 2022a).

4.3 Terrestrial Plants

No terrestrial plant studies were reasonably available to assess potential hazards from D4 exposure. For DMSD, there were no adverse effects at the highest soil concentration tested (NOEC > 4.3 mg/kg) for cabbage, corn, cucumber, oat, onion, perennial rye grass, radish, soybean, sunflower; and tomato (Smithers, 2021b). The highest nominal soil concentration of DMSD tested (5.0 mg/kg) was reported as being chosen as the most conservative concentration that could be available in the environment (Smithers, 2021b).

Table 4-2. Terrestrial Invertebrate Environmental Hazard Studies Used for D4

Test Organism (Species)	Endpoint	Hazard Values (mg/kg)	Geometric Mean[a] (mg/kg)	Effect	Citation	Data Evaluation Rating
Terrestrial invertebrates						
Earth worm (Eisenia fetida)	28-day NOEC	>130		Mortality (adult)	(Smithers, 2022b)	High
	28-day NOEC	>130		Growth (adult)		
	56-day NOEC/LOEC	75/130	98.7	Reproduction (F0 adult, F1 Juvenile)		
	56-day EC50	>130				

[a] Geometric mean of definitive values only.

Table 4-3. Terrestrial Invertebrate Environmental Hazard Studies Used for DMSD

Test Organism (Species)	Endpoint	Hazard Values (mg/kg)	Geometric Mean[a] (mg/kg)	Effect	Citation	Data Evaluation Rating
Terrestrial invertebrates						
Earth worm (Eisenia fetida)	28-day NOEC	>3.8		Mortality (adult)	(Smithers, 2022a)	High
	28-day NOEC	>3.8		Growth (adult)		
	56-day NOEC	>3.8		Reproduction (F0 adult, F1 Juvenile)		

[a] Geometric mean of definitive values only.

Table 4-4. Terrestrial plant Environmental Hazard Studies Used for DMSD

Duration	Test Organism (Species)	Endpoint	Hazard Values (mg/kg)	Geometric Mean[a] (mg/kg)	Effect	Citation	Data Evaluation Rating
Terrestrial invertebrates							
Acute	cabbage (*Brassica oleracea*); corn (*Zea mays*); cucumber (*Cucumis sativus*); oat (*Avena sativa*); onion (*Allium cepa*); perennial rye grass (*Lolium perenne*); radish (*Raphanus sativus*); soybean (*Glycine max*); sunflower (*Helianthus annuus*); tomato (*Lycopersicon esculentum*)	14-day NOEC	>4.3		Mortality	(Smithers, 2021b)	High
		14-day NOEC	>4.3		Developmental/ growth		

[a] Geometric mean of definitive values only.

5 Weight of the Scientific Evidence Conclusions for Environmental Hazard

EPA uses several considerations when weighing and weighting the scientific evidence to determine confidence in the environmental hazard data. These considerations include the quality of the database, consistency, strength and precision, biological gradient/dose response, and relevance (see Appendix A) and are consistent with the 2021 *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (U.S. EPA, 2021) and *Draft Systematic Review Protocol for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025). Table 5-1 summarizes how these considerations were determined for each environmental hazard threshold for exposure to D4 (see Section 6). For the overall confidence in the hazard thresholds, EPA considers the evidence for acute aquatic vertebrate, chronic aquatic invertebrate, acute and chronic benthic invertebrate, and terrestrial mammal hazard thresholds robust; the evidence for chronic aquatic vertebrate and terrestrial invertebrate hazard thresholds is moderate; and the evidence for acute aquatic invertebrate and aquatic plant hazard thresholds is slight. Because there were no reported adverse effects for aquatic and terrestrial organisms from exposure to DMSD a hazard threshold could not be established and exposure to DMSD will not be further evaluated. A more detailed explanation of the weight of the scientific evidence, uncertainties, and overall confidence levels is presented in Appendix A.

5.1 Strengths, Limitations, Assumptions, and Key Sources of Uncertainty for Environmental Hazard

Quality of the Database

All the studies used to calculate COCs (aquatic fish and invertebrates), TRVs (terrestrial mammals), and hazard thresholds (terrestrial invertebrates) were based on ecologically relevant species and received a high or medium overall quality determination from the systematic review data quality evaluation. For terrestrial mammal species, no wildlife toxicity studies were reasonably available via the systematic review process; however, four high- and two medium-quality level human health animal model D4 toxicity studies with two terrestrial species (rabbits and rats) represented were available. A TRV derived from the mammal studies was used to calculate the hazard threshold in mg/kg-bw/day. The confidence in quality of the database for aquatic acute and chronic fish, chronic aquatic invertebrates, acute and chronic benthic invertebrates, algae, TRVs (terrestrial mammals), and hazard thresholds (terrestrial invertebrates) is robust. For acute aquatic invertebrates the confidence in quality of the database is slight because test concentrations were above the limit of solubility and no additional information was reported on the use of solvents to increase solubility of D4.

Consistency

For aquatic fish species, two of the three acute rainbow trout early life stage studies had the same LC50 values (Sousa et al., 1995; Springborn Laboratories, 1990a). While the third study by Drottar (2008) had a very similar LC50 value, demonstrating consistent toxicity sensitivity. The single acute invertebrate study is insufficient to characterize consistency in its outcome (Dow Corning, 2009a). Additionally, the hazard values from this study do not agree with ECOSAR prediction or other aquatic organism data presented in Section 3. The confidence in consistency for acute aquatic invertebrate is slight. The two 28-day toxicity studies for D4 exposure to blackworms had similar reproductive hazard values (Krueger et al., 2009; Springborn Smithers Laboratories, 2009). Krueger et al. (2009) presented EC50 data that was used for the acute benthic COC. The confidence in consistency for the acute aquatic fish, and acute benthic invertebrate is robust.

