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Draft Environmental Exposure Assessment for Octamethylcyclotetrasiloxane (D4)

Technical Support Document for the Draft Risk Evaluation

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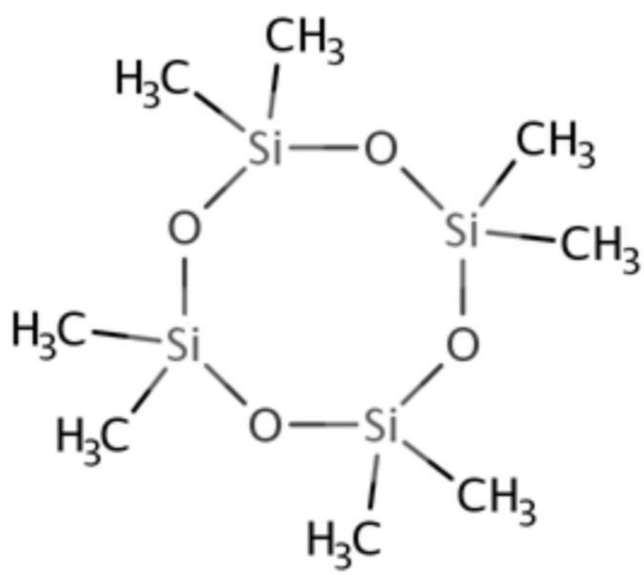

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ABBREVIATIONS AND ACRONYMS

7Q10	Lowest 7-day average flow that occurs in a 10-year period
ADME	Absorption, distribution, metabolism, and excretion
AUF	Area use factor
BCF	Bioconcentration factor
BMF	Biomagnification factor
BSAF	Biota-sediment accumulation factor
BST	Biosolids Screening Tool
bw	Body weight
COU	Condition of use
D4	Octamethylcyclotetrasiloxane
DMSD	Dimethylsilanediol
dw	Dry weight
ECA	Enforceable Consent Agreement
ECHO	EPA's Enforcement and Compliance History Online
EPA	Environmental Protection Agency (U.S.)
EROM	Flowline Network Enhanced Runoff Method
FIR	Food intake rate
LOD	Limit of detection
HE	High-end
Kh	Hydrolysis rate
Log K_{OC}	Logarithmic organic carbon/water partition coefficient
Log K_{OW}	Logarithmic octanol/water partition coefficient
LOQ	Limit of quantification
lw	Lipid weight
MT	Metric tons
ND	Non-detects
NHDPlus	National Hydrography Dataset Plus
OCSPP	Office of Chemical Safety and Pollution Prevention
OPPT	Office of Pollution Prevention and Toxics
OES	Occupational exposure scenario
P50	50th percentile (median) flow
P75	75th percentile flow
POTW	Publicly owned treatment work
SIR	Sediment Intake rate
TMF	Trophic magnification factor

TRV	Toxicity reference value
U.S.	United States
VVWM-PSC	Variable Volume Water Model in Point Source Calculator (model)
ww	Wet weight
WWTP	Wastewater treatment plant

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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

This technical support document is in support of the *TSCA Draft Risk Evaluation for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025f). EPA evaluated the reasonably available information for environmental exposures of D4 to aquatic and terrestrial species. The key points of the environmental exposure assessment are summarized below:

- EPA expects the main environmental exposure pathway for D4 to be released to surface water via wastewater treatment plant (WWTP) and subsequent deposition to sediment. The soil exposure pathway was also assessed for its biosolids application to soil.
- D4 exposure to aquatic species via surface water and sediment were modeled to estimate concentrations from the condition of use (COU) and occupational exposure scenario (OES) that resulted in the highest environmental media concentrations as a COU-based screening level analysis (Table 1-1). Concentrations of D4 in representative organisms for the screening level trophic transfer analysis were calculated using modeled sediment concentrations from EPA's Variable Volume Water Model in Point Source Calculator tool (VVWM-PSC) (Section 3.2.1).
- EPA does not expect industrial or commercial COUs with high D4 release scenarios to occur with the lowest flow (*i.e.*, small stream) scenarios. The P50 7Q10 low flow scenario from the high release scenario would result in a calculated surface water concentration 375.46 µg/L, which is nearly seven-fold greater than the water solubility limit of 56 µg/L (U.S. EPA, 2025e). Therefore, the P50 7Q10 low flow scenario was not used for modeling D4 concentrations in surface water or sediment. Based on the arithmetic mean of empirical lipid-normalized bioconcentration factors (BCFs) of 7,931 L/kg, the calculated concentration of D4 in fish represented by P75 7Q10 flows modeled within VVWM-PSC is 244.68 mg/kg, which is over an order of magnitude greater than the highest D4 calculated fish concentration from measured surface water concentrations of D4 in Enforceable Consent Agreement (ECA) reports. Chironomid D4 concentrations calculated using a biota-sediment accumulation factor (BSAF) of 1.27 is 20.6 mg/kg bw represented by P75 7Q10 flows modeled within VVWM-PSC from the COU/OES with highest release to sediment (Table 3-2), which is also over an order of magnitude greater than the highest D4 calculated chironomid concentration from measured sediment concentrations of D4 in ECA reports. The inclusion of both modeled and monitored data in this analysis help inform the amount of potential for uptake of D4 from prey to predators and environmental media sources such as water, soil, and sediment.
- D4 exposure to terrestrial species through soil via biosolid application was also assessed using data modeled using Biosolids Screening Tool (BST) (Section 4.2). The screening level trophic transfer analysis for terrestrial mammals based on the highest modeled and monitored releases of D4 from biosolid application to soil resulted in dietary exposure concentrations below the toxicity reference value (TRV) (Table 7-2).
- D4 exposure to aquatic-dependant mammals through surface water and sediment exposure pathway was assessed through trophic transfer analysis. Maximum D4 concentrations from modeled and monitored data presented no exposure of D4 greater than the calculated TRV from the screening level trophic transfer analysis (Table 7-1).
- Mean trophic magnification (TMF) for aquatic biota from five high quality studies and two medium quality studies was 0.79. Therefore, D4 is not expected to be bioaccumulative through dietary exposure based on trophic transfer analysis (Section 5.1) with representative species (Figure 5-1), which estimated the transfer of D4 from soil through the terrestrial food web (Table 5-4), and from surface water and sediment through the aquatic food web to aquatic dependent mammals (Table 5-5, Table 5-6).

- The highest OES estimate (Formulation of Adhesives and Sealants [Neat D4]) resulted in D4 exposure concentrations in a modeled terrestrial ecosystem of 2.18 mg/kg-bw/day in the earthworm (*Eisenia fetida*) consuming soil and resulted in estimated dietary intake of 1.25 mg/kg-bw/day in shorttail shrews (*Blarina brevicauda*). Within the aquatic modeled ecosystem, the highest OES estimate (Import-Repackaging) resulted in a D4 exposure concentration of 245.18 mg/kg in the blacktail redhorse (*Moxostoma poecilurum*) consuming chironomids and resulted in an estimated dietary intake of 53.94 mg/kg-bw/day in American mink (*Mustela vison*).

1 INTRODUCTION

D4 is a colorless, oily liquid with an annual total production volume between 250 million and 500 million pounds in the United States in 2020 (U.S. EPA, 2020). 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·m^3/mol at 21.7 °C). D4 is expected to undergo rapid hydrolysis in aquatic environments with dimethylsilanediol (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. 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 Logarithmic organic carbon/water partition coefficient ((log $K_{OC)}$ (4.19 and 4.22 at 24.4–24.8 °C) and Logarithmic octanol/water partition coefficient ((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 partition to air. A small percentage (9.5 percent) will remain in 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).

D4 Biomonitoring data are presented by trophic level from reasonably available studies across 12 countries. Concentration of D4 within biota provide evidence of D4 uptake by organism at polluted and remote sites. A summary of D4 biomagnification potential as measured by biomagnification factor (BMF) or trophic magnification factor (TMF) analysis are presented in the Section 7, Environmental Exposure Assessment Conclusions.

EPA assessed D4 exposures via surface water, sediment, and soil, which were used to determine exposures to aquatic and terrestrial species (Section 5.1). The media of release for these exposures originate from releases to water and releases from sludge and subsequent biosolids application to soil. Approaches for calculated and monitored concentrations of D4 within aquatic (Section 3) and terrestrial (Section 4) biota are presented. Dietary exposure to terrestrial and aquatic-dependent mammals consuming food items and media contaminated with D4 is described.

The screening level trophic transfer analysis was conducted by producing exposure estimates from the high-end exposure scenarios defined as those associated with the industrial and commercial releases from a condition of use (COU) and occupational exposure scenario (OES) that resulted in the highest environmental media concentrations. Table 1-1 summarizes the high-end exposure scenarios that were considered in this screening level analysis to estimate environmental and dietary exposures for terrestrial invertebrates and mammals. D4 is not expected to biomagnify across trophic levels in the aquatic environment. Therefore, screening level trophic transfer analysis will only be conducted for terrestrial organisms.

Table 1-1. Exposure Scenarios Representing the Highest Environmental Releases per Media of Release Assessed in the Screening Level Terrestrial Trophic Transfer Analysis

COU (Life Cycle Stage[a]/Category[b]/ Subcategory[c])	OES	Media of Release	Exposure Pathway	Receptors
Processing/Processing – Repackaging/All other basic inorganic chemical manufacturing; all other chemical product and preparation manufacturing; miscellaneous manufacturing	Import-Repackaging	Wastewater to onsite treatment or discharge to POTW	Biosolid application to soil	Aquatic dependent mammals
Processing/Processing as a reactant/Adhesives and sealant chemicals	Formulation of adhesives and sealants (neat D4)	Water, incineration, or landfill	Biosolid application to soil	Terrestrial invertebrates and mammals

POTW = Publicly owned treatment work; PV = Production volume

[a] Life Cycle Stage Use Definitions (40 CFR 711.3):

– "Industrial use" means use at a site at which one or more chemicals or mixtures are manufactured (including imported) or processed.

– "Commercial use" means the use of a chemical or a mixture containing a chemical (including as part of an article) in a commercial enterprise providing saleable goods or services.

– Although EPA has identified both industrial and commercial uses here for purposes of distinguishing scenarios in this document, the Agency interprets the authority over "any manner or method of commercial use" under TSCA section 6(a)(5) to reach both.

[b] These categories of conditions of use appear in the Life Cycle Diagram, reflect CDR codes, and broadly represent conditions of use of D4 in industrial and/or commercial settings.

[c] These subcategories reflect more specific conditions of use of D4.

2 APPROACH AND METHODOLOGY

2.1 Environmental Exposure Scenarios

EPA used two models to assess the environmental concentrations resulting from the industrial and commercial release estimates. These models are EPA's Variable Volume Water Model with Point Source Calculator tool (VVWM-PSC) and Biosolids Screening Tool (BST). Additional information on these models is available in the *Draft Environmental Media and General Population Screening for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025c). EPA modeled D4 in surface water, and sediment concentrations using VVWM-PSC, and D4 concentrations in soil via biosolid applications using BST.

EPA determined exposures of D4 to aquatic-dependent terrestrial species through surface water and sediment using modeled data from COUs in addition to environmental media concentrations from Enforceable Consent Agreement (ECA) data. For terrestrial species potential exposures through soil concentrations were based on COU-based modeled biosolid applications of D4 and monitored data from ECA reports. Specifically, exposures to aquatic dependent wildlife used modeled D4 concentrations in sediment from VVWM-PSC for highest release COU and OES in combination with D4 fish and chironomid concentrations derived using reasonably available BCF and BSAF values, respectively, in a screening level trophic transfer analysis. Soil concentrations from the COU/OES with the highest daily biosolid application to soil is used to demonstrate D4 exposure to terrestrial species via a screening level trophic transfer analysis. Exposure factors for terrestrial organisms used within the screening level trophic transfer analyses are presented in Section 5. Application of exposure factors and hazard values for organisms at different trophic levels is detailed within Section 5.1 and were used in equations as described in EPA's *Guidance for Developing Ecological Soil Screening Levels* (U.S. EPA, 2005).

2.2 Trophic Transfer

Because of the high biotransformation rate of D4 that is ingested and moves through the gastrointestinal tract (Section 5), significant bioaccumulation of D4 from dietary exposures is not expected (Cantu et al., 2024). This indicates that D4 uptake in fish though accumulation from diet may be much less significant. The empirical evidence from biomonitoring field studies further supports that D4 will undergo trophic dilution instead of trophic magnification in aquatic food webs (Section 3.1). Because D4 is not expected to biomagnify across trophic levels for aquatic organisms, trophic transfer analysis will not be conducted for aquatic species. Screening level trophic transfer analysis will be conducted for aquatic dependent mammals (mink), soil invertebrates (worm) and invertivore mammals (shrew). Representative species and the rationale for each are discussed further in Section 5.

3 EXPOSURES TO AQUATIC SPECIES

3.1 Measured Concentrations in Aquatic Species

EPA assigned an overall quality level of high or medium to 27 relevant biomonitoring studies from 12 countries, one study marked as supplemental (Rocha et al., 2019), and one uninformative study (COWI AS, 2018), on D4 concentrations in aquatic species within the pool of reasonably available information in aquatic ecosystems. COWI AS (2018) was rated uninformative because not all sample sizes were provided in the study. However, for the biota monitoring data presented in this assessment (*Gadus morhua*), sample size was provided within the study. Aquatic species with D4 concentrations reported below the limit of quantification (LOQ) are not presented. Samples with results below the LOQ in biomonitoring survey samples are not informative in the context of this review. D4 concentrations not reported below the LOQ include seven plant species (algae and phytoplankton), 39 invertebrate species (zooplankton, mollusk, worm, insect, echinoderm, and crustacean), 79 fish species, seven avian species, a single reptile species (turtle), and two mammal species (seals) (Table 3-1). Biomonitoring data are presented by trophic level and country. Concentration of D4 within biota are reported within this section as mg per kg wet weight (ww), dry weight (dw), or lipid weight (lw). Where studies provide BMF or TMF analysis, the BMF or TMF values are presented at the highest trophic level for each study. A summary of D4 biomagnification in aquatic ecosystems with the conclusion that EPA does not expect D4 to biomagnify across trophic levels is presented at the end of Section 3.1.

First Trophic Level

The first trophic level are primary producers which are organisms that convert abiotic sources such as sunlight or chemicals into energy (*e.g.*, phytoplankton and algae). Although no biomonitoring studies are represented from collections in the U.S. for this first trophic level, the remaining trophic levels include collections within the United States. Four studies reported bioaccumulation of D4 in seven species of primary producers from aquatic ecosystems (Rocha et al., 2019; Powell et al., 2018; Jia et al., 2015; Sanchis et al., 2015).

