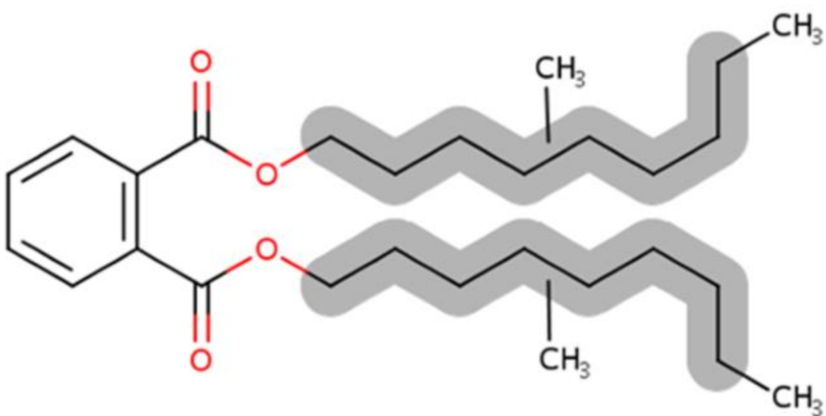
United States
Environmental Protection Agency

December 2024
Office of Chemical Safety and
Pollution Prevention

Environmental Exposure Assessment for Diisodecyl Phthalate (DIDP)

Technical Support Document for the Risk Evaluation

CASRNs: 26761-40-0 and 68515-49-1



(Representative Structure)

December 2024

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KEY ABBREVIATIONS AND ACRONYMS

7Q10	Lowest 7-day flow in a 10 year period
ADME	Absorption, distribution, metabolization, and excretion
AERMOD	AMS/EPA Regulatory Model
AUF	Area Use Factor
BAF	Bioaccumulation factor
BCF	Bioconcentration factor
BSAF	Biota to Sediment Accumulation Factor
CDR	Chemical Data Reporting (rule)
COU	Condition of use
DIDP	Diisodecyl phthalate
DPE	Dialkyl phthalate esters
EPA	(U.S.) Environmental Protection Agency (or the Agency)
FIR	Feed intake rate
NAICS	North American Industry Classification System
OES	Occupational exposure scenario
PVC	Polyvinyl chloride
SIR	Sediment intake rate
TRV	Toxicity reference value
TSD	Technical support document
VVWM-PSC	Variable Volume Water Mode – Point Source Calculator
WIR	Water intake rate

SUMMARY

EPA evaluated the reasonably available information for environmental exposures of DIDP to aquatic and terrestrial species. The key points of the environmental exposure assessment are summarized below.

- EPA expects the main environmental exposure pathway for DIDP to be released to surface water and subsequent deposition to sediment. The ambient air exposure pathway was also assessed for its limited contribution via deposition to soil, water, and sediment.
- DIDP exposure to aquatic species via surface water and sediment were modeled to estimate concentrations from the Toxic Substances Control Act (TSCA) condition of use (COU) and occupational exposure scenario (OES) that resulted in the highest environmental media concentrations. Concentrations of DIDP in representative organisms for the screening level trophic transfer analysis were calculated using modeled sediment concentrations from the Variable Volume Water Mode – Point Source Calculator (VVWM-PSC; Section 3.2.1).
- Based on a solubility of 1.7×10^{-4} mg/L and the predicted bioconcentration factor (BCF) of 1.29 L/kg, the calculated concentration of DIDP in fish was 2.2×10^{-4} mg/kg, which was two orders of magnitude lower than the highest DIDP measured concentrations reported in aquatic biota in peer-reviewed literature. Chironomid DIDP concentrations calculated using a Biota to Sediment Accumulation Factor of 0.6 ranged from 9.7 mg/kg bw to 16,560 mg/kg bw represented by 90th, 75th, and 50th percentile of the lowest 7-day flow in a 10-year period flows (7Q10) modeled within VVWM-PSC from the COU/OES with highest release to sediment (Table 3-1). Calculated concentrations of DIDP within chironomids were two to six orders of magnitude greater than the highest concentrations reported in the literature.
- Deposition of DIDP from air was modeled via the AMS/EPA Regulatory Model (AERMOD), then daily deposition values were modeled with VVWM-PSC to represent surface water and sediment concentrations (Section 3.2.2).
- Exposure to terrestrial species through soil via air deposition was also assessed using data modeled using AERMOD (Section 4.2).
- DIDP is not considered bioaccumulative, however, within the aquatic environment, relevant environmental exposures are possible through incidental ingestion of sediment while feeding and/or ingestion of food items that have become contaminated due to uptake from sediment.
- Exposure through diet was assessed through a trophic transfer analysis (Section 5.1) with representative species (Figure 5-1), which estimated the transfer of DIDP from soil through the terrestrial food web (Table 5-3), from surface water and sediment through the aquatic food web via releases to surface waters (Table 5-4, Table 5-5), and air deposition to surface water and sediment (Table 5-6, Table 5-7).
- The highest OES estimate (PVC plastics compounding) resulted in DIDP exposure concentrations in a modeled terrestrial ecosystem of 0.051 mg/kg-bw/day in the earthworm (*Eisenia fetida*) consuming soil with an estimated dietary intake of 0.03 mg/kg-bw/day in shorttail shrews (*Blarina brevicauda*).
- Within the aquatic modeled ecosystem, the highest OES estimate (PVC plastics compounding) resulted in a DIDP exposure concentration of 401 mg/kg in the blacktail redhorse (*Moxostoma poecilurum*) consuming chironomids (midges) and resulted in an estimated dietary intake of 92.4 mg/kg-bw/day in American mink (*Mustela vison*).