For chronic fish species, two rainbow trout studies show the same NOEC results which were the highest concentration tested (Sousa et al., 1995; Springborn Laboratories, 1991b). Because the test concentrations were below the LOEC, the confidence in consistency for the chronic aquatic vertebrates is moderate. For the chronic aquatic COC, both of the 28-day juvenile daphnia studies reported the same toxicity values (Springborn Smithers Laboratories, 2018; Sousa et al., 1995). For chronic benthic, *C. tentans* studies (Kent et al., 1994; Springborn Laboratories, 1991c) and *C. riparius* study (Wildlife International Ltd, 2008), had NOEC/LOEC mortality toxicity values in close agreement. The confidence in consistency for the chronic aquatic and benthic invertebrates is robust.

Terrestrial mammal study results are in agreement with respect to exposure to D4 resulting in significant reduction in body weight or reduced weight gain for adult and fetus rats and rabbits with LOAEL ranging from 250 to 1,600 mg/kg-bw/day (Mckim et al., 2001; MPI Research, 1999; Virginia Commonwealth University, 1997; Dow Corning, 1990a). The confidence in consistency for the terrestrial mammal species is robust.

The single dose green algae study is insufficient to characterize consistency in its outcome (Springborn Laboratories, 1990c). The confidence in consistency for green algae is slight. Because the single earthworm study (Smithers, 2022b) and the benthic blackworm studies (Krueger et al., 2009; Springborn Smithers Laboratories, 2009) had similar toxicity effects across the family Lumbricidae, confidence for earthworm consistency is moderate.

Strength (Effect Magnitude) and Precision

Magnitude of effect (LC50 and EC50) are shown for acute aquatic vertebrates, invertebrates, and benthic invertebrates (Table 3-1 and Table 3-4). Confidence for acute aquatic vertebrates, invertebrates, and benthic invertebrates is robust.

Magnitude of effect (LC50) are shown for chronic benthic invertebrates (Table 3-4). Confidence for chronic benthic invertebrates is robust. For chronic aquatic COC, the 21-day daphnia studies had NOEC / LOEC data and tested below the EC50 threshold (Table 3-3). Similarly, for terrestrial invertebrates, the 56-day earthworm study also had NOEC / LOEC data and tested below the EC50 threshold. Therefore, the effect magnitude was greater than or equal to the LOEC and less than the EC50. Confidence for chronic aquatic invertebrates and terrestrial invertebrates is moderate. Effect magnitude was not reported for chronic aquatic vertebrate that had NOEC values at the highest concentration tested or green algae that was tested under a single concentration to derive the LOEC value (Table 3-6). Confidence for chronic aquatic vertebrate and green algae is slight.

For terrestrial mammals, NOAELs and LOAELs were shown for all studies. Only the rabbit study showed greater than 50 percent effects with 5 of 6 fetal abortions occurring at the LOAEL dose. Confidence for terrestrial mammals is moderate.

Biological Gradient/Dose-Response

A dose response was reported for all studies with the exception of chronic aquatic vertebrates and green algae which used a single dose. Confidence based on dose response is slight for aquatic vertebrates and green algae. Confidence for all other aquatic and terrestrial taxa is robust.

Biological Relevance

Across taxa (fish, invertebrate, and algae) and endpoints (mortality and growth), hazard threshold values for aquatic organisms exposed to D4 via surface water are in close agreement with hazard threshold values ranging from 3.29 µg/L to 11.9 µg/L (Table 6-1). Whereas there is reduced confidence in the daphnia study for acute aquatic invertebrates with an LC50 of 23,440 µg/L (Table 3-3). The acute daphnia LC50 was well above the limit of solubility (56 µg/L) and three orders of magnitude greater than both the ECOSAR predictions for acute LC50 and the empirical 21-day CHV for daphnia at 11 µg/L. There is also some uncertainty with chronic vertebrate that had no effects at the highest concentration tested. For exposure to D4 via sediment for benthic invertebrates (blackworm and midge spp.), acute and chronic toxicity threshold vary by less than an order of magnitude (Table 6-1). The chronic benthic hazard value is also in good agreement with terrestrial soil invertebrate. Confidence for biological relevance for acute aquatic invertebrates is slight, for chronic aquatic vertebrates is moderate, and all other aquatic taxa groups robust.

For terrestrial mammals, all rat studies, including two strains, and a rabbit study exhibited weight loss or decreased weight gain from D4 exposure. For the rabbit study that showed weight loss during gestation, doses above the LOAEL for weight loss resulted in spontaneous abortions (IRDC, 1993). Confidence for biological relevance for terrestrial mammals is robust.

Physical/Chemical Relevance

Empirical data were on mortality, development, growth, or reproductive toxicity effects from D4 exposure the effects of the chemical of interest, which increases confidence. D4 was identified, including source and purity for all organisms except for purity in one Sprague-Dawley rat study (Falany and Li, 2005), and the acute daphnia study that only included the name of the chemical of interest (Dow Corning, 2009b). Confidence for physical/chemical relevance for acute aquatic invertebrate is slight. Confidence for physical/chemical relevance for all other taxa groups is robust.

Environmental Relevance

Test conditions for aquatic fish, chronic invertebrates, benthic invertebrates, and terrestrial invertebrates corresponded well with natural environmental conditions. The environmental conditions for acclimation and test periods were well described for these organisms. Additionally, the substrate for earthworms was comprised of a natural sandy loam soil amended with cow manure for toxicity testing. For algae, there were minor testing discrepancies where algae were subjected to constant illumination and decreases in D4 concentration throughout the study that the authors attributed to volatilization. A closed system was used to limit volitation of D4 and was expected have reduced growth rates due to lack of gas exchange. Furthermore, the authors reported that the LOEC of less than the EC50 did not represent an adverse effect (Springborn Laboratories, 1990c). There may be additional uncertainties associated with laboratory to field variation for exposures to D4 that may have some effect on hazard threshold; that is, gavage vs. natural forage diet for mammals (rats and rabbits). The single study for acute aquatic invertebrates was above the limit of solubility, lacking in detail for test conditions, and no acclimation period was reported. Confidence for environmental relevance is moderate for aquatic fish, chronic invertebrates, benthic invertebrates, terrestrial invertebrates, and terrestrial mammals. Confidence for environmental relevance is slight for acute aquatic invertebrates and algae.