Micro-plankton near facilities from the inner Oslofjord in Norway showed a D4 concentration of 0.0028 mg/kg ww and a lipid-normalized concentration of 0.379 mg/kg lw (Powell et al., 2018). The same study also took background samples of micro-plankton from the outer Oslofjord with D4 concentration of 0.00061 mg/kg ww and lipid-normalized concentration of 0.0557 mg/kg lw.

Rocha et al. (2019) reported a D4 concentration in phytoplankton of 0.00093 mg/kg dw in the Southern Ocean.

Rocha et al. (2019) reported bioaccumulation levels for three algae species (*Ulva lactuca*, *Porphyra sp.*, and *Fucus vesiculosus*) near facilities and background conditions in Portugal, and one algae species (*Posidonia oceanica*) near facilities and in background conditions in Spain. D4 tissue sample concentrations (mean ± standard deviation [SD]) in algae were similar across exposure conditions (near facility and background) and species, ranging from non-detects (ND) to 0.005 (± 0.0027) mg/kg dw.

D4 concentration in *Ulva lactuca* was also measured at 0.0063 (± 0.0023) mg/kg ww with a lipid-normalized concentration of 0.239 (± 0.127) mg/kg in Dalian Bay, China (Jia et al., 2015).

Second Trophic Level

The second trophic level are primary consumers (*i.e.*, herbivores and detritivores), which are organisms that mainly feed on primary producers. There were 11 studies that reported bioaccumulation of D4 in 25 species of primary consumers from aquatic ecosystems (Cui et al., 2019; Xue et al., 2019; Zhi et al., 2019; Kim, 2018b; Powell et al., 2018; Sanchís et al., 2016; Jia et al., 2015; Sanchis et al., 2015; McGoldrick et al., 2014a; Powell et al., 2009; Schlabach et al., 2007).

In the Southern Ocean, krill (*Euphausia superba*) had a mean D4 concentration of 0.0489 mg/kg dw (Sanchis et al., 2015).

In coastal areas of northern China, zooplankton, bivalve (*Ruditapes philippinarum*, *Mactra veneriformis*, *Mytilus galloprovincialis*, *Scapharca subcrenata*, *Cyclina sinensis*, and *Crassostrea talienwhanensis)*, clam worm (*Perinereis aibuhitensis*), and sea snail (*Neptunea cumingii* and *Omphalius rustica*) had a geometric mean of D4 concentration of 0.0061 (0.0038 to 0.0157) mg/kg ww, and a lipid-normalized concentration of 0.15 (0.083 to 0.57) mg/kg lw (Cui et al., 2019; Xue et al., 2019; Zhi et al., 2019; Jia et al., 2015).

In coastal regions of southeastern Spain, bivalve (*Mytilus edulis*, *Cerastoderma edule*, and *Ruditapes decussatus* had a geometric mean of D4 concentration of 0.0042 (0.0028 to 0.0056) mg/kg ww (Sanchís et al., 2016).

In Norway, blue mussel (*Mytilus edulis*), sea urchin (*Brissopsis lyrifera*), and zooplankton spp. had a geometric mean of D4 concentration of 0.002 (0.00051 to 0.00354)mg/kg ww, and a lipid-normalized concentration of 0.17 (0.015 to 0.55) mg/kg lw (Powell et al., 2018; Schlabach et al., 2007 Norwegian Environment Agency, 2019, 7002468). Samples were taken from both inner and outer Oslofjord where inner Oslofjord is closer to pollution sources and had higher geometric mean D4 concentration 0.280 (0.093 to 0.55) mg/kg lw compared to outer Oslofjord D4 concentration 0.049 (0.015 to 0.16) mg/kg lw.

In Canada at Lake Opeongo, zooplankton had a D4 lipid-normalized concentration of 0.01 mg/kg lw (Powell et al., 2010).

Two U.S. lakes had biomonitoring data for D4. Mayfly (*Hexagenia sp*.) from Lake Erie had a D4 concentration of 0.007 mg/kg ww (McGoldrick et al., 2014a). At Lake Pepin, zooplankton, mayfly (*Hexagenia sp.*), midge (*Chironomus sp.*), white sucker (*Catostomus commersoni*), and river carpsucker (*Carpiodes carpio*) had a geometric mean of D4 concentration of 0.0058 (0.00081 to 0.059) mg/kg ww, and a lipid-normalized concentration of 0.27 (0.065 to 0.89) mg/kg lw (Powell et al., 2009).

Third Trophic Level

The third trophic level are secondary consumers (*i.e.*, omnivores or carnivores), which are organisms that feed mainly on primary consumers and/or plants. There were 20 studies that reported bioconcentration of D4 in 83 species of secondary consumers from aquatic ecosystems (Radermacher et al., 2020; Cui et al., 2019; Norwegian Environment Agency, 2019b; Xue et al., 2019; Kim, 2018a, b, c; Powell et al., 2018; Powell et al., 2017; Sanchís et al., 2016; Jia et al., 2015; Hong et al., 2014; McGoldrick et al., 2014a; Borgå et al., 2013; Powell et al., 2010; Evenset et al., 2009; Evonik Goldschmidt, 2009; Powell et al., 2009; Schlabach et al., 2007).

In coastal areas of northern China, three crab species (*Scylla serrata*, *Charybdis japonica*, and *Portunus trituberculatus*), seven shrimp species (*Oratosquilla oratoria*, *Alpheus japonicus*, *Palaemon graviera*, *Fenneropenaeus chinensis*, *Penaeus chinensis*, *Metapenaeopsis barbata*, and *Squilla orarotia*), two sea snail species (*Glossaulax didyma* and *Rapana venosa*) and 10 fish species (*Clupea pallasii*, *Pneumatophorus japonicus*, *Hexagrammos otakii*, *Sebastes schlegelii*, *Synechogobius hasta*, *Lophius litulon*, *Chaemrichthys stigmatias*, *Muraenesox cinereus*, *Synechogobius hasta*, *Cynoglossus joyneri*

Günther, and *Hexagrammos otakii*) had a geometric mean of D4 concentration of 0.0077 (0.00042 to 0.021) mg/kg ww, and a lipid-normalized concentration of 0.256 (0.077 to 0.75) mg/kg lw (Cui et al., 2019; Xue et al., 2019; Jia et al., 2015; Hong et al., 2014). Xue et al. (2019) reported a BMF equal to 3.2 for zooplankton to Japanese snapping shrimp (*Alpheus japonicus*) predator-prey relationship. However, no trophic magnification was found for any of the three food chains tested. In Jia et al. (2015), the primary producers-primary consumers-secondary/omnivorous consumers food chain had a TMF equal to 1.16. However no significant correlations between lipid-normalized concentrations and trophic levels were found for D4 ($R^2 = 0.14$, $p = 0.16$).

In Tokyo Bay, Japan, six fish species (*Scomber japonicus*, *Konosirus punctatus*, *Engraulis japonicus*, *Sardinella zunasi*, *Pennahia argentata*, and *Konosirus punctatus*) had a geometric mean of D4 concentration of 0.012 (0.0084 to 0.022) mg/kg ww, and a lipid-normalized concentration of 0.145 (0.042 to 0.49) mg/kg lw (Powell et al., 2017).

Along the Xúquer river of Spain, six fish species (*Gobio gobio*, *Boops boops*, *Alburnus alburnus*, *Anguilla anguilla*, *Barbus barbus*, and *Perca fluviatilis*) had a geometric mean of D4 concentration of 0.0011 (0.00001 to 0.009) mg/k ww, and a lipid-normalized concentration of 0.044 (0.006 to 0.9) mg/kg lw (Sanchís et al., 2016). Panga (*Pangasius hypophthalmus*) was purchased from a market in Barcelona and had a mean D4 concentration of 0.007 mg/kg ww (Sanchís et al., 2016).

In Germany, biomonitoring concentration of D4 in bream (*Abramis brama*) filets from 1995 to 2017 near a WWTP ranged from less than limit of detection (LOD) to 0.216 mg/kg ww with a mean concentration of 0.075 mg/kg ww (Radermacher et al., 2020). Radermacher et al. (2020) also reported background concentration of D4 in bream filets from background locations from Lake Belau, Baltic Sea, and North Sea during the same time period (1995–2017), with all D4 concentration reported as less than the LOD.

At Inner (near facilities) Oslofjord Norway, eight fish species (*Trisopterus minutes*, *Lycodes vahii*, *Merlangius merlangus*, *Hippoglossoides platessoides*, *Melanogrammus aegflefinus*, *Trisopterus esmarkii*, *Pleuronectes platessa*, and *Clupea harengus*), northern shrimp (*Pandalus borealis*) and marine worm sp. had a lipid-normalized geometric mean of D4 concentration of 0.236 (0.075 to 2.7) mg/kg lw (Powell et al., 2018). Background biota samples from the outer Oslofjord were an order of magnitude less than the near facilities samples from the inner Oslofjord during the same time period where six fish species (*H. platessoides*, *M. aegflefinus*, *T. esmarkii*, *P. platessa*, *C. harengus*, *Amblyraja radiata*, and *Solea solea*), northern shrimp (*P. borealis*), jelly fish sp. and marine worm sp. had a D4 lipid-normalized geometric mean concentration of 0.024 (0.0021 to 0.13) mg/kg lw (Powell et al., 2018). Schlabach et al. (2007) reported D4 concentration of 0.002 mg/kg ww in a flounder sp. from inner Oslofjord, and a lipid-normalized concentration of 0.139 mg/kg lw in fillets. Kim (2018c) reported whole body D4 concentration in Atlantic herring (*C. harengus*) and northern shrimp (*P. borealis*) from inner Oslofjord with a geometric mean of D4 concentration of 0.0027 (0.95 to 7.47) mg/kg ww, and a lipid-normalized concentration of 0.032 (0.019 to 0.052) mg/kg lw. Norwegian Environment Agency (2019b) reported muscle D4 concentration for two fish species (*Coregonus albula* and *Osmerus eperlanus*) and whole body for *mysis* sp. from inner Oslofjord with a geometric mean of D4 concentration of 0.0011 (0.00093 to 0.0012) mg/kg ww, and a lipid-normalized concentration of 0.040 (0.037 to 0.043) mg/kg lw. Evonik Goldschmidt (2009) reported background D4 concentrations from outer Oslofjord, Norway in eight fish species (*T. esmarkii*, *P. platessa*, *M. aegflefinus*, *S. solea*, *H. platessoides*, *C. harengus*, *T. minutes*, and *L. vahii*) with a range of less than LOQ to 0.013 mg/kg ww, and a geometric mean of 0.007 mg/kg ww. Evenset et al. (2009) reported background D4 concentrations from near Moffen Island, svalbard in *Boreogadus saida* with geometric mean of 0.0064 (0.0036 to

0.0078) mg/kg ww. At Lake Mjosa and Lake Randsfjorden, Norway, whole body D4 concentrations in *Limnocalanus macrurus*, *Mysis relicta*, *Daphnia galeata*, *Heterocope appendiculata*, and *Eudiaptomus gracilis* had lipid-normalized geometric mean of 0.046 (0.036 to 0.053) mg/kg lw (Borgå et al., 2013).

There were two studies reporting whole organism D4 concentrations in background locations in Canada, Lake Opeongo, and Lake Ontario which is bounded to the south by the U.S. (Kim, 2018a; Powell et al., 2010). At Lake Opeongo two fish species (*Coregonus artedi* and *Perca flavescens*) had a D4 geometric mean concentration of 0.001 (0.00087 to 0.0012) mg/kg ww, and a lipid-normalized concentration of 0.023 (0.021 to 0.026) mg/kg lw (Powell et al., 2010). At Lake Ontario, three fish species (*Neogobius melanostomus*, *Osmerus mordax*, and *Alosa pseudoharengus*) and one shrimp species (*Mysis diluviana*) had a D4 geometric mean concentration of 0.0011 (0.00064 to 0.0018) mg/kg ww, and a lipid-normalized concentration of 0.024 (0.018 to 0.030) mg/kg lw (Kim, 2018a).

In the United States, whole organism D4 concentrations were taken from Lake Erie and Lake Pepin (Kim, 2018b; McGoldrick et al., 2014a; Powell et al., 2009). At Lake Erie, five fish species (*Luxilus cornutus*, *P. flavescens*, *Notropis atherinoides*, *Percopsis omiscomaycus*, and *Morone americana*) had a D4 geometric mean concentration of 0.01 (0.0079 to 0.013) mg/kg ww (McGoldrick et al., 2014a). At Lake Pepin, nine sampled fish species (*Cyprinus carpio*, *Dorosoma cepedianum*, *Moxostoma anisurum*, *Lepomis macrochirus*, *Moxostoma macrolepidotum*, *N. atherinoides*, *Pomoxis nigromaculatus*, *Morone chrysops*, and *Carpiodes cyprinus*) had a D4 geometric mean concentration of 0.0057 (0.0028 to 0.018) mg/kg ww and a lipid-normalized concentration of 0.088 (0.038 to 0.16) mg/kg lw (Powell et al., 2009). Kim (2018b) measured D4 concentrations in *D. cepedianum* at Lake Pepin from 2011 to 2016 with a mean D4 concentration of 0.0021 (SD ± 0.0014) mg/kg ww, and a mean lipid-normalized concentration of 0.037 (SD ± 0.023) mg/kg lw.

Fourth Trophic Level

The fourth trophic level are tertiary consumers (*e.g.*, carnivores that include secondary consumers such as finfish in their diet). There were 20 studies that reported bioconcentrations of D4 in 21 species of tertiary consumers from aquatic ecosystems (Green et al., 2021; Cui et al., 2019; Norwegian Environment Agency, 2019a, b; COWI AS, 2018; Kim, 2018a, b, c; Powell et al., 2018; Powell et al., 2017; Sanchís et al., 2016; McGoldrick et al., 2014a; McGoldrick et al., 2014b; Borgå et al., 2013; Powell et al., 2010; Evenset et al., 2009; Evonik Goldschmidt, 2009; Powell et al., 2009; Schlabach et al., 2007; Kaj et al., 2005).

In Bohai sea, China, a single fish species (*Trichiurus* lepturus) had a mean of D4 concentration of 0.008 mg/kg ww, and a lipid-normalized concentration of 0.110 mg/kg lw (Cui et al., 2019). Cui et al. (2019) found a TMF equal to 1.7 in a zooplankton-invertebrate-fish-seabird based food chain. The authors report that biomagnification may be overestimated due to uncertainties of whether biota were exposed to similar concentrations. This may be especially true for seabirds with their increased home range relative to the aquatic food web. In the primary consumers-secondary/omnivorous consumers-piscivore (seabirds excluded) food chain, the TMF was equal to 1.4. However no significant relationships for D4 were found (R^2 = 0.01, p = 0.23).