1 INTRODUCTION

EPA assessed DIDP 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 to air and subsequent deposition to soil or water and sediment. Approaches for calculated and monitored concentrations of DIDP 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 DIDP 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. This analysis was performed quantitatively only when environmental media concentrations were quantified for the appropriate exposure scenario. For example, exposure from soil or groundwater resulting from DIDP release to the environment via biosolids or landfills was not quantitatively assessed because DIDP concentrations to the environment from biosolids and landfills was not quantified. Details on considerations for these land pathways are provided in Section 9 of the *Environmental Media and General Population Exposure for Diisodecyl Phthalate (DIDP)* (U.S. EPA, 2024b) with qualitative risk estimates discussed within the environmental risk characterization presented within Section 5.3 of the Risk Evaluation for DIDP (U.S. EPA, 2024e).

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

COU (Life Cycle Stage[a]/ Category[b]/ Sub-Category[c])	OES	Media of Release	Exposure Pathway	Receptors
Processing/ Incorporation into formulation, mixture, or reaction product/ Plastic material and resin manufacturing	PVC plastics compounding	Surface water or wastewater	Surface water, sediment	Aquatic species and Aquatic dependent mammals
Processing/ Incorporation into formulation, mixture, or reaction product/ Other (part of the formulation for manufacturing synthetic leather)				
Processing/ Incorporation into formulation, mixture, or reaction product/ Plastic material and resin manufacturing	PVC plastics compounding	Fugitive or stack air release	Air deposition to surface water, sediment	Aquatic species and Aquatic dependent mammals
Processing/ Incorporation into formulation, mixture, or reaction product/ Other (part of the formulation for manufacturing synthetic leather)				
Processing/ Incorporation into formulation, mixture, or reaction product/ Plastic material and resin manufacturing	PVC Plastics compounding	Fugitive or stack air release	Air deposition to soil	Terrestrial mammals
Processing/ Incorporation into formulation, mixture, or reaction product/ Other (part of the formulation for manufacturing synthetic leather)				

COU (Life Cycle Stage[a]/ Category[b]/ Sub-Category[c])	OES	Media of Release	Exposure Pathway	Receptors

[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 COUs appear in the life cycle diagram, reflect Chemical Data Reporting (CDR) rule codes, and broadly represent conditions of use of DIDP in industrial and/or commercial settings.

[c] These subcategories reflect more specific COU of DIDP.

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—VVWM-PSC and AERMOD. Additional information on these models is available in the E*nvironmental Media and General Population Exposure for Diisodecyl Phthalate (DIDP)* technical support document (TSD) (U.S. EPA, 2024b). EPA modeled DIDP in surface water, benthic pore water, and sediment concentrations using VVWM-PSC. Both VVWM-PSC and AERMOD were used to model aquatic media concentrations from air deposition. EPA modeled DIDP concentrations in soil via air deposition near facility using AERMOD.