Table 5-1 summarizes the confidence ratings for each consideration used to derive the overall confidence by evidence type (taxa group) for aquatic, benthic, and terrestrial organisms. The bolded rows are the evidence type used for COC or hazard threshold to calculate risks.

Table 5-1. D4 Evidence Table Summarizing the Overall Confidence Derived from Hazard Thresholds.

Types of Evidence	Quality of the Database	Consistency	Strength and Precision	Biological Gradient/ Dose-Response	Relevance[a]	Hazard Confidence[b]
Aquatic						
Acute aquatic vertebrate assessment	+++	+++	+++	+++	+++	**Robust**
Acute aquatic invertebrate assessment	+	+	+++	+++	+	Slight
Chronic aquatic vertebrate assessment	+++	++	+	+	+++	Moderate
Chronic aquatic invertebrate assessment	+++	+++	++	+++	+++	**Robust**
Acute benthic assessment	+++	+++	+++	+++	+++	**Robust**
Chronic benthic assessment	+++	+++	+++	+++	+++	**Robust**
Aquatic plant (algae)	+++	+	+	+	+	**Slight**
Terrestrial						
Avian assessment	NA	NA	NA	NA	NA	Indeterminate
Mammalian assessment	+++	+++	++	+++	+++	**Robust**
Terrestrial invertebrates	+++	++	++	++	+++	**Moderate**

[a] Relevance includes biological, physical/chemical, and environmental relevance.
[b] Bolded font indicates used for COC or hazard threshold.
+++ Robust confidence suggests thorough understanding of the scientific evidence and uncertainties. The supporting weight of the scientific evidence outweighs the uncertainties to the point where it is unlikely that the uncertainties could have a significant effect on the hazard estimate.
++ Moderate confidence suggests some understanding of the scientific evidence and uncertainties. The supporting scientific evidence weighed against the uncertainties is reasonably adequate to characterize hazard estimates.
+ Slight confidence is assigned when the weight of the scientific evidence may not be adequate to characterize the scenario, and when the assessor is making the best scientific assessment possible in the absence of complete information. There are additional uncertainties that may need to be considered.
NA Indeterminate corresponds to entries in evidence tables where information is not available within a specific evidence consideration.

6 Environmental Hazard Thresholds

EPA calculates hazard thresholds to identify potential concerns to aquatic and terrestrial species. For aquatic species, the hazard threshold is called a COC, and for terrestrial species, the hazard threshold may be called a TRV in the case of terrestrial mammals and birds. These terms (COC, hazard value, and TRV) can encompass multiple taxa or ecologically relevant groups of taxa as the environmental risk characterization serves populations of organisms within a wide diversity of environments. After weighing the scientific evidence, EPA selects the appropriate hazard value from the integrated data to use for hazard thresholds. See Section 5 for more details about how EPA weighed the scientific evidence.

For aquatic species, EPA estimates hazard by calculating a COC for a hazard value. COCs can be calculated using a deterministic method by dividing a hazard value by an assessment factor (AF) according to EPA methods (U.S. EPA, 2016, 2013, 2012).

Equation 6-1

$$COC = toxicity\ value \div AF$$

The toxicity value from the most sensitive taxa is typically divided by an AF of 5 for acute, 10 for chronic, and 10 for aquatic plants, when data (considering all lines of evidence) are available for vertebrates, invertebrates, and aquatic plants. If, for example, there is only acute or chronic data (not both), there is more uncertainty, which may be accounted for using an AF of 10 for acute exposure durations and an AF of 10 times an acute to chronic ratio (*e.g.*, 10 times 10) for chronic exposure durations. An AF of 100 could be applied to the toxicity value from a single species to account for the uncertainty of not having multiple taxonomic groups represented in the dataset. Several analyses have shown that more uncertainty exists when only a small number of species is represented in a dataset (Raimondo et al., 2025; Etterson, 2011; Schudoma, 1994). Generally, as more data are available for more taxonomic groups, the smaller the assessment factor needed to account for that uncertainty.

COCs can also be calculated using probabilistic methods. For example, a species sensitivity distribution (SSD) can be used to calculate a hazardous concentration for 5 percent of species (HC05). The HC05 estimates the concentration of a chemical that is expected to protect 95 percent of aquatic species. This HC05 can then be used to calculate a COC. The modeling approach, Web-based Interspecies Correlation Estimation (Web-ICE), can be used to predict LC50 toxicity data to supplement empirical data to be used in the SSD from a database of 48- or 96-hour EC50/LC50 data (Raimondo and Barron, 2010). For D4, LC50 data are only available from a single fish species. Additionally, the LC50 data are from a 14-day exposure period. The limited empirical data and the disparity of exposure durations from the empirical and modeled datasets reduces confidence in the applicability in the Web-ICE model for D4. Therefore, the deterministic method was used to calculate a chronic COC.

For terrestrial species, EPA estimates hazard by calculating a TRV, in the case of terrestrial mammals and birds, or by assigning the hazard value as the hazard threshold in the case of terrestrial plants and soil invertebrates. EPA prefers to derive the TRV by calculating the geometric mean of the NOAELs across sensitive endpoints (growth, reproduction, and mortality) rather than using a single endpoint. The TRV method is preferred because the geometric mean of NOAELs across studies, species, and endpoints provides greater representation of environmental hazard to terrestrial mammals and/or birds. In cases where only LOAELs are reasonably available, the lowest LOAEL is used with an AF of 10 as the TRV (according to step 5 of the methodology described in (U.S. EPA, 2007), (Figure 6-1).