In Tokyo Bay, Japan, two fish species (*Lateolabrax japonicus* and *Sphyraena pinguis*) had a geometric mean of D4 concentration of 0.019 (0.016 to 0.024) mg/kg ww, and a lipid-normalized concentration of 0.24 (0.15 to 0.39) mg/kg lw (Powell et al., 2017). In the secondary/omnivorous consumers-piscivore food chain, the TMF was equal to 0.6.

Along the Xúquer river of Spain, three fish species (*Oncorhynchus mykiss*, *Micropterus salmoides*, and

Esox lucius) had a geometric mean of D4 concentration of 0.0004 (0.00003 to 0.0013) mg/kg ww, and a lipid-normalized concentration of 0.012 (0.0004 to 0.025) mg/kg lw (Sanchís et al., 2016). Market fish sampled from Barcelona included six species of fish (*Thunnus albacares*, *Salmo salar*, *O. mykiss*, *Merluccius merluccius*, *G. morhua*, and *Merluccius capensis*) and had a D4 geometric mean concentration of 0.011 (0.0056 to 0.021) mg/kg ww (Sanchís et al., 2016).

At Inner (near facilities) Oslofjord Norway, four fish species (*G. morhua*, *Pollachius pollachius*, *Merluccius merluccius*, and *Pollachius virens*), had a lipid-normalized geometric mean of D4 concentration of 0.198 (63.8 to 525) mg/kg lw from whole organism samples (Kim, 2018c; Powell et al., 2018). Powell et al. (2018) reported TMF equal to 0.6 for inner and outer Oslofjord for the primary producers-primary consumers-secondary/omnivorous consumers-piscivores food chain. Background biota samples from the outer Oslofjord were an order of magnitude less than the near facilities samples from the inner Oslofjord during the same time period where two fish species (*G. morhua* and *P. virens*) had a D4 lipid-normalized geometric mean concentration of 0.018 (0.016 to 0.020) mg/kg lw indicating that exposure did not impact TMF (Powell et al., 2018). D4 concentration in liver samples of *Gadidae sp*. and *G. morhua* from inner Oslofjord had a geometric mean of 0.066 (0.031 to 0.13) mg/kg ww (Green et al., 2021; COWI AS, 2018; Kim, 2018c; Schlabach et al., 2007; Kaj et al., 2005). Schlabach et al. (2007) also reported lipid-normalized D4 concentrations from *Gadidae sp*. liver samples with a D4 geometric mean concentration 0.47 (0.24 to 0.86) mg/kg lw. D4 concentration in liver of *G. morhua* from background areas on the southeast coast of Norway were below the LOQ (Kaj et al., 2005). Norwegian Environment Agency (2019a) reported D4 concentration from inner Oslofjord in *G. morhua* muscle, liver, and bile as 0.066 (0.016 to 0.13) mg/kg ww. Muscle tissue samples from Lake Mjosa, Lake Randsfjorden, Lake Femunden in *Salmo trutta* had a geometric mean of lipid-normalized D4 concentration of 0.032 (0.016 to 0.077) mg/kg lw (Norwegian Environment Agency, 2019b; Borgå et al., 2013). The (secondary/omnivorous consumers-piscivores) food web biomagnification of D4 did not differ between Lake Mjosa and Lake Randsfjorden with a TMF was equal to 0.7 (Borgå et al., 2013). The authors note there is uncertainty due to 66 percent of samples having D4 concentrations below the LOQ and therefore cannot firmly conclude that trophic dilution is occuring. However, the authors do conclude that the classification of D4 as very bioaccumulative (vB) is not supported. Muscle tissue samples in six fish species (*Salvelinus alpinus*, *S. trutta*, *P. virens*, *G. morhua*, *M. merluccius*, and *P. pollachius*) from background locations (Lake Femunden and Oslofjord) ranged from less than the LOQ to 0.008 mg/kg ww (Borgå et al., 2013; Evonik Goldschmidt, 2009).

Kaj et al. (2005) also reported D4 concentrations in liver from *E. lucius* located near facilities in Finland and Sweden with a D4 concentration ranging from less than the LOQ to 0.007 mg/kg ww. Concentrations of D4 from fish liver samples in three fish species (*G. morhua*, *S. alpinus*, and *S. trutta*) from background locations (Faroe Islands, Svalbard) were less than 0.005 mg/kg ww (Evenset et al., 2009; Kaj et al., 2005).

In Canada, there were three studies reporting whole organism D4 concentrations in lake trout (*Salvelinus namaycush*) from eight lakes (Lake Kusawa, Lake Athabasca, Lake Winnipeg, Lake Superior, Lake Huron, Lake Erie, Lake Ontario, and Lake Opeongo) (Kim, 2018a; McGoldrick et al., 2014b; Powell et al., 2010). The geometric mean of D4 concentration in *S. namaycush* was 0.0038 (0.00086 to 0.013) mg/kg ww. Lipid-normalized values were reported for D4 concentration in *S. namaycush* from Lake Opeongo and Lake Ontario with a geometric mean of lipid-normalized concentration of 0.044 (0.034 to 0.051) mg/kg lw (Kim, 2018a; Powell et al., 2010).

In the United States, whole organism D4 concentrations were taken from Lake Erie and Lake Pepin (Kim, 2018b; McGoldrick et al., 2014a; Powell et al., 2009). At Lake Erie, two fish species (*Aplodinotus* *grunniens* and *Sander vitreus*) had a D4 geometric mean concentration of 0.011 (0.0096 to 0.013) mg/kg ww (McGoldrick et al., 2014a). The (primary consumer-secondary/omnivorous consumers-piscivores) freshwater food chain had a TMF equal to 0.74. McGoldrick et al. (2014a) reported that TMF estimates were highly dependent on the inclusion/exclusion of the organisms occupying the highest and lowest trophic levels. At Lake Pepin, five fish species (*Aplodinotus grunniens*, *Micropterus dolomieu*, *Sander vitreus*, *Micropterus salmoides*, and *Sander canadensis*) had a D4 geometric mean concentration of 0.0026 (0.00088 to 0.0053) mg/kg ww, and a lipid-normalized concentration of 0.049 (0.017 to 0.091) mg/kg lw (Kim, 2018b; Powell et al., 2009). The (secondary/omnivorous consumers-piscivores) freshwater food chain had a TMF equal to 0.31 (Powell et al., 2009). The lipid-normalized concentrations were greatest in the lowest trophic levels and significantly decreased at higher trophic levels.

Aquatic-Dependent Terrestrial Organisms

Aquatic-dependent avian species are part of the upper trophic level in aquatic ecosystems. EPA assigned an overall quality level of high or medium to four studies, and one study marked as supplemental (Wang et al., 2017), that reported bioconcentrations of D4 in seven species of piscivore birds from aquatic ecosystems (Cui et al., 2019; Norwegian Environment Agency, 2019a; Lu et al., 2017; Wang et al., 2017; Evenset et al., 2009).

In Bohai sea, China, a two bird species (*Larus saundersi and L. argentatus*) had a geometric mean of D4 concentration of 0.068 (0.062 to 0.074) mg/kg ww, and a lipid-normalized concentration of 0.41 (0.35 to 0.47) mg/kg lw (Cui et al., 2019). In the primary consumers-secondary/omnivorous consumers-piscivore (seabirds included) food chain, the TMF equal to 1.7.

At Inner Oslofjord Norway, eider duck (*Somateria mollissima*) blood and egg samples were collected (Norwegian Environment Agency, 2019a). D4 concentrations were not detected in blood samples and egg samples had a mean D4 concentration of 0.001 (> 0.001 to 0.0065) mg/kg ww.

At Svalbard, two bird species (*S. mollissima* and *Rissa tridactyla*) had D4 concentrations in liver samples ranging from less than the LOQ to 0.004 mg/kg ww, with lipid-normalized D4 concentrations ranging from less than the LOQ to 0.125 mg/kg lw (Evenset et al., 2009).

In Canada, blood samples were taken from double-crested cormorant (*Phalacrocorax auritus*) from Snake Island, Toronto Harbor, and Hamilton Harbor, and had a D4 geometric mean of 0.00007 (0.000051 to 0.000085) mg/kg ww (Wang et al., 2017). Lu et al. (2017) measured D4 concentrations from egg sample homogenates from three bird species (*L. argentatus*, *L. glaucescens*, and *L. californicus*) at 14 bird colonies across Canada with a median D4 concentration of 0.0033 mg/kg ww.

Wang, D.G. et al. (2017) reported D4 concentration in blood samples from common snapping turtle (*Chelydra serpentina*) from three locations (Binbrook Reservoir, Hamilton Harbor, and Toronto Harbor) in Canada, and had a D4 geometric mean of 0.00009 (0.000077 to 0.00012) mg/kg ww.

For aquatic mammals, harbor seal (*Phoca vitulina concolor* and *P. vitulina*) were sampled in Canada and Denmark, respectively (Wang et al., 2017 Kaj, 2005, 7002477). Wang, D.G. et al. (2017) reported D4 concentration in blood samples for *P. vitulina concolor* collected from St. Paul's Inlet and Gulf of St. Lawrence Estuary, Canada with a D4 geometric mean concentration of 0.00024 (0.00019 to 0.00031) mg/kg ww. Kaj et al. (2005) reported D4 concentration from blubber of *P. vitulina* from Denmark with a D4 concentration ranging from less than the LOQ to 0.012 mg/kg ww.

Summary

BMF is the ratio of the chemical concentrations in the organism and the diet of the organism, which considers specific predator-prey relationships. Whereas TMF refers to the increasing concentration of a chemical in the tissues of organisms at successively higher levels in a food chain. Xue et al. (2019) in Shuangtaizi estuary, China, reported a BMF equal to 3.2 of D4 from planktons to Japanese snapping shrimp. However, trophic magnification was not found in any of the three food chains tested.

Mean TMF for aquatic biota from seven studies with medium and high data quality was 0.79 (range: 0.31–1.4) (Cui et al., 2019; Powell et al., 2018; Powell et al., 2017; Jia et al., 2015; McGoldrick et al., 2014a; Borgå et al., 2013; Powell et al., 2009). Two studies had TMFs greater than 1. These studies were in adjacent bodies of water in the Bohai Sea, China (TMF = 1.4) and Dalian Bay, China (TMF = 1.16) which feeds out to the Bohai sea (Cui et al., 2019; Jia et al., 2015). Jia et al. (2015) found no significant correlation between lipid-normalized D4 concentration and trophic levels among algae, aquatic invertebrates and fish ($p = 0.16$). Cui et al. (2019) found a TMF equal to 1.7 in a zooplankton-invertebrate-fish-seabird based food chain. The authors report that biomagnification may be overestimated due to uncertainties of whether biota were exposed to similar concentrations. This may be especially true for seabirds with their increased home range relative to the aquatic food web. The TMF with seabirds excluded was 1.4, but the authors did not find any significant relationships for D4 ($R^2 = 0.01$, $p = 0.23$).

TMF does not appear to vary by freshwater vs saltwater environments. Powell et al. (2018) sampled aquatic biota in both the inner (near facility) and outer (background) Oslofjord and concluded that TMF does not vary by D4 concentration in water, with no evidence of biomagnification in the Oslofjord. Rather the results indicate trophic dilution. Therefore, D4 may have BMFs greater than one in specific predator prey relationships (*e.g.*, planktons to Japanese snapping shrimp) (Xue et al., 2019). However, EPA does not expect D4 to biomagnify across trophic levels.

Table 3-1. List of Relevant Biomonitoring Species with D4 Concentration Above the LOQ

Taxa	Common Name	Latin Name	Trophic Level
Algae	Fucus vesiculosus	*Fucus vesiculosus*	Primary Producer
Algae	Porphyra sp.	*Porphyra sp.*	Primary Producer
Algae	Posidonia oceanica	*Posidonia oceanica*	Primary Producer
Algae	Sea lettuce	*Ulva lactuca*	Primary Producer
Algae	Sea lettuce	*Ulva spp.*	Primary Producer
Plankton	Net plankton (200-um)	Unspecified	Primary Producer
Plankton	Phytoplankton	Unspecified	Primary Producer
Plankton	Zooplankton	Unspecified	Primary consumer
Mollusk (aquatic)	Ark shell	*Scapharca subcrenata*	Primary consumer
Mollusk (aquatic)	Arthritic neptune	*Neptunea cumingii*	Primary consumer
Mollusk (aquatic)	Black fovea snail	*Omphalius rustica*	Primary consumer
Mollusk (aquatic)	Duck clam	*Mactra veneriformis*	Primary consumer
Mollusk (aquatic)	Carpet shell clam	*Ruditapes decussatus*	Primary consumer
Mollusk (aquatic)	Mediterranean mussel	*Mytilus galloprovincialis*	Primary consumer
Mollusk (aquatic)	Mussel	Unspecified	Primary consumer
Mollusk (aquatic)	Venus clam	*Cyclina sinensis*	Primary consumer
Mollusk (aquatic)	Oyster	*Crassostrea talienwhanensis*	Primary consumer
Mollusk (aquatic)	Short-necked clam	*Ruditapes philippinarum*	Primary consumer
Mollusk (aquatic)	Blue mussel	*Mytilus edulis*	Primary consumer
Mollusk (aquatic)	Cockle	*Cerastoderma edule*	Primary consumer
Invertebrate (aquatic)	Worms	Unspecified	Primary consumer
Insect	Midge	*Chironomus sp.*	Primary consumer
Insect	Mayfly	*Hexagenia sp.*	Primary consumer
Echinoderm	Sea urchin	*Brissopsis lyrifera*	Primary consumer
Crustacean	Krill	*Euphausia superba*	Primary consumer
Fish	River carpsucker	*Carpiodes carpio*	Primary consumer
Fish	White sucker	*Catostomus commersoni*	Primary consumer
Plankton	Copepods	*Eudiaptomus gracilis*	Secondary/omnivorous consumers