EPA determined exposures of DIDP to aquatic-dependent terrestrial species through surface water and sediment using modeled data and to terrestrial species through soil concentrations based on modeled daily air deposition from fugitive and stack releases of DIDP. Specifically, exposures to aquatic dependent wildlife used modeled DIDP concentrations in sediment from VVWM-PSC for highest release COU and OES in combination with DIDP fish and chironomid concentrations derived using reasonably available BCF and Biota to Sediment Accumulation Factor (BSAF) values, respectively, in a screening level trophic transfer analysis. Soil concentrations from the COU/OES with the highest daily deposition from air to soil is used to demonstrate DIDP 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 the *Guidance for Developing Ecological Soil Screening Levels* (U.S. EPA, 2005).

3 EXPOSURES TO AQUATIC SPECIES

3.1 Measured Concentrations in Aquatic Species

Studies on DIDP concentration in aquatic species within the pool of reasonably available information were primarily coupled with larger investigations on dialkyl phthalate esters (DPE). Concentrations of DIDP within several different aquatic species originate from four previously published studies.

Lin et al. (2003) sampled sediment and striped seaperch (*Embiotoca lateralis*) at three locations along False Creek Harbor, Vancouver, British Columbia, Canada. This location was characterized by the authors as an urbanized marine ecosystem. A majority of this published work was centered on refinement of analytical methodology for phthalate ester quantification. Concentrations of DIDP in striped seaperch muscle tissue were graphically reported in µg/kg wet weight for the three sites as less than 0.01 mg/kg wet weight. This study provided groundwork for further sampling and analysis on DIDP concentrations in biota from this same marine environment and author group (Blair et al., 2009; McConnell, 2007; Mackintosh et al., 2004).

Mackintosh et al. (2004) surveyed 18 species representing four trophic levels collected between June and September of 1999 within the marine environment of False Creek Harbor, Vancouver, British Columbia, Canada. Mean DIDP concentrations were reported in six out of the eight fish species, ranging from 5.75×10^{-3} mg/kg to 13.8 mg/kg equivalent lipid in spiny dogfish (*Squalus acanthias*) whole embryos and striped seaperch muscle tissue, respectively. Mean concentration of DIDP in whole Juvenile shiner pearch (*Cymatogaster aggregata*) were 8.36×10^{-3} mg/kg wet weight. For aquatic invertebrates and algae, mean DIDP concentrations were recorded in nine out of the nine species sampled, ranging from 0.043 mg/kg to 7.41 mg/kg equivalent lipid in purple seastar (*Pisaster ochraccus*) cross-sections and whole plankton samples, respectively.

Additional aquatic biota sampled at False Creek Harbor, Vancouver, British Columbia, Canada, were collected from July to September 2005 and resulted in DIDP concentrations recorded for seven out of eight aquatic species (McConnell, 2007). The two highest geometric mean concentrations of DIDP within aquatic organisms were recorded for green algae and juvenile shiner perch at 0.091 mg/kg and 0.057 mg/kg wet weight, respectively. Grouping DPE congeners, authors noted that dogfish concentrations in muscle were significantly higher in 2005 collections vs. the collections from 1999 reported within Mackintosh et al. (2004), while clam DPE concentrations were statistically unchanged between sample periods.

In a study primarily centered on mono-alkyl phthalate ester concentrations within seawater, sediment and aquatic species collected between 2004 to 2006 at False Creek Harbor, Vancouver, British Columbia, Canada, Blair et al. (2009) reported DIDP concentrations for blue mussel (*Mytilus edulis*). Geometric mean DIDP concentrations for blue mussel was reported graphically as approximately 0.008 mg/kg wet weight. Authors noted that concentrations of DIDP within biota were low compared to the predominance of the compounds within water and sediment as graphically reported at less than 7.0×10^{-5} mg/L and less than 0.12 mg/kg dry weight, respectively.

3.2 Calculated Concentrations in Aquatic Species

3.2.1 Releases to Surface Water

Concentrations of DIDP in representative organisms within the screening level trophic transfer analysis were calculated using modeled surface water and sediment concentrations from VVWM-PSC.