6.1 Aquatic Species Hazard Values

The AF of 5 was used for deriving the acute COCs and an AF of 10 was used for chronic and algae COCs based on the reasonably available data from 16 aquatic studies presented in Section 3. These studies included seven aquatic vertebrate, three aquatic invertebrate, six benthic invertebrate, and a single algae study.

Acute aquatic threshold

To derive the acute COC for D4, EPA considered both vertebrate and invertebrate data from Table 3-1 and Table 3-3. EPA used three fish mortality studies for deriving the acute aquatic COC that included 14-day LC50 data for juvenile (Drottar, 2008; Springborn Laboratories, 1990a) and larvae (Sousa et al., 1995) rainbow trout. The geometric mean of the three early life stage LC50s = 11.9 µg/L. EPA then applied an AF of 5 to derive the COC. Therefore, the acute COC derived from the LC50 = (11.9 µg/L) / AF of 5 = 2.4 µg/L or ppb.

Acute benthic threshold

To derive the acute benthic COC for D4, EPA considered benthic invertebrate data from Table 3-4. EPA used a 28-day acute EC50 toxicity study for blackworm to derive the acute benthic COC (Krueger et al., 2009). The EC50 = 9.32 mg/kg. EPA then applied an AF of 5 to derive the COC. Therefore, the acute COC derived from the EC50 = (9.32 mg/kg) / AF of 5 = 1.9 mg/kg.

Chronic aquatic threshold

To derive the chronic COC for D4, EPA considered both vertebrate and invertebrate data from Table 3-1 and Table 3-3. EPA used two aquatic invertebrate mortality studies for deriving the chronic aquatic COC that included 21-day NOEC and LOEC data (Springborn Smithers Laboratories, 2018; Sousa et al., 1995). The NOEC (7.9 µg/L) and LOEC (15 µg/L) were the same for both studies. The geometric means of the NOEC and LOEC is used to calculate the ChV. EPA then applied an AF of 10 to derive the COC. Therefore, the chronic COC derived from the ChV = (11 µg/L) / AF of 10 = 1.1 µg/L or ppb.

Chronic benthic threshold

To derive the chronic benthic COC for D4, EPA considered benthic invertebrate data from Table 3-4. EPA used a single 28-day mortality toxicity study with midge (*C. riparius*) larvae with a NOEC = 44 mg/kg, LOEC = 131 mg/kg and ChV = 73.3 mg/kg (Wildlife International Ltd, 2008). Therefore, the chronic COC derived from the ChV = (73.3 mg/kg) / AF of 10 = 7.3 mg/kg.

Aquatic plant threshold

To derive the COC for D4, EPA used a single 96-hour growth study with green algae from Table 3-6 (Springborn Laboratories, 1990c). The single concentration had a LOEC = 3.29 µg/L that was below the EC50. Algae was assessed separately and not incorporated into acute or chronic COCs, because durations normally considered acute for other species (*e.g.*, up to 96 hours) can encompass several generations of algae. EPA then applied an AF of 10 to derive the COC. Therefore, the chronic COC derived from the ChV = (3.29 µg/L) / AF of 10 = 0.33 µg/L or ppb.

6.2 Terrestrial Species Hazard Values

Terrestrial invertebrate threshold

To derive the hazard value for D4, EPA used a single soil invertebrate study from Table 4-2: for the 56-day exposure to D4 the NOEC = 75 mg/kg, and the LOEC = 130 mg/kg for the reproductive endpoint (Smithers, 2022b). The ChV of 98.7 was then used as the terrestrial invertebrate hazard value.

Terrestrial vertebrate threshold

For terrestrial vertebrates exposed to D4, EPA estimated hazard by calculating a TRV for mammals (Figure 4-1). The TRV is expressed as doses in units of mg/kg-bw/day. Although the TRV for D4 was derived from laboratory rats and rabbit studies, body weight was normalized, therefore the TRV could be used with ecologically relevant wildlife species to evaluate chronic dietary exposure to D4. Representative wildlife species chronic hazard threshold will be evaluated in the trophic transfer assessments using the TRV. The following criteria and flow chart (Figure 6-1) were used to select the data to calculate the TRV with NOAEL and/or LOAEL data (U.S. EPA, 2007).

Step 1: The minimum data set required to derive either a mammalian or avian TRV consists of three results (NOAEL or LOAEL values) for reproduction, growth, or mortality for at least two mammalian or avian species (Table 4-1).

- For rats (Fischer 344 and Sprague-Dawley), a 4-day NOAEL/LOAEL for reproduction was used (Falany and Li, 2005). For growth, two 7-day, a 14-day, and a 28-day NOAEL/LOAEL were used (Mckim et al., 2001; MPI Research, 1999; Virginia Commonwealth University, 1997; Dow Corning, 1990a).
- For rabbits, a 13-day NOAEL/LOAEL for growth and reproduction was used (IRDC, 1993).
- Because this condition was met, proceed to step 2.

Step 2: Calculation of a geometric mean requires at least three NOAEL results from the reproduction and growth effect groups.

- Because there were two reproduction effects and four growth effect results, proceed to step 4.

Step 4: Calculate the geometric mean of NOAELs for reproduction and growth.

- The geometric mean of NOAELs for reproduction and growth is 95 mg/kg-bw/day.
- Is geometric mean NOAEL less than the lowest bounded LOAEL for reproduction, growth or mortality?
    - The lowest bounded LOAEL for reproduction, growth or mortality is 100 mg/kg-bw/day.
- Then the TRV is equal to the geometric mean of NOAELs for reproduction and growth.

The TRV for D4 is 95 mg/kg-bw/day.