Taxa	Common Name	Latin Name	Trophic Level
Plankton	Waterflea	*Daphnia galeata*	Secondary/omnivorous consumers
Plankton	Copepod	*Limnocalanus macrurus*	Secondary/omnivorous consumers
Plankton	Copepod	*Heterocope appendiculata*	Secondary/omnivorous consumers
Crustacean	Chinese ditch prawn	*Palaemon graviera*	Secondary/omnivorous consumers
Crustacean	Chinese shrimp	*Penaeus chinensis*	Secondary/omnivorous consumers
Crustacean	Chinese white shrimp	*Fenneropenaeus chinensis*	Secondary/omnivorous consumers
Crustacean	Japanese mantis shrimp	*Oratosquilla oratoria*	Secondary/omnivorous consumers
Crustacean	Japanese snapping shrimp	*Alpheus japonicus*	Secondary/omnivorous consumers
Crustacean	Mantis shrimp	*Squilla orarotia*	Secondary/omnivorous consumers
Crustacean	Mysis	*Mysis spp.*	Secondary/omnivorous consumers
Crustacean	Mysis relicta	*Mysis relicta*	Secondary/omnivorous consumers
Crustacean	Northern shrimp	*Pandalus borealis*	Secondary/omnivorous consumers
Crustacean	Opossum shrimp	*Mysis diluviana*	Secondary/omnivorous consumers
Crustacean	Whiskered velvet shrimp	*Metapenaeopsis barbata*	Secondary/omnivorous consumers
Crustacean	Japanese stone crab	*Charybdis japonica*	Secondary/omnivorous consumers
Crustacean	Mud crab	*Scylla serrata*	Secondary/omnivorous consumers
Crustacean	Swimming crab	*Portunus trituberculatus*	Secondary/omnivorous consumers
Invertebrate (aquatic)	Clamworm	*Perinereis aibuhitensis*	Secondary/omnivorous consumers
Mollusk (aquatic)	Moon shell	*Glossaulax didyma*	Secondary/omnivorous consumers
Mollusk (aquatic)	Veined rapa whelk	*Rapana venosa*	Secondary/omnivorous consumers
Fish	Alewife	*Alosa pseudoharengus*	Secondary/omnivorous consumers
Fish	Atlantic herring	*Clupea harengus*	Secondary/omnivorous consumers
Fish	Barbel	*Barbus barbus*	Secondary/omnivorous consumers
Fish	Black crappie	*Pomoxis nigromaculatus*	Secondary/omnivorous consumers
Fish	Bleak	*Alburnus alburnus*	Secondary/omnivorous consumers
Fish	Bluegill sunfish	*Lepomis macrochirus*	Secondary/omnivorous consumers
Fish	Boga	*Boops boops*	Secondary/omnivorous consumers
Fish	Bream	*Abramis brama*	Secondary/omnivorous consumers
Fish	Chub mackerel	*Scomber japonicus*	Secondary/omnivorous consumers

Taxa	Common Name	Latin Name	Trophic Level
Fish	Cisco	*Coregonus artedi*	Secondary/omnivorous consumers
Fish	Common carp	*Cyprinus carpio*	Secondary/omnivorous consumers
Fish	Common shiner	*Luxilus cornutus*	Secondary/omnivorous consumers
Fish	Common sole	*Solea solea*	Secondary/omnivorous consumers
Fish	Eel	*Anguilla anguilla*	Secondary/omnivorous consumers
Fish	Emerald shiner	*Notropis atherinoides*	Secondary/omnivorous consumers
Fish	European plaice	*Pleuronectes platessa*	Secondary/omnivorous consumers
Fish	European smelt	*Osmerus eperlanus*	Secondary/omnivorous consumers
Fish	European whiting	*Merlangius merlangus*	Secondary/omnivorous consumers
Fish	Flounder	Unspecified	Secondary/omnivorous consumers
Fish	Gizzard shad	*Dorosoma cepedianum*	Secondary/omnivorous consumers
Fish	Gobio	*Gobio gobio*	Secondary/omnivorous consumers
Fish	Goby	*Synechogobius hasta*	Secondary/omnivorous consumers
Fish	Greenling	*Hexagrammos otakii*	Secondary/omnivorous consumers
Fish	Haddock	*Melanogrammus aegflefinus*	Secondary/omnivorous consumers
Fish	Japanese anchovy	*Engraulis japonicus*	Secondary/omnivorous consumers
Fish	Japanese sardinella	*Sardinella zunasi*	Secondary/omnivorous consumers
Fish	Joyner's tonguesole	*Cynoglossus joyneri Günther*	Secondary/omnivorous consumers
Fish	Juvenile gizzard shad	*Konosirus punctatus*	Secondary/omnivorous consumers
Fish	Long rough dab	*Hippoglossoides platessoides*	Secondary/omnivorous consumers
Fish	Mackerel	*Pneumatophorus japonicus*	Secondary/omnivorous consumers
Fish	Marked lancet-tail goby	*Chaemrichthys stigmatias*	Secondary/omnivorous consumers
Fish	Moray	*Muraenesox cinereus*	Secondary/omnivorous consumers
Fish	Norway pout	*Trisopterus esmarkii*	Secondary/omnivorous consumers
Fish	Pacific herring	*Clupea pallasii*	Secondary/omnivorous consumers
Fish	Panga	*Pangasius hypophthalmus*	Secondary/omnivorous consumers
Fish	Perch	*Perca fluviatilis*	Secondary/omnivorous consumers
Fish	Polar cod	*Boreogadus saida*	Secondary/omnivorous consumers
Fish	Poor cod	*Trisopterus minutes*	Secondary/omnivorous consumers

Taxa	Common Name	Latin Name	Trophic Level
Fish	Quillback carpsucker	*Carpiodes cyprinus*	Secondary/omnivorous consumers
Fish	Rainbow smelt	*Osmerus mordax*	Secondary/omnivorous consumers
Fish	Roach	*Rutilus rutilus*	Secondary/omnivorous consumers
Fish	Round goby	*Neogobius melanostomus*	Secondary/omnivorous consumers
Fish	Schlegel's black rockfish	*Sebastes schlegelii*	Secondary/omnivorous consumers
Fish	Sea catfish	*Synechogobius hasta*	Secondary/omnivorous consumers
Fish	Shorthead redhorse	*Moxostoma macrolepidotum*	Secondary/omnivorous consumers
Fish	Silver croaker	*Pennahia argentata*	Secondary/omnivorous consumers
Fish	Silver redhorse	*Moxostoma anisurum*	Secondary/omnivorous consumers
Fish	Smelt	*Osmerus eperlanus*	Secondary/omnivorous consumers
Fish	Starry skate	*Amblyraja radiata*	Secondary/omnivorous consumers
Fish	Trout perch	*Percopsis omiscomaycus*	Secondary/omnivorous consumers
Fish	Vahls eelpout	*Lycodes vahii*	Secondary/omnivorous consumers
Fish	Vendace	*Coregonus albula*	Secondary/omnivorous consumers
Fish	White bass	*Morone chrysops*	Secondary/omnivorous consumers
Fish	White perch	*Morone americana*	Secondary/omnivorous consumers
Fish	Yellow goosefish	*Lophius litulon*	Secondary/omnivorous consumers
Fish	Yellow perch	*Perca flavescens*	Secondary/omnivorous consumers
Fish	Arctic char	*Salvelinus alpinus*	Piscivores
Fish	Atlantic cod	*Gadus morhua*	Piscivores
Fish	Black bass	*Micropterus salmoides*	Piscivores
Fish	Brown trout	*Salmo trutta*	Piscivores
Fish	Coalfish	*Pollachius virens*	Piscivores
Fish	Cod	Unspecified	Piscivores
Fish	European hake	*Merluccius merluccius*	Piscivores
Fish	Freshwater drum	*Aplodinotus grunniens*	Piscivores
Fish	Hairtail	*Trichiurus lepturus*	Piscivores
Fish	Hake	*Merluccius capensis*	Piscivores
Fish	Japanese seabass	*Lateolabrax japonicus*	Piscivores

Taxa	Common Name	Latin Name	Trophic Level
Fish	Lake trout	*Salvelinus namaycush*	Piscivores
Fish	North Atlantic pollock	*Pollachius pollachius*	Piscivores
Fish	Pike	*Esox lucius*	Piscivores
Fish	Red barracuda	*Sphyraena pinguis*	Piscivores
Fish	Salmon	*Salmo salar*	Piscivores
Fish	Sauger	*Sander canadensis*	Piscivores
Fish	Smallmouth bass	*Micropterus dolomieu*	Piscivores
Fish	Trout	*Oncorhynchus mykiss*	Piscivores
Fish	Tuna	*Thunnus albacares*	Piscivores
Fish	Walleye	*Sander vitreus*	Piscivores
Bird (aquatic)	California gull	*Laurus californicus*	Piscivores
Bird (aquatic)	Double-crested cormorant	*Phalacrocorax auritus*	Piscivores
Bird (aquatic)	Eider duck	*Somateria mollissima*	Piscivores
Bird (aquatic)	Glaucous-winged gull	*Larus glaucescens*	Piscivores
Bird (aquatic)	Herring gull	*Larus argentatus*	Piscivores
Bird (aquatic)	Kittiwakes	*Rissa tridactyla*	Piscivores
Bird (aquatic)	Saunder's gull	*Larus saundersi*	Piscivores
Reptile	Common snapping turtle	*Chelydra serpentina*	Piscivores
Mammal (aquatic)	Northwest Atlantic harbour seal	*Phoca vitulina concolor*	Piscivores
Mammal (aquatic)	Seal	*Phoca vitulina*	Piscivores

3.2 Calculated Concentrations in Aquatic Species

3.2.1 Releases to Surface Water

Concentrations of D4 in representative organisms within the screening level trophic transfer analysis were calculated using modeled surface water and sediment concentrations from VVWM-PSC and monitored data from ECA reports. Calculated concentrations within aquatic species will be presented using both modeled and monitored data (Section 5.1).

Surface water concentrations of D4 modeled with VVWM-PSC by COU/OES with the highest water releases (Import-Repackaging) and the lowest flow scenario (P50 7Q10: 18,541 m^3/day) exceeded the estimates of the water solubility limit for D4 which is approximately 56 µg/L (U.S. EPA, 2025e) by nearly seven-fold. Flow information for all facilities represented by the relevant NAICS code aligned OES was extracted from EPA's Enforcement and Compliance History Online (ECHO) that contains facilities with a NPDES permit, National Hydrography Dataset Plus (NHDPlus), and NHDPlus V2.1 Flowline Network Enhanced Runoff Method (EROM) Flow. Each OES has a flow rate that represents a 7Q10 flow (*i.e.*, lowest 7-day average flow that occurs in a 10-year period). The distribution of hydrologic flows representing 7Q10 flow for each OES is represented with median, 75th, and 90th percentiles represented herein as P50, P75, and P90, respectively. Generic scenario OESs also contain uncertainties such as the number of sites, release volumes among sites, and days of release that could contribute to variability in the estimation of instream chemical concentrations. When considering these factors and estimated flows for specific OESs, the EPA determined that modeled scenarios using VVWM-PSC and P50 7Q10 flow conditions do not accurately reflect the typical industrial and commercial contexts where D4 releases occur, see Section 3.3.1 of the *Draft Risk Evaluation for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025f). EPA does not expect industrial or commercial COUs with high D4 release scenarios to occur with the lowest flow (*i.e.*, small stream) scenarios. Therefore, the P50 7Q10 low flow scenario will not be used for modeling D4 concentrations in surface water or sediment. At the highest release scenarios with the 75th (226,528 m^3/day), and 90th (1.37×10^7 m^3/day) percentile 7Q10 flow scenarios, surface water concentrations of D4 are below the water solubility limit. The 75th percentile 7Q10 will be used as a conservative (most protective) flow scenario for the screening level trophic transfer analyses.

The BCF and BSAF are used to represent uptake of D4 from surface water and sediment, respectively. A predicted fish BCF using ADME-B model (Gobas et al., 2019) of 8,429 L/kg was in agreement with the arithmetic mean of empirical lipid-normalized BCF values of 7,931 L/kg from six high quality studies used to represent uptake of D4 from surface water exposure to fishes (Bernardo et al., 2022; Kim et al., 2020; Xue et al., 2020; Fackler et al., 1995; Dow Corning, 1992). Half of these studies were conducted within the United States. Immature stages of aquatic flies, such as the model test species, *Chironomus riparius*, were used to represent the aquatic organisms within the benthic compartment. The family Chironomidae are diverse, abundant, and ubiquitous across North America with numerous species inhabiting and feeding in stream sediments during their larval stage. Chironomid D4 concentrations calculated using a BSAF of 1.27 (Kent et al., 1994) and D4 concentrations resulting from 75th, and 90th percentile 7Q10 flow rates were 20.06 mg/kg bw, and 0.33 mg/kg bw, respectively, for the COUs and OES with the highest surface water release and resulting sediment concentration (Table 3-2). The flow rates of Lake Pepin, U.S. (https://water.noaa.gov/gauges/lkcm5) are comparable to the 90th percentile 7Q10 flow rates. Calculated concentrations of D4 within chironomids and biomonitoring data of *Chironomus* spp. collected at Lake Pepin are similar with a lipid-normalized D4 concentration of 0.89 mg/kg bw (Powell et al., 2009), thus increasing confidence that modeled data are representative of monitoring data. However, sediment and surface water concentrations modeled with VVWM-PSC do not limit media concentrations based on water solubility and maximum saturation of D4 in sediment, which may lead to overestimating D4 concentrations. As reported in the *Draft Environmental Media and General Population Screening for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025c), EPA has slight confidence in the modeled concentrations as being representative of actual releases, due to the bias toward overestimation, but robust confidence that no surface water release scenarios exceed the concentrations presented in this screening level assessment. Table 3-2 presents the mean of maximum sample concentrations of D4 in sediments within the reasonably available literature. These values from published literature should be considered to represent D4 concentrations from ambient monitoring and not directly comparable to COUs and OESs within the current risk evaluation.