Surface water concentrations of DIDP modeled with VVWM-PSC by COU/OES water releases exceeded the estimates of the water solubility limit for DIDP which is approximately 1.7×10^{-4} mg/L (U.S. EPA, 2024c) by up to five orders of magnitude. DIDP sorbed onto suspended solids in the water column could lead to DIDP amounts greater than solubility concentrations. However, these molecules would likely not be available for incorporation into aquatic organisms (*i.e.*, epithelial uptake from skin and/or gills) due to sorption and its physical and chemical properties. DIDP has the potential to remain for longer periods of time in soil and sediments due to the inherent hydrophobicity (log K_{OW} = 10.21) and sorption potential (log K_{OC} = 5.04–6.00). Furthermore, within the water column, high sorption coefficients indicate that freely dissolved and bioavailable concentrations would be very low and further decreased by DIDP's low water solubility (Mackintosh et al., 2006). Therefore, EPA expects that the main pathway for exposure to DIDP in the aquatic and terrestrial environments is through direct consumption of contaminated food sources and incidental ingestion of contaminated media (Mackintosh et al., 2004).

A predicted fish BCF (Arnot-Gobas method) of 1.29 L/kg was used to represent uptake of DIDP from surface water exposure to fishes (U.S. EPA, 2017a). Based on a solubility of 1.7×10^{-4} mg/L and the predicted BCF of 1.29 L/kg, the calculated concentration of DIDP in fish is 2.2×10^{-4} mg/kg, which was two orders of magnitude lower than the highest DIDP concentrations reported within aquatic biota presented in Section 3.1. For example, whole body concentrations of DIDP reported for juvenile shiner perch were 8.4×10^{-3} and 5.7×10^{-2} mg/kg wet weight in Mackintosh et al. (2004) and McConnell (2007), respectively.

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 DIDP concentrations calculated using a BSAF of 0.6 (Brown et al., 1996) and DIDP concentrations resulting from median, 75th, and 90th percentile 7Q10 flow rates were 16,560 mg/kg bw, 1,650 mg/kg bw, and 9.78 mg/kg bw, respectively, for the COUs and OES with the highest surface water release and resulting sediment concentration (Table 3-1). Sediment and surface water concentrations modeled with VVWM-PSC do not limit media concentrations based on water solubility and maximum saturation of DIDP in sediment. Calculated concentrations of DIDP within chironomids are two to five orders of magnitude greater than the highest concentrations recorded with aquatic biota presented in Section 3.1.

Modeled values from VVWM-PSC for surface water and sediment based on COU/OES estimated water releases from hypothetical facilities resulted in DIDP concentrations within surface water and sediment with a confidence rank of slight as reported within the *Environmental Media and General Population Exposure for Diisodecyl Phthalate (DIDP)* (U.S. EPA, 2024b). Modeled concentrations of DIDP within sediment represent bounds of values based on different percentile 7Q10 flows (median, 75th and 90th percentile) from the distribution of pooled flow data of relevant NAICS codes representing specific COU/OES. Table 3-1 also presents maximum concentrations of DIDP in sediments within the reasonably available literature. These values from published literature should be considered to represent

DIDP concentrations from ambient monitoring and not directly comparable to COUs and OESs within the current risk evaluation.

Table 3-1. Calculated DIDP Chironomid Concentrations from VVWM-PSC Modeled Values of DIDP in Sediment and Published Literature

COU (Life Cycle Stage[a]/ Category[b]/ Sub-Category[c])	OES	Flow Rate (m^3/day)	Annual Release per Site (kg/site-yr^{-1}) [d]	Sediment Concentration (mg/kg) [e]	Calculated Chironomid Concentration (mg/kg bw)
Processing/ Incorporation into formulation, mixture, or reaction product/ Plastic material and resin manufacturing	PVC plastics compounding	P50 7Q10: 17,616	33,786	27,600	16,560
Processing/ Incorporation into formulation, mixture, or reaction product/ Other (part of the formulation for manufacturing synthetic leather)		P75 7Q10: 178,012	33,786	2,750	1,650
		P90 7Q10: 3.01E07	33,786	16.3	9.78
Published Literature					
Sample collection conditions/ location		Reference (overall quality determination)		Sediment concentration (mg/kg)	Calculated chironomid concentration (mg/kg bw)
Maximum concentration of DIDP within sediments/ Industrialized harbor, Kaohsiung Harbor, Taiwan		(Chen et al., 2016) (Medium)		3.7 $\pm$ 1.1	2.22
Maximum concentration of DIDP within sediments/ urban areas in Sweden collected by the Swedish National Screening Program, Swedish Environmental Research Institute		(Cousins et al., 2007) (Medium)		3.4	2.04
Maximum concentration of DIDP within sediments/ urbanized ecosystem, False Creek Harbor, Vancouver, British Columbia, Canada		(Mackintosh et al., 2006) (High)		0.58	0.34