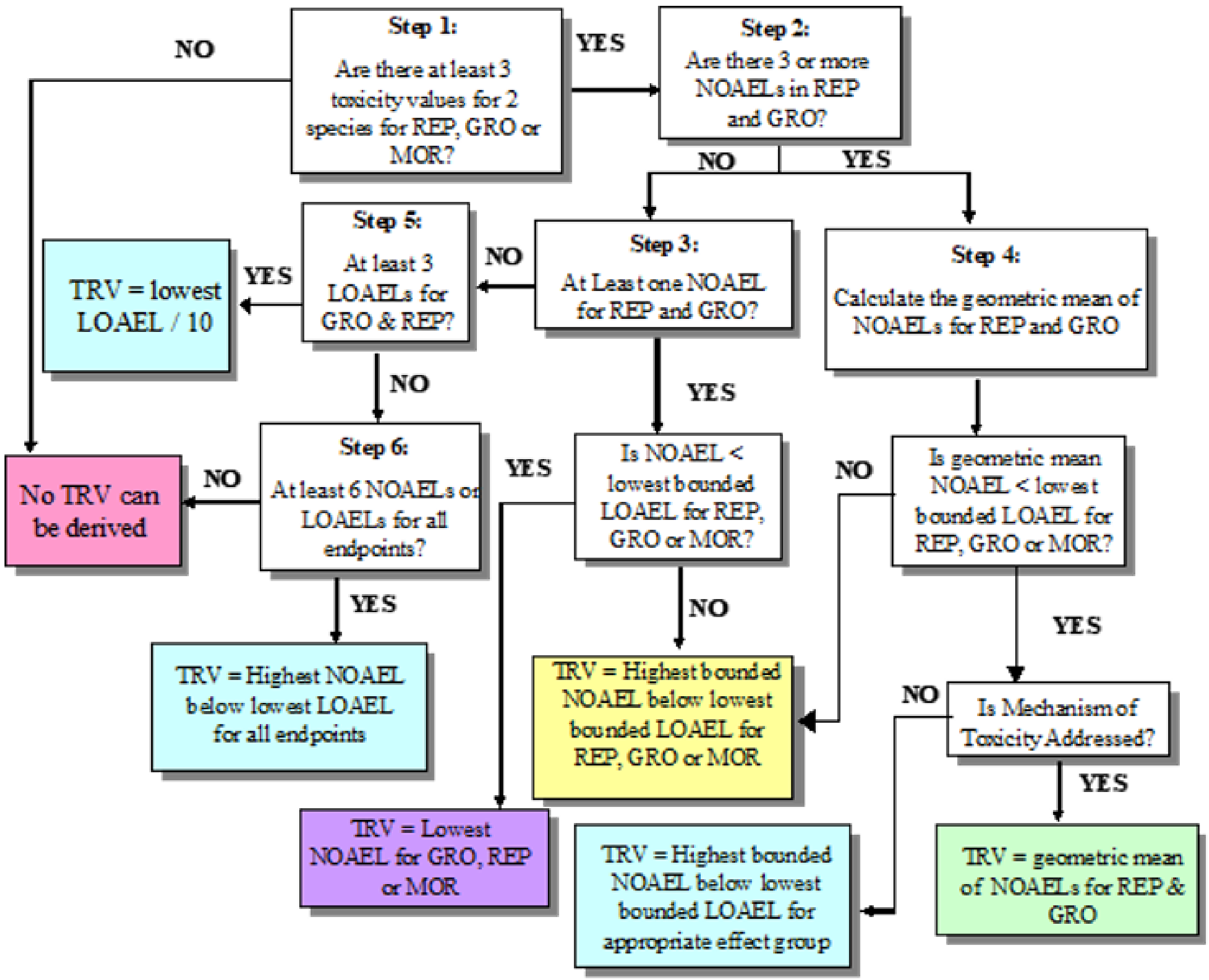


Figure 6-1. TRV Flow Chart

6.3 Summary of Environmental Hazard Thresholds

Overall, EPA has robust confidence in the evidence that D4 presents hazard potential to aquatic species, with the exception of algae that had an overall confidence of slight (Table 5-1). EPA used three rainbow trout high-quality studies with 14-day LC50 toxicity values (10, 10, and 17 µg/L) for deriving the acute aquatic COC of 2.4 µg/L (Drottar, 2008; Sousa et al., 1995; Springborn Laboratories, 1990a). For the adult life stage rainbow trout study, Bayer AG (1991) found the LOEC (51.7 µg/L) to be five times greater than the early life stage rainbow trout LC50 studies. These data suggest that early life stages are more sensitive to D4 exposure than the adult life stage in adult rainbow trout. In agreement that earlier life stages are more sensitive to D4 exposure Dow Corning (1992) found fish weighing 1 g to have 80% mortality at 23.2 µg/L and fish weighing 5 g to have no mortalities at 31 µg/L in an 18-day rainbow trout study. EPA used two *D. magna* high-quality studies with the same 21-day chronic toxicity values (NOEC = 7.9 µg/L, LOEC = 15 µg/L, and a ChV = 11 µg/L) for deriving the chronic aquatic COC of 1.1 µg/L (Springborn Smithers Laboratories, 2018; Sousa et al., 1995). For aquatic plants, the COC was derived from a single 96-hour high quality growth study. Although the algae study is the most sensitive with a LOEC = 3.29 µg/L and a COC of 0.33 µg/L, the growth effect was less than the EC50 and there is uncertainty of whether the Lowest-observable-effect level (LOEL) represents an adverse effect. EPA's overall confidence in the hazard threshold for algae is slight.

In the benthic environment, EPA used a blackworm high-quality study for survival/reproduction with a 28-day EC50 toxicity values of 9.32 mg/kg for deriving the acute benthic COC of 1.9 mg/kg (Krueger et al., 2009). Survival and reproduction were considered a single endpoint because it was not possible to differentiate between adult and young worms, and worms can reproduce within the study duration (Krueger et al., 2009). EPA used a single high-quality midge mortality study for deriving the chronic benthic COC of 7.3 mg/kg (Wildlife International Ltd, 2008). The acute and chronic benthic studies were based on exposure from sediment concentration of D4. Chronic benthic pore water toxicity test results show no adverse effects to midges at the maximum concentration tested (15 µg/L) (Kent et al., 1994; Springborn Laboratories, 1991a).