Table 3-2. Calculated D4 Fish and Chironomid Concentrations from VVWM-PSC Modeled Values of D4 in Surface Water Sediment

<table>
<tr><th>COU (Life Cycle Stage[a]/Category[b]/Subcategory</th><th>OES</th><th>Flow Rate (m^3/day)</th><th>Surface Water Concentration (µg/L)[d]</th><th>Calculated Fish Concentration (mg/kg bw)</th><th>Sediment Concentration (mg/kg)[e]</th><th>Calculated Chironomid Concentration (mg/kg bw)</th></tr>
<tr><td>Processing/Processing – Repackaging/All other basic inorganic chemical manufacturing; all other chemical product and preparation manufacturing; miscellaneous manufacturing</td><td>Import-Repackaging</td><td>P75 7Q10: 226,528</td><td>30.85</td><td>244.68</td><td>15.79</td><td>20.06</td></tr>
<tr><td>D4 Environmental Testing Report, ECA (ERM, 2017)</td><td>DD3 WWTP</td><td></td><td>0.7</td><td>5.55</td><td>0.416</td><td>0.53</td></tr>
<tr><th colspan="7">Published Literature</th></tr>
<tr><th colspan="3">Sample Collection Conditions/Location</th><th colspan="2">Reference</th><th colspan="2">D4 Sediment Concentration (mg/kg)</th></tr>
<tr><td colspan="3">Mean of maximum sample concentrations of D4 within sediments/Inner Oslofjord, Norway</td><td colspan="2">Kim (2018c)</td><td colspan="2">9.28E–03</td></tr>
</table>

ECA = Enforceable Consent Agreement; DD = Direct discharge; WWTP = Wastewater treatment plant

[a] Life Cycle Stage Use Definitions (40 CFR 711.3):

– "Industrial use" means use at a site at which one or more chemicals or mixtures are manufactured (including imported) or processed.

– "Commercial use" means the use of a chemical or a mixture containing a chemical (including as part of an article) in a commercial enterprise providing saleable goods or services.

– Although EPA has identified both industrial and commercial uses here for purposes of distinguishing scenarios in this document, the Agency interprets the authority over "any manner or method of commercial use" under TSCA section 6(a)(5) to reach both.

[b] These categories of conditions of use appear in the Life Cycle Diagram, reflect CDR codes, and broadly represent conditions of use of D4 in industrial and/or commercial settings

[c] These subcategories reflect more specific conditions of use of D4

[d] Production volume uses high-end release distribution estimates (95th percentile)

[e] Sediment concentration represented by maximum daily average over the estimated days of release for each COU based on COU/OES characteristics described within the engineering supplement for D4. Sediment and surface water concentrations modeled with VVWM-PSC do not limit media concentrations based on water solubility and maximum saturation of D4 in sediment.

3.2.2 Releases to Air

Air deposition of D4 to soil or surface water from industrial releases are not expected based on the results from the analysis of the maximum estimated release and high-end exposure concentrations presented in the *Draft Environmental Media and General Population Screening for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025c). Therefore, exposure to D4 via the air pathway is not assessed in the screening level trophic transfer analysis.

3.3 Modeled Concentrations in the Aquatic Environment

EPA conducted modeling with VVWM-PSC (U.S. EPA, 2019) to estimate concentrations of D4 within surface water and sediment. PSC inputs include physical and chemical properties of D4 (*i.e.*, K_{OW}, K_{OC}, water column half-life, photolysis half-life, hydrolysis half-life, and benthic half-life) and reported or estimated D4 releases to water (U.S. EPA, 2025d), which are used to predict receiving water column concentrations. PSC was also used to estimate D4 concentrations in settled sediment in the benthic region of streams.

Site-specific parameters influence how partitioning occurs over time. For example, the concentration of suspended sediments, water depth, and weather patterns all influence how a chemical may partition between compartments. Physical and chemical properties of the chemical itself also influence partitioning and half-lives into environmental media. D4 has a log K_{OC} of 5.17 (Panagopoulos et al., 2015), indicating a high potential to sorb to suspended particles in the water column and settled sediment in the benthic environment.

Physical, chemical, and environmental fate properties selected by EPA for this assessment were applied as inputs to the PSC model (U.S. EPA, 2025c). Selected values are described in detail in the *Draft Physical Chemistry and Fate Assessment for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025e). Briefly, EPA used ADME-B model (Gobas et al., 2019) to predict the BCF of D4 varying C_{DOC} from 1 to 10 mg/L, levels typical of U.S. rivers (Breitmeyer et al., 2019). The input values for the BCF model parameters in equations listed in Appendix B-3 of the *Draft Physical Chemistry and Fate Assessment for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025e). A representative dissolved organic carbon concentration of 5 mg/L commonly used in exposure modeling (*e.g.*, default value in the Point Source Calculator (PSC) (U.S. EPA, 2019) was selected to calculate a BCF of 8,429 L/kg for rainbow trout (*Oncorhynchus mykiss*) based on the D4 elimination kinetics determined by Cantu et al. (2024).

A common setup for the model environment and media parameters was applied consistently across all PSC runs. The standard EPA "farm pond" waterbody characteristics were used to parameterize the water column and sediment parameters, which are applied consistently as a conservative screening scenario and are described in Table 4-2 of *Draft Environmental Media and General Population Exposure for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025c). Standardized waterbody geometry was also applied consistently across runs, with a standardized width of 5 m, length of 40 m, and depth of 1 m. Only the release parameters (daily release amount and days of release) and the hydrologic flow rate were changed between model runs for this chemical to reflect differences in COU scenarios.

A 7Q10 flow (lowest 7-day average flow that occurs in a 10-year period) with the 75th percentile and 90th percentile values of the flow distribution is used to estimate exceedances of concentrations of concerns for aquatic life (U.S. EPA, 2007). The facility effluent flow averaged across all facilities sharing the same industrial code was also added to the hydrologic flows in the receiving waterbodies. Facility effluent flow was also incorporated because it can increase the flow of the receiving waterbody.

For each COU with modeled surface water releases of wastewater effluent, surface water release values from the Import-Repackaging, High-end (HE) OES (OES with the highest estimated release to surface water) were used as a conservative screening analysis. The total days of release value associated with the Import-Repackaging, HE OES was applied as continuous days of release per year as a conservative approach (for example, a scenario with 250 days of release per year was modeled as 250 consecutive days of release, followed by 115 days of no release per year). The highest water column concentration averaged over the number of release days (*i.e.*, 250) was used to estimate aquatic exposure.

The modeled releases after wastewater treatment were evaluated for resulting environmental media concentrations at the point of discharge (*i.e.*, in the immediate receiving waterbody receiving the effluent). Due to D4's volatilization and partitioning to sediment, wastewater treatment is expected to be highly effective at removing D4 from the water column prior to discharge. The mean removal efficiency reported in three U.S. and Canadian studies is 94 percent (U.S. EPA, 2025e).

4 EXPOSURES TO TERRESTRIAL SPECIES

4.1 Measured Concentrations in Terrestrial Species

EPA assigned an overall quality level of high or medium to two relevant studies with D4 concentrations above the LOQ within the pool of reasonably available information in terrestrial ecosystems. Samples with results below the LOQ in biomonitoring survey samples are not informative in the context of this review. D4 concentrations were reported in liver of brown rat (*Rattus norvegicus*) and red fox (*Vulpes vulpes*) in Norway with a D4 geometric mean concentration of 0.002 mg/kg ww (Heimstad et al., 2019, 2018). These studies also sampled earthworm, fieldfare, sparrow hawk, and European badger. However, D4 was either not detected or below the LOQ. Biota monitoring studies in terrestrial species collected within the U.S. was not reasonably available.

4.2 Modeled Concentration in the Terrestrial Environment

Estimation of D4 Concentration in Biosolids-Amended Soil using Biosolids Screening Tool (BST)
Soil concentration modeling is described in Section 3 of the *Draft Environmental Media and General Population Screening for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025c). BST was used to estimate D4 soil concentrations resulting from biosolids application (U.S. EPA, 2023). In addition to the modeled biosolids concentration of D4 resulting from the highest-releasing OES (Formulation of Adhesives and Sealants [Neat D4]), both the mean and the 95th percentile biosolids concentrations from both industrial and non-industrial WWTPs provided in the ECA reports were used as biosolid concentration inputs to BST. For the screening level assessment only the 95th percentile information is presented. Two land application scenarios were run for each of the high-end biosolids concentrations to determine D4 concentrations relevant for incidental ingestion exposure: (1) Crop: default biosolids application rate of 10 metric tons (MT) dw per hectare per application *with* tilling; and (2) Pasture: biosolids application rate of 10 MT dw hectare per application *without* tilling (U.S. EPA, 2023). The land application mode was used as this scenario represents biosolids application under agronomic operating conditions. Additionally, three different climate scenarios (average, dry, and wet) were applied to assess the impact of precipitation on the persistence of D4 in the biosolids-amended soil. The physical and chemical properties for D4 used in the SimpleTreat model were also applied in the BST. Additionally, because hydrolysis is the main degradation mechanism for D4 in soil, the average of the hydrolysis rates reported by Durham (2005) and Gatidou et al. (2016) at pH 7 was used as a first-order hydrolysis rate (Kh) for D4 in the pore water of the soil compartment. The remaining parameters were kept at their default values (U.S. EPA, 2023). results are available in the *Draft Biosolids-Amended Soil Concentration Results and Risk Calculations for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025a).

Monitoring from non-industrial WWTPs ranged from 0.055 to 0.659 mg/kg dw, while those from industrial WWTPs ranged from 0.455 to 6.16 mg/kg dw. Comparison of monitoring data to the modeled D4 concentration of 57,049 mg/kg dw in biosolids indicates that the model likely overestimates D4 levels in biosolids (SEHSC, 2021; ERM, 2017). Additionally, modeled soil concentrations (0.52 to 2.18 mg/kg dw) using the high-end screening scenario are much greater than D4 concentrations reported in biosolids-amended soil from experimental and commercial agricultural soils in Canada (<0.008–0.017 mg/kg dw (Wang et al., 2013)). While there is slight confidence in the magnitude of the modeled D4 biosolids concentration (and therefore the soil concentration), the modeled value is several orders of magnitude greater than the D4 concentrations in biosolids reported in the ECA (Table 5-3). As such, EPA has increased confidence that the subsequent screening levels based on soil concentration and exposure estimates are protective for terrestrial organisms.

5 TROPHIC TRANSFER EXPOSURE

Trophic transfer is the process by which chemical contaminants can be taken up by organisms through diet and media exposures and be transferred through dietary consumption of prey from one trophic level to another. The physical and chemical properties of D4, including log K_{OW} (6.488), BCF (mean 9,433 L/kg ww whole body), and BAF (5,021 L/kg ww in muscle) indicate that D4 has high bioaccumulation potential that would also normally suggest high biomagnification potential. However, the empirical evidence from laboratory and field studies suggests low potential for biomagnification of D4; trophic dilution is more likely. The divergence between bioaccumulation potential (BCF and BAF) and biomagnification potential (BMF and TMF) may be explained by differences in which exposure route(s) are represented by each of these metrics, as well as differences in subsequent biotransformation rates.

D4 Biotransformation in Fish

Biotransformation is the transformation of chemicals within an organism via metabolic or other biochemical processes. Biotransformation within an organism will mitigate the extent to which the chemical accumulates within biological tissues, and thus the extent of subsequent exposures to ecological and human consumers of the organism. In the absence of metabolic/biotransformation rate data, many bioaccumulation estimates assume no biotransformation occurs, yielding an overestimation of the chemical's bioaccumulation potential.

Four laboratory-controlled studies were identified that examine D4 distribution in rainbow trout (*Oncorhynchus mykiss*) tissues as part of dietary exposure studies. Such dietary studies can provide granular information on the fate and biotransformation potential of D4 in various fish tissues. Domoradzki et al. (2017) performed an oral gavage study using mature rainbow trout given a nominal [^{14}C]D4 bolus dose of 15 mg/kg (mean measured [^{14}C]D4 13.6 ± 2.6 mg/kg). The administration of an oral gavage of a radiolabeled ration ensures the dose amount for this laboratory controlled study. Dorsal aortic blood, urine, and fecal samples were taken periodically, while carcass, tissue, and bile samples were collected at study termination after 96 hours. After 96 hours, the ^{14}C distribution showed 69 percent of the dose recovered in the carcass, 12 percent in tissues, 1 percent in urine, and 18 percent in feces (mean recovery: 82 percent). Biotransformation was not observed in fat or the gastrointestinal (GI) tract: 103 and 98 percent of the total radioactivity in the fatty tissues and GI tract were identified as parent [^{14}C]D4, respectively. However, the composition of ^{14}C in the remaining carcass was not analyzed. To contrast, radioactivity detected in the bile, liver, and milt fractions were determined to contain 5, 60, and 80 percent parent [^{14}C]D4, with the remaining percentages as D4 metabolites. A single compartment model was used to fit the uptake rate of [^{14}C]D4 to blood (k_1 = 0.182 d^{-1}), whole-body (including digestate) metabolic transformation rate (k_M = 0.10 d^{-1}), and elimination rate to storage and waste (k_2 = 0.458 d^{-1}).

Woodburn et al. (2013) conducted a 35-day uptake/42-day depuration study with juvenile rainbow trout and nominal [^{14}C]D4 dose of 500 µg/g-food administered at a feeding rate of 3 percent of mean trout ww. At each sampling point, whole-body minus GI tract, liver, and GI tract were analyzed separately to assess ^{14}C and [^{14}C]D4 distribution and to estimate the assimilation efficiency (α) across the gut. Similar to results from Domoradzki et al. (2017), the radiolabeled concentrations of ^{14}C and [^{14}C]D4 in the carcasses were very similar, showing negligible biotransformation, while liver and tissue from the GI tract contained one or more metabolites that were not further identified. From the kinetic tissue concentration data, growth-corrected uptake (k_1) and elimination (k_2) rate constants were modeled to be 0.0119 d^{-1} and 0.0069 d^{-1}, respectively. See Section 3.6.4 of the *Draft Physical Chemistry and Fate Assessment for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025e) for discussion on uncertainties with these modeled kinetic rates.

Compton (2019) administered a dietary D4 dose of 0.84 (± 0.07) g/kg-food to juvenile rainbow trout (n = 252) at a feeding rate of 1 percent of trout ww in a 10-day uptake/28-day depuration study. Parent D4 and non-biodegradable reference chemical profiles were analyzed in somatic tissues (carcass minus intestinal tract and stomach), from which a somatic depuration rate (k_{BT}) and somatic biotransformation rate (k_{BM}) were determined to be 0.045 (± 0.018 d^{-1} SE) and 0.039 (± 0.019 d^{-1} SE), respectively. A two-compartment model (Absorption, Distribution, Metabolism, and Excretion Fish Bioaccumulation Calculator, ADME-B beta v. 1.14, described in Gobas et al. (2019)) representing fish body (somatic) and intestines (digestive) was used to obtain an intestinal biotransformation (k_{GM}) rate of 1.26 (± 0.61 d^{-1} SE). These results demonstrate that biotransformation in the gut is a significant route of D4 depuration in fish exposed via diet, and that D4 uptake from the dietary pathway will not accumulate as readily as D4 uptake from gill respiration (Compton, 2019).