[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 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 COU appear in the life cycle diagram, reflect CDR codes, and broadly represent COUs of DIDP in industrial and/or commercial settings
[c] These subcategories reflect more specific COUs of DIDP
[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 DIDP. Sediment and

COU (Life Cycle Stage[a]/ Category[b]/ Sub-Category[c])	OES	Flow Rate (m^3/day)	Annual Release per Site (kg/site-yr^{-1}) [d]	Sediment Concentration (mg/kg) [e]	Calculated Chironomid Concentration (mg/kg bw)
surface water concentrations modeled with VVWM-PSC do not limit media concentrations based on water solubility and maximum saturation of DIDP in sediment.					

3.2.2 Releases to Air

Deposition of DIDP from air was modeled via AERMOD, then an analysis in VVWM-PSC modeled surface water and sediment concentrations based on these daily deposition values. This latter analysis was performed for the OES with the highest release to air data, which was the PVC plastics compounding OES. Air deposition to sediment and water modeling is described in Section 2 of the *Environmental Media and General Population Exposure for Diisodecyl Phthalate (DIDP)* TSD (U.S. EPA, 2024b). AERMOD was used to assess the estimated release of DIDP via air deposition from specific exposure scenarios to water and sediment. This modeling represents the highest COU/OES based estimated daily deposition rate of DIDP onto water and sediment via air deposition at 1,000 m from a hypothetical release source. At 1,000 m, the Plastic compounding OES fugitive source resulted in the highest deposition rate of 8.5×10^{-3} g/m^2 per day. A full table of deposition rates across all OESs is in U.S. EPA (2024b). Using VVWM-PSC as described within Section 3 within U.S. EPA (2024b), the highest daily deposition rate at 1,000 m resulted in a surface water concentration of 9.5×10^{-5} mg/L and deposition to sediment resulted in a sediment concentration of 0.35 mg/kg from the Plastic compounding/PVC plastic compounding COU/OES. Chironomid DIDP concentration calculated from modeled air deposition to sediment (VVWM-PSC) and BSAF of 0.6 (Brown et al., 1996) is 0.21 mg/kg-bw. The further use of DIDP concentrations in surface water and sediment from air deposition is detailed in Section 5.1.

4 EXPOSURES TO TERRESTRIAL SPECIES

4.1 Measured Concentrations in Terrestrial Species

Studies representing measured concentrations in terrestrial species are represented largely by investigations of domesticated mammals such as cats, dogs, and pigs (Yue et al., 2020; Braouezec et al., 2016) and do not represent ecologically relevant DIDP exposure conditions for terrestrial wildlife species. One study, described previously in Section 3.1, provides data on aquatic species concentrations of DIDP, including the marine avian species *Melanitta perspicillata* (Mackintosh et al., 2004). The authors reported a liver DIDP concentration of 1.41 mg/kg lipid equivalent based on a wet weight concentration of 0.031 mg/kg and mean lipid content of 2.2 percent.