Overall, EPA has robust confidence in the evidence that D4 presents hazard to terrestrial mammals via dietary exposure, and moderate confidence that D4 poses hazard to soil invertebrates (Table 5-1). For chronic terrestrial mammalian exposures to D4, the toxicity data for deriving the TRV ranged from a Sprague-Dawley rat NOAEL of 20 mg/kg-bw/day to a rabbit LOAEL of 101.4 mg/kg-bw/day for the reproduction endpoint, and from a Fischer 344 rat NOAEL of 100 mg/kg-bw/day to a Sprague-Dawley rat LOAEL of 1,600 mg/kg-bw/day for the growth endpoint. Five of the reproduction and growth studies included in these ranges were assigned an overall quality determination of high (Mckim et al., 2001; MPI Research, 1999; Virginia Commonwealth University, 1997; IRDC, 1993; Dow Corning, 1990a) and one medium quality determination was assigned for a reproduction endpoint (Falany and Li, 2005) used for calculating the TRV of 95 mg/kg-bw/day. For terrestrial invertebrates, EPA used a single earthworm high-quality study for reproduction with a 56-day toxicity values (NOEC = 75 mg/kg, and a LOEC = 130 kg/mg) for deriving the hazard threshold of 98.7 mg/kg soil (Smithers, 2022b).

Table 6-1. Environmental Hazard Thresholds for Aquatic Environmental Toxicity

Environmental Aquatic Toxicity	Hazard Value	Assessment Factor (AF)	COC
Toxicity from acute exposure based on: LC50 of aquatic fish EC50 of benthic invertebrate	 11.9 µg/L 9.3 mg/kg	 5 5	 2.4 µg/L 1.9 mg/kg
Toxicity from chronic exposure based on: ChV of aquatic invertebrate ChV of benthic invertebrate	 11 µg/L 73.3 mg/kg	 10 10	 1.1 µg/L 7.3 mg/kg
Toxicity to aquatic plants based on LOEC of algae	3.29 µg/L	10	0.33 µg/L

Table 6-2. Environmental Hazard Thresholds for Terrestrial Environmental Toxicity

Environmental Terrestrial Toxicity	Hazard Value or TRV
Toxicity to mammals	95 mg/kg-bw/day
Toxicity to earthworms (*Eisenia fetida*)	98.7 mg/kg soil

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Appendix A Evidence Integration

A.1 Evidence Integration

Data integration includes analysis, synthesis, and integration of information for the draft risk evaluation. During data integration, EPA considers quality, consistency, relevancy, coherence, and biological plausibility to make final conclusions regarding the weight of scientific evidence. As stated in the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (U.S. EPA, 2021), data integration involves transparently discussing the significant issues, strengths, and limitations as well as the uncertainties of the reasonably available information and the major points of interpretation. The general analytical approaches for integrating evidence for environmental hazard is discussed in Section 7.4 of the 2021 *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (U.S. EPA, 2021) and Draft Systematic Review Protocol for Octamethylcyclotetrasiloxane (D4) (U.S. EPA, 2025).

The organization and approach to integrating hazard evidence is determined by the reasonably available evidence regarding routes of exposure, exposure media, duration of exposure, taxa, metabolism and distribution, effects evaluated, the number of studies pertaining to each effect, as well as the results of the data quality evaluation. The environmental hazard integration is organized around effects to aquatic and terrestrial organisms as well as the respective environmental compartments (*e.g.*, pelagic, benthic, soil). Environmental hazard assessment may be complex based on the considerations of the quantity, relevance, and quality of the available evidence.

For D4, environmental hazard data from toxicology studies identified during systematic review have used evidence that characterizes apical endpoints; that is, endpoints that could have population-level effects such as reproduction, growth, and/or mortality. Additionally, mechanistic data that can be linked to apical endpoints will add to the weight of scientific evidence supporting hazard thresholds.

A.2 Weight of the Scientific Evidence

After calculating the hazard thresholds that were carried forward to characterize risk, a narrative describing the weight of scientific evidence and uncertainties was completed to support EPA's decisions. The weight of scientific evidence fundamentally means that the evidence is weighed (*i.e.*, ranked) and weighted (*i.e.*, a piece or set of evidence or uncertainty may have more importance or influence in the result than another). Based on the weight of scientific evidence and uncertainties, a confidence statement was developed that qualitatively ranks (*i.e.*, robust, moderate, slight, or indeterminate) the confidence in the hazard threshold. The qualitative confidence levels are described below.

The evidence considerations and criteria detailed within (U.S. EPA, 2021) guides the application of strength-of-evidence judgments for environmental hazard effect within a given evidence stream and were adapted from Table 7-10 of the 2021 *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (U.S. EPA, 2021).

EPA used the strength-of-evidence and uncertainties from (U.S. EPA, 2021) for the hazard assessment to qualitatively rank the overall confidence using evidence (Table 5-1) for environmental hazard. Confidence levels of robust (+ + +), moderate (+ +), slight (+), or indeterminate are assigned for each evidence property that corresponds to the evidence considerations (U.S. EPA, 2021). The rank of the *Quality of the Database* consideration is based on the systematic review overall quality determination

(High, Medium, or Low) for studies used to calculate the hazard threshold, and whether there are data gaps in the toxicity dataset. Another consideration in the *Quality of the Database* is the risk of bias (*i.e.*, how representative is the study to ecologically relevant endpoints). Additionally, because of the importance of the studies used for deriving hazard thresholds, the *Quality of the Database* consideration may have greater weight than the other individual considerations. The high, medium, and low systematic review overall quality determination ranks correspond to the evidence table ranks of robust (+ + +), moderate (+ +), or slight (+), respectively. The evidence considerations are weighted based on professional judgment to obtain the overall confidence for each hazard threshold. In other words, the weights of each evidence property relative to the other properties are dependent on the specifics of the weight of scientific evidence and uncertainties that are described in the narrative and may or may not be equal. Therefore, the overall score is not necessarily a mean or defaulted to the lowest score. The confidence levels and uncertainty type examples are described below.