Cantu et al. (2024) conducted a feeding study similar to Compton (2019) with juvenile rainbow trout to determine BMF of D4, among other metabolic parameters such as dietary uptake efficiency, somatic/body biotransformation rate (k_{BM}), and intestinal/digestive biotransformation rate (k_{GM}). A dose of 1.4 (± 0.22 SE) g/kg-food was administered at a feeding rate of 1.25 percent of trout ww over a 35-day uptake/60-day depuration study. Parent D4 and non-biotransformable reference chemical profiles were analyzed in somatic tissues (carcass minus intestinal tract and stomach), from which a k_{BM} was determined to be 0.02 (± 0.002 d^{-1} SE). The above-mentioned ADME-B model (Gobas et al., 2019) was used to determine the gut biotransformation rate (k_{GM}) of 2.11 (± 0.70) d^{-1}, and gut transformation accounting for 88 percent of the total D4 biotransformation. The dietary uptake coefficient was determined to be 0.160 (± 0.030), low compared to the non-biotransformable reference compounds that yielded E_{Diet} values ranging from 0.243 (PCB209) to 0.493 (HCB). Because of D4's low tendency to be absorbed through dietary exposure—driven primarily by biotransformation in the gut (k_{GM})—the resulting lipid-normalized BMF at 0.444 kg lipid/kg lipid indicates that D4 is unlikely to biomagnify in fish.

Taken together, the above studies indicate that biotransformation of D4 can occur in fish, namely from digestive processes: D4 that occurs in somatic/carcass tissues (*e.g.*, D4 accumulated from gill respiration) is unlikely to be appreciably transformed (Cantu et al., 2024; Domoradzki et al., 2017). However, D4 that is ingested and moves through the GI tract can be metabolized, contributing to a dietary uptake coefficient that precludes significant accumulation from dietary exposures (Cantu et al., 2024). This indicates that D4 uptake in fish will occur via both dietary and environmental exposure routes, though accumulation from diet may be much less significant. Bioaccumulation metric data are presented and discussed in Section 3.6 and Appendix B in the *Draft Physical Chemistry and Fate Assessment for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025e). Because D4 is not expected to biomagnify across trophic levels in aquatic food webs, trophic transfer screening level analysis will not be conducted for aquatic organisms.

Although D4 is not expected to biomagnify within the terrestrial environment, relevant environmental exposures are possible through dietary exposure to soil and prey species contaminated with D4. The current trophic transfer screening level assessment was used to determine if terrestrial uptake and trophic transfer from D4 contaminated soils are a concern relative to the derived TRV for mammals. Soil concentrations from application of biosolids can be expected even if D4 is not persistent in soil. If media or prey species D4 concentration is high enough, terrestrial organisms can have hazard effect from D4 exposure. EPA has assessed the available studies collected in accordance with the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (U.S. EPA, 2021) and *Final Scope of the Risk Evaluation for D4* (U.S. EPA, 2022) relating to the biomonitoring of D4.

Potential contaminants can transfer from contaminated media and diet to biological tissue and accumulate throughout an organisms' lifespan (bioaccumulation) if the chemicals are not readily excreted or metabolized. The screening level trophic transfer analysis is conservative in that it assumes no *in vivo* metabolism or excretion for any representative organism.

Representative mammal species are chosen to connect the D4 transport exposure pathway via terrestrial trophic transfer from earthworm uptake of D4 from contaminated soil to the representative worm-eating mammal, the short-tailed shrew (*Blarina brevicauda*). Short-tailed shrew primarily feed on invertebrates with earthworms comprising approximately 31 percent (stomach volume) to 42 percent (frequency of occurrence) of their diet (U.S. EPA, 1993). The calculations for assessing D4 exposure from soil uptake by earthworms and the transfer of D4 through diet to higher trophic levels used maximum soil concentrations from BST modeling of biosolid application to soil in Section 4.2.

The representative aquatic-dependent terrestrial species is the American mink (*Mustela vison*), whose diet is highly variable depending on their habitat. In a riparian habitat, American mink derive 74 to 92 percent of their diet from aquatic organisms, which includes fishes, crustaceans, and amphibians (Alexander, 1977). Sediment and surface water concentrations of D4 modeled using VVWM-PSC represent the high-end annual release per COU/OES and were used as an inputs for the D4 concentration found in the American mink's diet in the form of water intake, incidental sediment ingestion, and a diet of fish.

The representative fish for the screening level trophic transfer analysis is the blacktail redhorse (*Moxostoma poecilurum*) serving as a prey item for the American mink. This species is within the Catostomidae family of fishes commonly referred to as suckers. Catostomids are represented by approximately 67 species in North America inhabiting lakes, rivers, and streams (Boschung and Mayden, 2004). Taxa within this family are characterized with sub-terminal mouths and feed primarily on sediment associated prey such as chironomids, zooplankton, crayfish, and mollusks in addition to algae (Boschung and Mayden, 2004; Dauble, 1986). The representative prey item for the blacktail redhorse was chironomid larvae (*Chironomus riparius*). These fish have the potential to be exposed to D4 within sediment through ingestion of sediment containing D4 during feeding, and D4 concentrations were detected in shorthead redhorse (*M. macrolepidotum*) at of 0.0061 mg/kg ww and a lipid-normalized concentration of 0.101 mg/kg lw at Lake Pepin, U.S. (Powell et al., 2009) The largescale sucker (*Catostomus macrocheilus*) was observed to have up to 20 percent of its total gut content represented with sand (Dauble, 1986). Gut content composition sampled in March to November from shorthead redhorse sampled within the Kankakee River drainage resulted in a mean of approximately 42 percent unidentified inorganic matter and sand (Sule and Skelly, 1985). Sediment within the gut ranged from 19 to 59 percent with a mean of 38 percent sediment for shorthead redhorse using a radionuclide tracer (^{238}U) approach with an adjusted mass balance tracer method equation (Doyle et al., 2011).

5.1 Dietary Exposure

EPA conducted screening level approaches for terrestrial risk estimation based on exposure via trophic transfer using conservative assumptions for factors such as: area use factor, fraction of D4 absorbed from diet, soil, sediment, and water. Concentration of D4 within biota were calculated using the media to biota accumulation factor of 1.0 and the VVWM-PSC-modeled concentrations of D4 within the sediment and surface water 75th percentile 7Q10 flow rates for the OES/COU that resulted in the highest D4 concentration in each environmental medium. The screening level approach employs a combination of conservative assumptions (*i.e.*, conditions for several exposure factors included within Equation 5-1 and Equation 5-2) and utilization of the maximum values obtained from modeled and/or monitoring data from relevant environmental compartments. For Example, accumulation factors of 1.0 indicate 100% efficiency of chemical uptake which is standard conservative approach for the current screen level analysis.

Following the basic equations as reported in Chapter 4 of the *U.S. EPA Guidance for Developing Ecological Soil Screening Levels* (U.S. EPA, 2005), wildlife receptors may be exposed to contaminants in soil by two main pathways: 1) incidental ingestion of soil while feeding, and 2) ingestion of food items that have become contaminated due to uptake from soil. The general equation used to estimate dietary exposure via these two pathways is provided below and has been adapted to also include consumption of water contaminated with D4, and, for aquatic-dependent mammals, ingestion of D4 within sediment instead of soil:

Equation 5-1. Terrestrial and Aquatic Mammals

$$E_j = \left(\left[S_j * P_s * \mathrm{FIR} * \mathrm{AF}_{sj}\right] + \left[W_j * WIR * AF_{wj}\right] + \left[\sum_{i=1}^{N} B_{ij} * P_i * \mathrm{FIR} * \mathrm{AF}_{ij}\right]\right) * AUF$$

Equation 5-2. Fish

$$E_j = \left(\left[S_j * P_s * \mathrm{FIR} * \mathrm{AF}_{sj}\right] + \left[\sum_{i=1}^{N} B_{ij} * P_i * \mathrm{FIR} * \mathrm{AF}_{ij}\right]\right) * AUF$$

Where:

E_j	=	Exposure rate for contaminant (j) (mg/kg-bw/day)
S_j	=	Concentration of contaminant (j) in soil or sediment (mg/kg dry weight)
P_s	=	Proportion of total food intake that is soil or sediment (kg soil/kg food; SIR/((FIR)(body weight [bw])))
SIR	=	Sediment intake rate (kg of sediment [dry weight] per day)
FIR	=	Food intake rate (kg of food [dry weight] per kg body weight per day)
AF_{sj}	=	Absorbed fraction of contaminant (j) from soil or sediment (s) (for screening purposes set equal to 1)
W_j	=	Concentration of contaminant (j) in water (mg/L) assumed to equal water solubility for the purposes of terrestrial trophic transfer
WIR	=	Water intake rate (kg of water per kg body weight per day)
AF_{wj}	=	Absorbed fraction of contaminant (j) from water (w) (for screening purposes set equal to 1)
N	=	Number of different biota type (i) in diet
B_{ij}	=	Concentration of contaminant (j) in biota type (i) (mg/kg dry weight)
P_i	=	Proportion of biota type (i) in diet
AF_{ij}	=	Absorbed fraction of contaminant (j) from biota type (i) (for screening purposes set equal to 1)
AUF	=	Area use factor (for screening purposes set equal to 1)

Table 5-1. Terms and Values Used to Assess Trophic Transfer of D4 in Terrestrial Ecosystems

Term	Earthworm (*Eisenia fetida*)	Short-Tailed Shrew (*Blarina brevicauda*)
P_s	1	0.03[a]
FIR	1	0.555[b]
AF_{sj}	1	1
P_i	1	1
AF_{wj}	1	1
AF_{ij}	1	1
N	1	1
AUF	1	1
S_j	mg/kg D4	mg/kg D4
B_{ij}	mg/kg D4 (soil)	mg/kg D4 (worm)

[a] Soil ingestion as proportion of diet represented at the 90th percentile sourced from EPA's *Guidance for Developing Ecological Soil Screening Levels* (U.S. EPA, 2005).
[b] Exposure factors (FIR and WIR) sourced from EPA's *Wildlife Exposure Factors Handbook* (U.S. EPA, 1993).

Table 5-2. Terms and Values Used to Assess Trophic Transfer of D4 from Aquatic to terrestrial Ecosystems

Term	Blacktail redhorse (*Moxostoma poecilurum*)	American Mink (*Mustela vison*)
P_s	0.32[a]	5.35E−04[b]
FIR	0.02[c]	0.22[d]
AF_{sj}	1	1
P_i	1	1
WIR	NA	0.105[d]
AF_{wj}	1	1
AF_{ij}	1	1
SIR	9.5E−04[e]	1.20E−04[f]
Bw	0.148 kg[g]	1.0195 kg[h]
N	1	1
AUF	1	1
S_j	mg/kg[i] D4	mg/kg[i] D4
W_j	mg/L D4	mg/L[j] D4
B_{ij}	mg/kg[k] *C. riparius*	mg/kg[l] Fish

[a] Sediment ingestion as proportion of diet, calculated from the geometric mean of sediment as a proportion of diet reported in published literature for catostomids (Doyle et al., 2011; Dauble, 1986; Sule and Skelly, 1985)
[b] Sediment ingestion as proportion of diet, calculated by dividing the SIR by kg food, where kg food equal to FIR multiplied by body weight (bw) of the mink
[c] Daily feed rate reported from apparent satiation in laboratory growth study for juvenile black buffalo (*Ictiobus niger*) (Guy et al., 2018)
[d] Exposure factors (FIR and WIR) sourced from EPA's *Wildlife Exposure Factors Handbook* (U.S. EPA, 1993) for mink
[e] SIR reported as kg of sediment in diet at a FIR of 0.02 based on a mean body weight of 148g (Guy et al., 2018) and sediment ingestion rate of 0.32
[f] Exposure factor (SIR) for mink sourced from EPA's *Second Five Year Review Report Hudson River PCBs Superfund Site Appendix 11 Human Health and Ecological Risks* (U.S. EPA, 2017).
[g] Fish body weight used to calculate FIR (Guy et al., 2018).
[h] Mink body weight used to calculate P_s sourced from EPA's *Wildlife Exposure Factors Handbook* (U.S. EPA, 1993)
[i] Sediment concentration of D4 obtained using VVWM-PSC modeling for each respective COU/OES presented in Table 3-1.
[j] Surface water concentration of D4 obtained using VVWM-PSC modeling for each respective COU/OES
[k] Chironomid D4 concentration (mg/kg) calculated from modeled sediment concentration of D4 (VVWM-PSC).
[l] Fish D4 Dietary Exposure Rate (mg/kg bw/day) represented from application of Equation 5-2