4.2 Calculated Concentrations in Terrestrial Species

Air deposition to soil modeling is described in Section 2 of the *Environmental Media and General Population Exposure for Diisodecyl Phthalate (DIDP)* TSD (U.S. EPA, 2024b). AERMOD was used to assess the estimated release of DIDP via air deposition from specific exposure scenarios to soil. AERMOD modeling represents the highest and lowest COU/OES based estimated daily deposition rate of DIDP onto soil via air deposition at 1,000 m from a hypothetical release source. At 1,000 m, the PVC plastics compounding OES fugitive source resulted in the highest deposition rate of 8.5×10^{-3} g/m^2 per day and paint and coating manufacturing OES stack source resulted in the lowest deposition rate of 2.8×10^{-14} g/m^2 per day. A full table of deposition rates across all OESs is in U.S. EPA (2024b). Using equations 5.1.1-1 and 5.1.1-2 from the Environmental Media TSD (U.S. EPA, 2024b), the highest daily deposition rate at 1,000 m resulted in a soil concentration of 0.051 mg/kg from the Plastic compounding/PVC plastic compounding COU/OES (U.S. EPA, 2024b). The highest concentration of DIDP reported in rural soil within reasonably available published literature is 0.013 mg/kg (Tran et al., 2015). The further use of DIDP concentrations in soil from AERMOD and published literature is detailed in Section 5.1.

5 TROPHIC TRANSFER

The *Fate Assessment for Diisodecyl Phthalate (DIDP)* TSD determined that DIDP is expected to have a low potential for both short- and long-term bioaccumulation and biomagnification in both aquatic and terrestrial organisms (U.S. EPA, 2024c). Results of Level III Fugacity modeling indicate DIDP is expected to partition primarily to soil and sediment (U.S. EPA, 2024c). DIDP is not expected to undergo long-range transport and is expected to be found predominantly in sediments near point sources, with a decreasing trend in sediment concentrations downstream. This is primarily due to strong affinity and sorption potential for organic carbon in soil and sediment (see Sections 4 and 5 of the Fate Assessment TSD (U.S. EPA, 2024c)). Strong sorption to organic matter and low water solubility suggests that DIDP is expected to have limited bioavailability in soils, which is supported by reported BCF values within earthworms (*Eisenia fetida*) of 0.1 to 0.2 L/kg (ECJRC, 2003). In an extensive investigation of the field based trophodynamics of dialkyl phthalate esters and polychlorinated biphenyls, Mackintosh et al. (2004) determined a food-web magnification factor of 0.44 for DIDP. DIDP is not considered bioaccumulative, however, within the aquatic environment relevant environmental exposures are possible through incidental ingestion of soil or sediment while feeding and/or ingestion of food items that have become contaminated due to uptake from soil or sediment. The species within the screening level trophic transfer analysis were not selected based on sensitivity to DIDP or hazard data but rather their representation as prey, predators, or feeding ecology that could potentially result in uptake of DIDP within media such as soil and sediment and concentrations of DIDP in diet.

Trophic transfer is the process by which chemical contaminants can be taken up by organisms through diet and media exposures and be transferred from one trophic level to another. Through dietary consumption of prey, the contaminant can subsequently be transferred from one trophic level to another. EPA has assessed the available studies collected in accordance with the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances, Version 1.0: A Generic TSCA Systematic Review Protocol with Chemical-Specific Methodologies* (U.S. EPA, 2021a) and Final Scope of the Risk Evaluation for DIDP (U.S. EPA, 2021b) relating to the biomonitoring of DIDP. 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 (Mackintosh et al., 2004). Phthalate ester chemicals and their absorption, distribution, metabolization, and excretion (ADME) in finfish are of interest due to their ubiquity as plasticizers (Hu et al., 2016; Melancon and Lech, 1976). DIDP first metabolizes into its mono-ester form of monoisodecyl phthalate (MIDP) before undergoing oxidation for eventual excretion in urine and/or fecal matter (Kato et al., 2007). Additional details on ADME within mammals is available within Section 2, Toxicokinetics, within the *Human Health Hazard Assessment for Diisodecyl Phthalate* (U.S. EPA, 2024d). Although ADME for DIDP in finfish was not identified within the reasonably available literature, studies on ADME from oral exposure to DIDP within mammals indicate that this compound is metabolized and excreted. 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 (U.S. EPA, 1993) are chosen to connect the DIDP transport exposure pathway via terrestrial trophic transfer from earthworm uptake of DIDP from contaminated soil to the representative worm-eating mammal, the short-tailed shrew (*Blarina brevicauda*). Short-tailed shrews 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 DIDP exposure from soil uptake by earthworms and the transfer of DIDP through diet to higher trophic levels used maximum soil concentrations from AERMOD modeling of deposition from air to soil in Section 4.2. Because surface water sources for wildlife water ingestion are typically ephemeral, the trophic transfer analysis for terrestrial organisms assumed DIDP exposure concentration for wildlife water intake are equal to Surface water concentration of DIDP (VVWM-PSC) limited to water solubility reported within the Fate Assessment TSD (U.S. EPA, 2024c).