Confidence Levels

- Robust (+ + +) confidence suggests thorough understanding of the scientific evidence and uncertainties. The supporting weight of scientific evidence outweighs the uncertainties to the point where it is unlikely that the uncertainties could have a significant effect on the exposure or hazard estimate.
- Moderate (+ +) confidence suggests some understanding of the scientific evidence and uncertainties. The supporting scientific evidence weighed against the uncertainties is reasonably adequate to characterize exposure or hazard estimates.
- Slight (+) confidence is assigned when the weight of scientific evidence may not be adequate to characterize the scenario, and when the assessor is making the best scientific assessment possible in the absence of complete information. There are additional uncertainties that may need to be considered.
- Indeterminate (N/A) corresponds to entries in evidence tables where information is not available within a specific evidence consideration.

Types of Uncertainties

The following uncertainties may be relevant to one or more of the weight of scientific evidence considerations listed above and will be integrated into that property's rank in the evidence table (Table 5-1):

- *Scenario Uncertainty:* Uncertainty regarding missing or incomplete information needed to fully define the exposure and dose.
    - The sources of scenario uncertainty include descriptive errors, aggregation errors, errors in professional judgment, and incomplete analysis.
- *Parameter Uncertainty:* Uncertainty regarding some parameter.
    - Sources of parameter uncertainty include measurement errors, sampling errors, variability, and use of generic or surrogate data.
- *Model Uncertainty:* Uncertainty regarding gaps in scientific theory required to make predictions on the basis of causal inferences.
    - Modeling assumptions may be simplified representations of reality.

Table_Apx A-1 summarizes the weight of scientific evidence and uncertainties, while increasing transparency on how EPA arrived at the overall confidence level for each exposure hazard threshold. Symbols are used to provide a visual overview of the confidence in the body of evidence, while de-emphasizing an individual ranking that may give the impression that ranks are cumulative (*e.g.*, ranks of different categories may have different weights).

Table_Apx A-1. Considerations that Inform Evaluations of the Strength of the Evidence within an Evidence Stream (*i.e.*, Apical Endpoints, Mechanistic, or Field Studies)

Consideration	Increased Evidence Strength (of the Apical Endpoints, Mechanistic, or Field Studies Evidence)	Decreased Evidence Strength (of the Apical Endpoints, Mechanistic, or Field Studies Evidence)
The evidence considerations and criteria laid out here guide the application of strength-of-evidence judgments for an outcome or environmental hazard effect within a given evidence stream. Evidence integration or synthesis results that do not warrant an increase or decrease in evidence strength for a given consideration are considered "neutral" and are not described in this table (and, in general, are captured in the assessment-specific evidence profile tables).		
Quality of the database[a] (risk of bias)	• A large evidence base of *high*- or *medium*-quality studies increases strength. • Strength increases if relevant species are represented in a database.	• An evidence base of mostly *low*-quality studies decreases strength. • Strength also decreases if the database has data gaps for relevant species, *i.e.*, a trophic level that is not represented. • Decisions to increase strength for other considerations in this table should generally not be made if there are serious concerns for risk of bias; in other words, all the other considerations in this table are dependent upon the quality of the database.
Consistency	Similarity of findings for a given outcome (*e.g.*, of a similar magnitude, direction) across independent studies or experiments increases strength, particularly when consistency is observed across species, life stage, sex, wildlife populations, and across or within aquatic and terrestrial exposure pathways.	• Unexplained inconsistency (*i.e.*, conflicting evidence; see U.S. EPA (2005) decreases strength.) • Strength should not be decreased if discrepant findings can be reasonably explained by study confidence conclusions; variation in population or species, sex, or life stage; frequency of exposure (*e.g.*, intermittent or continuous); exposure levels (low or high); or exposure duration.
Strength (effect magnitude) and precision	• Evidence of a large magnitude effect (considered either within or across studies) can increase strength. • Effects of a concerning rarity or severity can also increase strength, even if they are of a small magnitude. • Precise results from individual studies or across the set of studies increases strength, noting that biological significance is prioritized over statistical significance. • Use of probabilistic model (*e.g.*, Web-ICE, SSD) may increase strength.	Strength may be decreased if effect sizes that are small in magnitude are concluded not to be biologically significant, or if there are only a few studies with imprecise results.
Biological gradient/dose-response	• Evidence of dose-response increases strength. • Dose-response may be demonstrated across studies or within studies and it can be dose- or duration-dependent.	• A lack of dose-response when expected based on biological understanding and having a wide range of doses/exposures evaluated in the evidence base can decrease strength.

Consideration	Increased Evidence Strength (of the Apical Endpoints, Mechanistic, or Field Studies Evidence)	Decreased Evidence Strength (of the Apical Endpoints, Mechanistic, or Field Studies Evidence)
	• Dose response may not be a monotonic dose-response (monotonicity should not necessarily be expected, *e.g.*, different outcomes may be expected at low vs. high doses due to activation of different mechanistic pathways or induction of systemic toxicity at very high doses). • Decreases in a response after cessation of exposure (*e.g.*, return to baseline fecundity) also may increase strength by increasing certainty in a relationship between exposure and outcome (this particularly applicable to field studies).	• In experimental studies, strength may be decreased when effects resolve under certain experimental conditions (*e.g.*, rapid reversibility after removal of exposure). • However, many reversible effects are of high concern. Deciding between these situations is informed by factors such as the toxicokinetics of the chemical and the conditions of exposure, see (U.S. EPA, 1998), endpoint severity, judgments regarding the potential for delayed or secondary effects, as well as the exposure context focus of the assessment (*e.g.*, addressing intermittent or short-term exposures). • In rare cases, and typically only in toxicology studies, the magnitude of effects at a given exposure level might decrease with longer exposures (*e.g.*, due to tolerance or acclimation). • Like the discussion of reversibility above, a decision about whether this decreases evidence strength depends on the exposure context focus of the assessment and other factors. • If the data are not adequate to evaluate a dose-response pattern, then strength is neither increased nor decreased.
Biological relevance	Effects observed in different populations or representative species suggesting that the effect is likely relevant to the population or representative species of interest (*e.g.*, correspondence among the taxa, life stages, and processes measured or observed and the assessment endpoint).	An effect observed only in a specific population or species without a clear analogy to the population or representative species of interest decreases strength.
Physical/chemical relevance	Correspondence between the substance tested and the substance constituting the stressor of concern.	The substance tested is an analogue of the chemical of interest or a mixture of chemicals which include other chemicals besides the chemical of interest.
Environmental relevance	Correspondence between test conditions and conditions in the region of concern.	The test is conducted using conditions that would not occur in the environment.