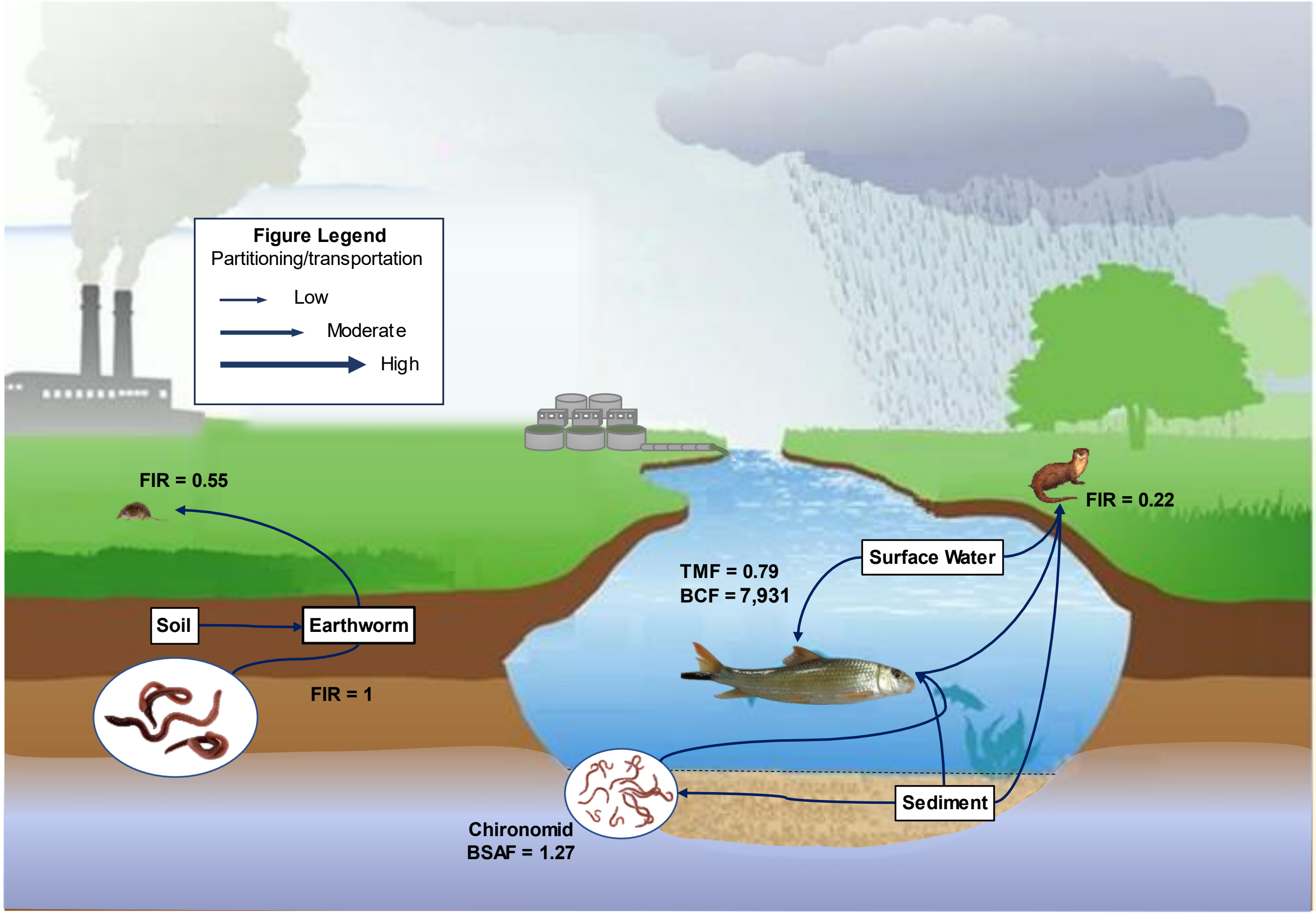

Figure 5-1. Trophic Transfer of D4 in Aquatic and Terrestrial Ecosystems

At the screening level, the conservative assumption is that the invertebrate diet for the short-tailed shrew is comprised entirely of earthworms from contaminated soil. The screening level analysis for trophic transfer of D4 to the short-tailed shrew used the highest calculated soil contaminant concentration to determine if a more detailed assessment is required. The highest concentration of D4 in soil from modeled biosolid application from the Formulation of Adhesives and Sealants (Neat D4) OES at 2.18 mg/kg per day (Table 5-3).

Exposure factors for mammals included food intake rate (FIR) and water intake rate (WIR) and were sourced from the EPA's *Wildlife Exposure Factors Handbook* (U.S. EPA, 1993). The exposure factor for sediment intake rate (SIR) for mammals was sourced from the EPA's *Second Five Year Review Report Hudson River PCBs Superfund Site – Appendix 11: Human Health and Ecological Risks* (U.S. EPA, 2017). FIR for the blacktail redhorse is represented with daily feed rate reported from apparent satiation in a laboratory growth study for juvenile black buffalo (*Ictiobus niger*) (Guy et al., 2018). The proportion of total food intake that is soil (P_s) is represented at the 90th percentile for short-tailed shrew and was sourced from calculations and modeling in EPA's *Guidance for Developing Ecological Soil Screening Levels* (U.S. EPA, 2005). The proportion of total food intake that is sediment (P_s) for representative taxa (American mink) was calculated by dividing the SIR by food consumption which was derived by multiplying the FIR by the body weight of the mink (sourced from *Wildlife Exposure Factors Handbook* (U.S. EPA, 1993)). The SIR for American mink was sourced from calculations in EPA's *Second Five Year Review Report Hudson River PCBs Superfund Site – Appendix 11: Human Health and Ecological Risks* (U.S. EPA, 2017). For the purposes of the current screening level trophic transfer analysis using the blacktail redhorse, EPA used a geometric mean of 0.32 for P_s as the proportion of total food intake that is sediment (kg sediment/kg food) based on several studies (Doyle et al., 2011; Dauble, 1986; Sule and Skelly, 1985). The proportion of total food intake that is sediment (P_s) is 5.35×10^{-4} and was calculated with SIR (1.2×10^{-4} kg of sediment per day) sourced from calculation within EPA's *Second Five Year Review Report Hudson River PCBs Superfund Site – Appendix 11: Human Health and Ecological Risks* (U.S. EPA, 2017). As a conservative assumption, in this screening level assessment the American mink's diet is comprised entirely of fish as a prey item while the fish diet is comprised entirely of chironomids as a prey item. Similarly, the short-tailed shew was assumed to have a diet comprised entirely of earthworms. If D4 exposures are indicated to exceed hazard values from the derived mammal TRV within these intentional conservative screening level assessment, a refined analysis will be performed.

The highest concentrations of D4 in soil are reported as the highest daily biosolid application to soil in mg/kg per day which originate from the Formulation of Adhesives and Sealants (Neat D4) OES (Section 4.2). Sediment concentrations modeled via VVWM-PSC were used to represent D4 concentrations in media for trophic transfer for fish consuming chironomids to an aquatic-dependant mammal (American mink). Additional assumptions for this analysis have been considered to represent conservative screening values (U.S. EPA, 2005). Within this model, incidental oral soil or sediment exposure is added to the dietary exposure resulting in total oral exposure to D4. In addition, EPA assumes that 100 percent of the contaminant is absorbed from the soil or sediment (AF_{sj}), water (AF_{wj}) and biota representing prey (AF_{ij}). The proportional representation of time an animal spends occupying an exposed environment is known as the area use factor (AUF) and has been set at 1 for all biota.

Values for calculated dietary exposure are shown in Table 5-4 for trophic transfer to shrew from the maximum concentrations modeled from BST, ECA report, and biomonitoring study. For trophic transfer from surface water release of D4 to fish consuming chironomids and mink consuming fish are shown in Table 5-5 and Table 5-6, respectively. Chironomid concentrations (mg/kg) were calculated using sediment concentrations of D4.

Table 5-3. D4 Soil Screening Level Concentration

D4 Screening Soil Concentrations (C_{soil})	Value	Units	Run Notes from BST Model
Formulation of adhesives and sealants (Neat D4)	0.5168	mg/kg	Maximum crop; solubility limit exceeded
ECA industrial - 95th percentile	0.0490	mg/kg	Maximum crop
Formulation of adhesives and sealants (Neat D4)	2.1845	mg/kg	Maximum pasture; solubility limit exceeded
ECA industrial – 95th percentile	1.62E–04	mg/kg	Maximum pasture
ECA non-industrial – 95th percentile	1.90E–05	mg/kg	Maximum pasture

Table 5-4. Dietary Exposure Estimates Using EPA's Wildlife Risk Model for Eco-SSLs for Screening Level Trophic Transfer of D4 (Biosolid Application to Soil) to Short-tailed Shrew

COU (Life Cycle Stage/Category/Subcategory)	OES	Earthworm D4 Concentration (mg/kg)[a]	Shrew D4 Dietary Exposure Rate (mg/kg bw/day)[b]
Processing/Processing as a Reactant/Adhesives and sealant chemicals	Formulation of adhesives and sealants (Neat D4)	2.1845	1.25
ECA Industrial – 95th percentile (ERM, 2017)	Maximum crop	0.049	2.80E–02
Published Literature			
Sample Collection Conditions/Location		**Reference**	**D4 Soil Concentration (mg/kg)**
Maximum mean concentration of D4 reported within reasonably available published literature in soil was from a remote location in the Shetland Islands, Antarctica		Sanchis et al. (2015)	0.0143

ECA = Enforceable Consent Agreement

[a] Estimated D4 concentration in representative soil invertebrate, earthworm, assumed equal to aggregated highest calculated soil via biosolid application to soil (Section 5.2)

[b] Dietary exposure (Equation 5-1) to D4 includes consumption of biota (earthworm), incidental ingestion of soil, and ingestion of water

Table 5-5. Dietary Exposure Estimates Using EPA's Wildlife Risk Model for Eco-SSLs for Screening Level Trophic Transfer of D4 (Releases to Surface Water) to Fish

COU (Life Cycle Stage/Category/Subcategory)	OES	Flow Rate (m^3/day)	D4 in Sediment Ingestion Rate (mg/kg bw/day)[a]	D4 in Chironomids Ingestion Rate (mg/kg bw/day)[b]	Fish D4 Dietary Exposure Rate (mg/kg bw/day)[c]
Processing/Processing – Repackaging/All other basic inorganic chemical manufacturing; all other chemical product and preparation manufacturing; miscellaneous manufacturing	Importing-Repackaging	P75 7Q10: 226,528	0.10	0.40	245.18
D4 Environmental Testing Report, ECA (ERM, 2017)	DD3 WWTP		2.66E–03	1.06E–02	5.56

Published Literature

Sample Collection Conditions/Location	Reference	D4 Sediment Concentration (mg/kg)
Maximum mean concentration of D4 within sediments/ Inner Oslofjord, Norway	Kim (2018c)	9.28E–03

ECA = Enforceable Consent Agreement; DD = Direct discharge; WWTP = Wastewater treatment plant

[a] Calculated from Equation 5-2 with factors representing: concentration of D4 in sediment, proportion of food intake that is sediment, food intake rate, and absorbed fraction of D4 from sediment

[b] Calculated from Equation 5-2 with factors representing: concentration of D4 in prey, proportion of prey in diet, feed intake rate, and absorbed fraction of D4 from prey

[c] Dietary exposure (Equation 5-2) to D4 includes consumption of biota (chironomids) and ingestion of sediment during feeding

Table 5-6 Dietary Exposure Estimates Using EPA's Wildlife Risk Model for Eco-SSLs for Screening Level Trophic Transfer of D4 (Releases to Surface Water) to Mink-Eating Fish

COU (Life Cycle Stage/ Category/Subcategory)	OES	Flow Rate (m^3/day)	D4 in Sediment Ingestion Rate (mg/kg bw/day)[a]	D4 in Water Intake Rate (mg/kg bw/day)[b]	D4 in Fish Ingestion Rate (mg/kg bw/day)[c]	Mink D4 Dietary Exposure Rate (mg/kg bw/day)[d]
Processing/Processing – Repackaging/All other basic inorganic chemical manufacturing; all other chemical product and preparation manufacturing; miscellaneous manufacturing	Importing-Repackaging	P75 7Q10: 226,528	1.86E–03	3.22E–03	245.18	0.12
D4 Environmental Testing Report, ECA (ERM, 2017)	DD3 WWTP		5.00E–05	7.00E–05	5.56	3.03E–03
Published Literature						

Sample Collection Conditions/Location	Reference	D4 Sediment Concentration (mg/kg)	D4 Surface Water Concentration (µg/L)
Maximum mean concentration of D4 reported within reasonably available published literature in sediment and seawater was from Huanghai Sea near Dalian, China	Hong et al. (2014)	6.71E–04	6.93E–03

ECA = Enforceable Consent Agreement; DD = Direct discharge; WWTP = Wastewater treatment plant

[a] Calculated from Equation 5-1 with factors representing: concentration of D4 in sediment, proportion of food intake that is sediment, food intake rate, and absorbed fraction of D4 from sediment.

[b] Calculated from Equation 5-1 with factors representing: water intake rate, concentration of D4 in surface water, and absorbed fraction of D4 from water.

[c] Calculated from Equation 5-1 with factors representing: concentration of D4 in prey, proportion of prey in diet, feed intake rate, concentration of D4 in surface water, and absorbed fraction of D4 from prey.

[d] Dietary exposure from Equation 5-1 to D4 includes consumption of biota (fish), incidental ingestion of sediment, and ingestion of water.

6 WEIGHT OF SCIENTIFIC EVIDENCE CONCLUSIONS FOR ENVIRONMENTAL EXPOSURE ASSESSMENT

EPA uses several considerations when weighing the scientific evidence to determine confidence in the dietary exposure estimates. These considerations include the quality of the database, consistency, strength and precision, and relevance (refer to Appendix A in the *Draft Environmental Hazard Assessment for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025b)). This approach is in agreement with the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (U.S. EPA, 2021). Table 6-1 summarizes how these considerations were determined for each dietary exposure threshold. For trophic transfer, EPA considers the evidence for worm-eating terrestrial mammals moderate and the evidence for fish-consuming aquatic-dependent mammals moderate (Table 6-1).

6.1 Strengths, Limitations, Assumptions, and Key Sources of Uncertainty for the Environmental Exposure Assessment

The current environmental exposure and screening level trophic transfer analysis utilized both modeled and monitored data from ECA. Modeled data were used to calculate dietary exposure estimates based on water and releases to soil from the COU/OES with the highest modeled environmental releases as reported within the *Draft Environmental Media and General Population Screening for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025c) providing a screening level approach for this analysis. As reported within the *Draft Environmental Media and General Population Screening for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025c), modeled values from VVWM-PSC for surface water and sediment based on COU/OES estimated water releases from hypothetical facilities resulted in D4 concentrations within surface water and sediment with a confidence rank of slight due to the bias toward overestimation, but robust confidence that no surface water release scenarios exceed the concentrations presented in this screening level assessment. A strength within this screening level trophic transfer analysis is the use of modeled sediment concentrations resulting from conservative 75th percentile 7Q10 flow rates in addition to the presentation and comparison with monitored concentrations of D4 from the ECA. Modeled D4 concentrations from BST for biosolid application to soil was determined to have robust confidence that soil concentrations are protective as reported within the *Draft Environmental Media and General Population Screening for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025c). Results of the trophic transfer exposure and screening level analysis are compared to the TRV derived for mammals within Section 7.

6.2 Trophic Transfer Confidence

Quality of the Database, and Strength (Effect Magnitude) and Precision

Seven studies conducted biomonitoring samples across multiple trophic levels and completed TMF analysis (Cui et al., 2019; Powell et al., 2018; Powell et al., 2017; Jia et al., 2015; McGoldrick et al., 2014a; Borgå et al., 2013; Powell et al., 2009). All studies were in agreement that that D4 concentration in aquatic organisms do not magnify across trophic levels and may undergo trophic dilution. Additionally, TMF does not appear to vary by freshwater vs. saltwater environments. Measured concentrations within aquatic species were represented with empirical biomonitoring data within 32 studies while measured concentrations within terrestrial species were limited to two studies. Empirical biomonitoring data for aquatic organisms were reasonably available with biota concentrations represented within a variety of aquatic taxa inhabiting 10 countries including the United States and Canada. Biomonitoring data were available for aquatic species with D4 concentrations above the LOQ for seven plant species (algae and phytoplankton), 39 invertebrate species (zooplankton, mollusk, worm, insect, echinoderm, and crustacean), 79 fish species, seven aquatic dependent avian species, a single reptile species (turtle), and two mammal species (seals). These biotas were spread across four trophic levels. The confidence in quality of the database for the chronic mammalian assessment using aquatic-dependent terrestrial species consuming fishes that prey on the sediment invertebrate chironomid is robust.

Applying BCF and BSAF values for aquatic species was accomplished using empirical values. The arithmetic mean of empirical lipid-normalized BCF values from six high quality studies were used to represent uptake of D4 from surface water exposure to fishes (Bernardo et al., 2022; Kim et al., 2020; Xue et al., 2020; Fackler et al., 1995; Dow Corning, 1992). Empirical data were used for a BSAF value within chironomids from (Kent et al., 1994). Use of this BSAF value increases the confidence in the uptake of D4 in chironomids as part of the trophic transfer analysis for aquatic dependent mammals. The confidence in strength and precision for the chronic mammalian screening level trophic transfer assessment using aquatic-dependent terrestrial species consuming fishes that prey on the sediment invertebrate chironomid is robust.

The use of species-specific exposure factors (*i.e.*, feed intake rate, water intake rate, the proportion of soil or sediment within the diet) from reliable resources assisted in obtaining dietary exposure estimates (U.S. EPA, 2017, 1993), thereby increasing the confidence for strength and precision, resulting in a robust confidence for the dietary exposure estimates in terrestrial trophic transfer. Exposure factors for the fish species were obtained to represent potential sediment uptake from feeding activity and included: diet composition (Boschung and Mayden, 2004; Dauble, 1986), feed intake rate (Guy et al., 2018), and the proportion of sediment in diet (Doyle et al., 2011; Dauble, 1986; Sule and Skelly, 1985). The confidence in quality of the database for the chronic mammalian assessment using a worm-eating mammal consuming earthworms as a prey item is robust. Whereas confidence in strength and precision is moderate.

Consistency

The confidence in consistency for the chronic mammalian assessment using a worm-eating mammal consuming earthworms as a prey item is moderate. While there is slight confidence in the magnitude of the modeled D4 biosolids concentration (and therefore the soil concentration), the modeled value is several orders of magnitude greater than the D4 concentrations in biosolids reported in the ECA. As such, EPA has increased confidence that the subsequent screening levels based on soil concentration and exposure estimates are protective for terrestrial organisms (Table 5-4). The modeled concentration was represented by the Formulation of Adhesives and Sealants (Neat D4) OES from biosolid application to soil.

For aquatic ecosystems, lipid-normalized concentrations of D4 do not appear to vary across species or trophic levels which supports the conclusion that D4 does not biomagnify through dietary exposure. Powell et al. (2018) sampled aquatic biota in both near facility and in adjacent background environments and concluded that TMF does not vary by D4 concentration in water, with no evidence of biomagnification. In addition, TMF values do not appear to vary from freshwater and saltwater environments. Consistency in TMF values provides robust confidence that D4 does not biomagnify in aquatic ecosystems. The confidence in consistency for the chronic mammalian assessment using aquatic-dependent terrestrial species consuming fishes that prey on the sediment invertebrate chironomid is moderate.

Relevance (Biological and Environmental)

The short-tailed shrew and American mink were selected as appropriate representative mammals

(Section 5) for the soil- and aquatic-based trophic transfer analysis, respectively (U.S. EPA, 1993). Overall, the use of exposure factors (*i.e.*, feed intake rate, water intake rate, the proportion of soil within the diet) from a consistent resource assisted in addressing species specific differences for dietary exposure estimates (U.S. EPA, 1993). The confidence in biological relevance for the chronic mammalian assessment using a worm-eating mammal consuming earthworms as a prey item is moderate. Selection of a benthic oriented fish species increases confidence with considerations made for sediment ingestion due to feeding behavior and further increases confidence in representing exposure pathways from sediment to aquatic species. The application of conservative assumptions at each trophic level ensures a conservative approach to determining potential risk, whereby none of the calculated values exceeded the hazard threshold derived for mammals (Section 7). Conservative assumptions associated with a lack of metabolic transformation within prey items such as chironomids, earthworms and fish increase the confidence in biological relevance that the resulting screening level assessment is protective. The overall confidence is robust for biological relevance for the screening level chronic mammalian assessment using an aquatic-dependent terrestrial species.

The screening level trophic transfer analysis investigated dietary exposure resulting from D4 in biota and environmentally relevant media such as soil, sediment, and water. The analysis used equation terms (*e.g.*, area use factor and the proportion of D4 absorbed from diet, and soil or sediment) all set to the most conservative values, emphasizing a conservative approach to estimating exposure of D4. Assumptions within the trophic transfer equations (Equation 5-1 and Equation 5-2) represent conservative screening values (U.S. EPA, 2005) and those assumptions were applied similarly for each trophic level and representative species. The AUF, defined as the home range size relative to the contaminated area (*i.e.*, site ÷ home range = AUF) was designated as 1 for all organisms, which assumes a potentially longer residence within an exposed area or a large exposure area. These conservative approaches likely overrepresent D4 ability to transfer among the trophic levels, however, this increases confidence that risks are not underestimated. As a result, there is an overall robust confidence for environmental relevance of the dietary exposure estimates.

The confidence in relevance for the chronic mammalian assessment using a worm-eating mammal consuming earthworms as a prey item is robust. The confidence in relevance for the chronic mammalian assessment using an aquatic-dependent terrestrial species consuming fishes that prey on the sediment invertebrate chironomid is robust.

Table 6-1. D4 Evidence Table Summarizing Overall Confidence Derived for Trophic Transfer

Types of Evidence	Quality of the Database	Strength and Precision	Consistency	Relevance[a]	Trophic Transfer Confidence
Aquatic					
Acute aquatic assessment	N/A	N/A	N/A	N/A	N/A
Chronic aquatic assessment	N/A	N/A	N/A	N/A	N/A
Aquatic plants (vascular and algae)	N/A	N/A	N/A	N/A	N/A
Terrestrial					
Chronic avian assessment	N/A	N/A	N/A	N/A	N/A

Types of Evidence	Quality of the Database	Strength and Precision	Consistency	Relevance[a]	Trophic Transfer Confidence
Chronic mammalian assessment (worm-eating)	+ + +	+ +	+ +	+ + +	Robust
Chronic mammalian assessment (fish consumption)	+ + +	+ + +	+ +	+ + +	Robust

[a] Relevance includes biological and environmental relevance.
+ + + 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 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 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.

7 ENVIRONMENTAL EXPOSURE ASSESSMENT CONCLUSIONS

Dietary exposure estimates were calculated based on water and releases to soil from the COU/OES with the highest modeled environmental releases as reported within the *Draft Environmental Media and General Population Screening for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025c). The Import-Repackaging OES resulted in the highest environmental releases to surface water and sediment. The Formulation of Adhesives and Sealants (Neat D4) OES resulted in the highest environmental releases to soil from biosolid applications. Although terrestrial hazard data for D4 were not available for mammalian wildlife species, studies in laboratory animals were used to derive hazard values for mammalian species (U.S. EPA, 2025b). Specifically, empirical toxicity data for rats and rabbits were used to estimate a TRV for terrestrial mammals at 95 of mg/kg-bw/day (U.S. EPA, 2025b) based on the *Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)* (U.S. EPA, 2003).

Trophic magnification through dietary exposure of aquatic organisms was calculated in seven biomonitoring studies across multiple trophic levels with a mean TMF of 0.79 (Cui et al., 2019; Powell et al., 2018; Powell et al., 2017; Jia et al., 2015; McGoldrick et al., 2014a; Borgå et al., 2013; Powell et al., 2009). TMF did not vary by freshwater vs. saltwater environments, by D4 concentration in water, or by trophic level for lipid-normalized D4 concentrations in biota (Section 3.1). Therefore, EPA does not expect D4 to biomagnify across trophic levels.

Results for calculated dietary exposures of D4 to mammals from modeled concentrations within relevant pathways such as water, sediment, and soil indicated exposure concentrations below the TRV. The conclusion of screening level trophic transfer analyses for aquatic-dependent mammals with exposure pathways for surface water and sediment are presented within Table 7-1. Maximum concentrations of D4 reported from the ECA report were also used to calculate dietary exposure estimates. Maximum D4 concentrations from modeled and monitored data presented no exposure of D4 greater than the calculated TRV from the screening level trophic transfer analysis. Similarly, the screening level trophic transfer analysis for terrestrial mammals based on the highest modeled and monitored releases of D4 from biosolid application to soil also resulted in dietary exposure concentrations below the TRV (Table 7-2). Exposure pathways with aquatic-dependant mammals and terrestrial mammals as receptors were not examined further since, even with conservative assumptions, dietary D4 exposure concentrations from this analysis are not equal to or greater than the TRV. These results align with previous studies indicating that D4 has limited biomagnification potential as summarized within (U.S. EPA, 2025e).

The screening level trophic transfer analyses were conducted with both modeled D4 concentrations from COU/OESs for different media of release and exposure pathways, and maximum values reported in ECA reports for surface water, sediment, and soil. Differences in D4 exposure value results between modeled and monitored data could reflect COU/OES based variables and the role of low flow conditions applied for the modeled data. Specifically, the modeled data used a P75 7Q10 flow scenario while the ECA collected media samples under normal annual flow conditions. Modeled concentrations of D4 within surface water and sediment from hypothetical facility surface water releases have a confidence rank of slight as reported within the *Draft Environmental Media and General Population Screening for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025c). The slight confidence rank is due to the bias toward overestimation, but robust confidence that no surface water release scenarios exceed the concentrations presented in this screening level assessment. The inclusion of modeled sediment concentrations of D4 from 75th percentile 7Q10 flow rates demonstrate conservative dietary exposure rates of D4 for representative mammals based on low flow conditions from COU/OES with the highest release to surface water and sediment. Conservative approaches within both environmental media modeling (*e.g.*, BST and VVWM-PSC) and the screening level trophic transfer analysis likely overrepresent D4 ability to transfer among the trophic levels, however, this increases confidence that risks are not underestimated. The screening level trophic transfer assessments for terrestrial invertebrates, mammals, and aquatic dependent mammals has moderate confidence that D4 exposures from the highest release exposure scenarios are well below the hazard thresholds that would present risk.

Table 7-1. Dietary Exposure Estimates for Mammals Representing the Highest Modeled Environmental Releases to Surface Waters and D4 in Sediment and Soil from Biosolid Application

COU (Life Cycle Stage[a]/Category[b]/Subcategory[c])	OES	Media of Release/ Exposure Pathway[d]	Mink D4 Dietary Exposure (mg/kg bw/day)	D4 TRV for Mammals (mg/kg bw/day)[e]
Processing/Processing – Repackaging/All other basic inorganic chemical manufacturing; all other chemical product and preparation manufacturing; miscellaneous manufacturing	Importing-Repackaging	Surface water/ sediment (P75 7Q10: 226,528 mg^3/day)	53.94	95
D4 Environmental Testing Report, ECA (ERM, 2017)	DD3 WWTP	Surface water/ sediment	1.22	

Published Literature

Sample Collection Conditions/Location	Reference	D4 Sediment Concentration (mg/kg)	D4 Surface Water Concentration (µg/L)
Maximum mean concentration of D4 reported within reasonably available published literature in sediment and seawater was from Huanghai Sea near Dalian, China	Hong et al. (2014)	6.71E–04	6.93E–03

ECA = Enforceable Consent Agreement; DD = Direct discharge; WWTP = Wastewater treatment plant
[a] Life Cycle Stage Use Definitions (40 CFR 711.3):
– "Industrial use" means use at a site at which one or more chemicals or mixtures are manufactured (including imported) or processed.
– "Commercial use" means the use of a chemical or a mixture containing a chemical (including as part of an article) in a commercial enterprise providing saleable goods or services.
– Although EPA has identified both industrial and commercial uses here for purposes of distinguishing scenarios in this document, the Agency interprets the authority over "any manner or method of commercial use" under TSCA section 6(a)(5) to reach both.
[b] These categories of conditions of use appear in the Life Cycle Diagram, reflect CDR codes, and broadly represent conditions of use of D4 in industrial and/or commercial settings.
[c] These subcategories reflect more specific conditions of use of D4.
[d] Sediment concentrations for screening level trophic transfer analysis represented with 75th percentile 7Q10 flow rates.
[e] Toxicity Reference Value (TRV) for mammals calculated using empirical toxicity data for rats as detailed within the Environmental Hazard Assessment for D4 Technical Support Document (U.S. EPA, 2025b).

Table 7-2 Dietary Exposure Estimates for Terrestrial Mammal Representing the Highest Modeled Environmental Releases of D4 in Soil

COU (Life Cycle Stage[a]/Category[b]/Subcategory[c])	OES	Media of Release/ Exposure Pathway[d]	Shrew D4 Dietary Exposure (mg/kg bw/day)	D4 Terrestrial Hazard Thresholds
Earthworm				
Processing/Processing as a reactant/Adhesives and sealant chemicals	Formulation of adhesives and sealants (Neat D4)	Biosolid application to soil	2.1845	98.7 (mg/kg)
ECA industrial – 95th percentile (ERM, 2017)	Maximum crop		4.90E–02	
Short-tailed Shrew				
Processing/Processing as a reactant/Adhesives and sealant chemicals	Formulation of adhesives and sealants (Neat D4)	Biosolid application to soil	1.25	95 (mg/kg bw/day)[d]
ECA industrial – 95th percentile (ERM, 2017)	Maximum crop		2.80E–02	

Published Literature

Sample Collection Conditions/Location	Reference	D4 Sediment Concentration (mg/kg)
Maximum mean concentration of D4 reported within reasonably available published literature in soil was from a remote location in the Shetland Islands, Antarctica	Sanchis et al. (2015)	0.0143

[a] Life Cycle Stage Use Definitions (40 CFR 711.3):
– "Industrial use" means use at a site at which one or more chemicals or mixtures are manufactured (including imported) or processed.
– "Commercial use" means the use of a chemical or a mixture containing a chemical (including as part of an article) in a commercial enterprise providing saleable goods or services.
– Although EPA has identified both industrial and commercial uses here for purposes of distinguishing scenarios in this document, the Agency interprets the authority over "any manner or method of commercial use" under TSCA section 6(a)(5) to reach both.

[b] These categories of conditions of use appear in the Life Cycle Diagram, reflect CDR codes, and broadly represent conditions of use of D4 in industrial and/or commercial settings.

[c] These subcategories reflect more specific conditions of use of D4.

[d] Toxicity Reference Value (TRV) for mammals calculated using empirical toxicity data for rats as detailed within the Environmental Hazard Assessment for D4 Technical Support Document (U.S. EPA, 2025b).

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