[a] Database refers to the entire dataset of studies integrated in the environmental hazard assessment and used to inform the strength of the evidence. In this context, database does *not* refer to a computer database that stores aggregations of data records such as the ECOTOX Knowledgebase.

A.3 Hazard Threshold Comparison

EPA reviewed D4 risk assessments from Silicones Environmental health and Safety (SEHSC), European Chemicals Agency (ECHA), and Environment Canada risk assessments to provide awareness of previous hazard thresholds and approaches used within ecological risk assessments (**Table_Apx A-2**). All studies used in the previous risk assessments were also considered or used by the EPA for this risk assessment.

Table_Apx A-2. Aquatic Hazard Studies Used for D4 Risk Assessments

Duration	Test Organism (Species)	Endpoint	Hazard Values (µg/L)	Geometric Mean[a] (µg/L)	Effect	Citation	Risk Assessment Citation
Aquatic vertebrates							
Acute	Rainbow trout (*Oncorhynchus mykiss*)	14-day LC50	10 (8.5-13)[b]		Mortality (juvenile)	(Springborn Laboratories, 1990a)	(SEHSC, 2020)
		14-day NOEC/LOEC	4.4/6.9	5.51	Mortality (larvae)	(Sousa et al., 1995)	(ECHA, 2016) (EC/HC, 2008)
		14-day LC50	10 (8.5-13)[b]		Mortality (larvae)	(Sousa et al., 1995)	(EC/HC, 2008)
	Sheepshead minnow (Cyprinodon variegatus)	14-day NOEC	6.3		Mortality		
		14-day LC50	>6.3				
Chronic	Rainbow trout (*Oncorhynchus mykiss*)	93-day (60-day post hatch) NOEC	>4.4		Mortality (larvae)	(Springborn Laboratories, 1991b)	(SEHSC, 2020)
		93-day NOEC	>4.4		Growth/ development (larvae)		
		93-day NOEC	>4.4		Mortality (embryo)	(Sousa et al., 1995)	(ECHA, 2016) (EC/HC, 2008)

Duration	Test Organism (Species)	Endpoint	Hazard Values (µg/L)	Geometric Mean[a] (µg/L)	Effect	Citation	Risk Assessment Citation
		93-day NOEC	>4.4		Growth/ development (larvae)		
Aquatic Invertebrates							
Acute	mysid shrimp (Mysidopsis bahia)	96-hour LC50	>9.1		immobilization	(Sousa et al., 1995)	(EC/HC, 2008)
	Water flea (*D. magna*)	48-hour NOEC	15				
Chronic	Water flea (*D. magna*)	21-day NOEC/LOEC	7.9/15	11	Mortality (juvenile)	(Sousa et al., 1995)	(ECHA, 2016) (EC/HC, 2008)
	Water flea (*D. magna*)	21-day (positive effect)	11		Reproduction (juvenile)	(Springborn Laboratories, 1990b)	(SEHSC, 2020)
Aquatic Invertebrates (Benthic)							
Acute	Blackworm (*Lumbriculus variegatus*)	28-day NOEC	>0.73		Developmental/ growth (adult)	(Krueger et al., 2009)	(ECHA, 2016)
		28-day NOEC/LOEC	13/19	15.7	Reproduction (adult)	(Springborn Smithers Laboratories, 2009)	(SEHSC, 2020) (ECHA, 2016)
Chronic	Midge (*Chironomus tentans*)	14-day NOEC (Aqueous)	>15 µg/L		Mortality (larvae)	(Kent et al., 1994)	(EC/HC, 2008)
		14-day NOEC (Aqueous)	>15 µg/L		Growth (larvae)		
		14-day NOEC (low organic carbon sediment)	>130		Mortality (larvae)		
		14-day NOEC/LOEC **(**medium	120/250		Mortality (larvae)		

Duration	Test Organism (Species)	Endpoint	Hazard Values (µg/L)	Geometric Mean[a] (µg/L)	Effect	Citation	Risk Assessment Citation
		organic carbon Sediment)					
		14-day NOEC/LOEC (medium organic carbon Sediment)	120/250	170	Growth (larvae)		
		14-day NOEC/LOEC (low organic carbon sediment)	65/130	92	Growth (larvae)		
		14-day NOEC/LOEC (high organic carbon sediment)	54/170	95.8	Mortality (larvae)		
		14-day LC50 (high organic carbon sediment)	>170				
		14-day NOEC/LOEC (high organic carbon sediment)	54/170	95.8	Growth (larvae)		
		14-day LC50 (high organic carbon sediment)	>170		Mortality (larvae)	(Springborn Laboratories, 1991c)	(SEHSC, 2020)
Aquatic plants							

Duration	Test Organism (Species)	Endpoint	Hazard Values (µg/L)	Geometric Mean[a] (µg/L)	Effect	Citation	Risk Assessment Citation
	Freshwater green algae, (*Selenastrum capricornutum*)	96-hour LOEC (No adverse effect)	3.29		Growth (no adverse effect)	(Springborn Laboratories, 1990c)	(EC/HC, 2008)

[a] Geometric mean of definitive values only.
[b] 95% confidence interval