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 DIDP modeled using VVWM-PSC represent the high-end annual release per COU/OES and were used as a surrogate for the DIDP 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 DIDP within sediment through ingestion of sediment containing DIDP during feeding. 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 (*Moxostoma macrolepidotum*) sampled within the Kankakee River drainage resulted in a mean of approximately 42 percent unidentified inorganic matter and sand (Sule and Kelly, 1985, 11361932). 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 aquatic and terrestrial risk estimation based on exposure via trophic transfer using conservative assumptions for factors such as area use factor, fraction of DIDP absorbed from diet, soil, sediment, and water. Within the aquatic environment, DIDP is expected to be found predominantly in sediments near point sources based on sorption, with a decreasing trend in sediment concentrations downstream. Concentration of DIDP within *Chironomus riparius* were calculated using the biota to sediment accumulation factor of 0.6 (concentration in animal dry weight/ concentration in sediment dry weight) within Brown et al. (1996) and the VVWM-PSC-modeled concentrations of DIDP within the sediment representing median, 75th, and 90th percentile 7Q10 flow rates. Section 3.2, Calculated Concentrations in Aquatic Species, reports estimated concentrations of DIDP within *C. riparius* based on the BSAF reported within Brown et al. (1996). 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.

Following the basic equations as reported in Chapter 4 of the *Guidance for Developing Ecological Soil Screening Levels* (U.S. EPA, 2005), wildlife receptors may be exposed to contaminants in soil by two main pathways—incidental ingestion of soil while feeding, and 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 DIDP, and for aquatic-dependent mammals, ingestion of DIDP within sediment instead of soil:

Equation 5-1. Terrestrial and Aquatic Mammals

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

Equation 5-2. Fish

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

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; sediment intake rate (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 DIDP 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
WIR	1	0.223[b]
W_j	NA	0.00017 mg/L[c] DIDP
AF_{wj}	1	1
AF_{ij}	1	1

Term	Earthworm (*Eisenia fetida*)	Short-Tailed Shrew (*Blarina brevicauda*)
N	1	1
AUF	1	1
S_j [c]	*x* mg/kg DIDP[d]	*x* mg/kg DIDP[d]
B_{ij}	*x* mg/kg DIDP[e] (soil)	*x* mg/kg DIDP (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). [c] Surface water concentration of DIDP (VVWM-PSC) limited to water solubility reported within the Fate Assessment TSD [d] DIDP concentration in soil and soil pore water for Earthworm and Short-Tailed Shrew [e] Highest daily soil concentration of DIDP reported from the PVC plastic compounding OES		

Table 5-2. Terms and Values Used to Assess Potential Trophic Transfer of DIDP in Aquatic 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	*x* mg/kg [i] DIDP	*x* mg/kg [i] DIDP
W_j	0.00017 mg/L[j] DIDP	*x* mg/L [k] DIDP
B_{ij}	*x* mg/kg [l] *C. riparius*	*x* mg/kg [m] Fish

Term	Blacktail redhorse (*Moxostoma poecilurum*)	American Mink (*Mustela vison*)

[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 = 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, 2017b).
[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 DIDP obtained using VVWM-PSC modeling for each respective COU/OES presented in Table 3-1.
[j] Surface water concentration of DIDP (VVWM-PSC) limited to water solubility reported within the Chemistry and Fate Technical Support Document.
[k] Surface water concentration of DIDP obtained using VVWM-PSC modeling for each respective COU/OES.
[l] Chironomid DIDP concentration (mg/kg) calculated from modeled sediment concentration of DIDP (VVWM-PSC) and BSAF of 0.6 (Brown et al., 1996) presented in Table 3-1.
[m] Fish DIDP Dietary Exposure Rate (mg/kg bw/day) represented from application of Equation 5-3.

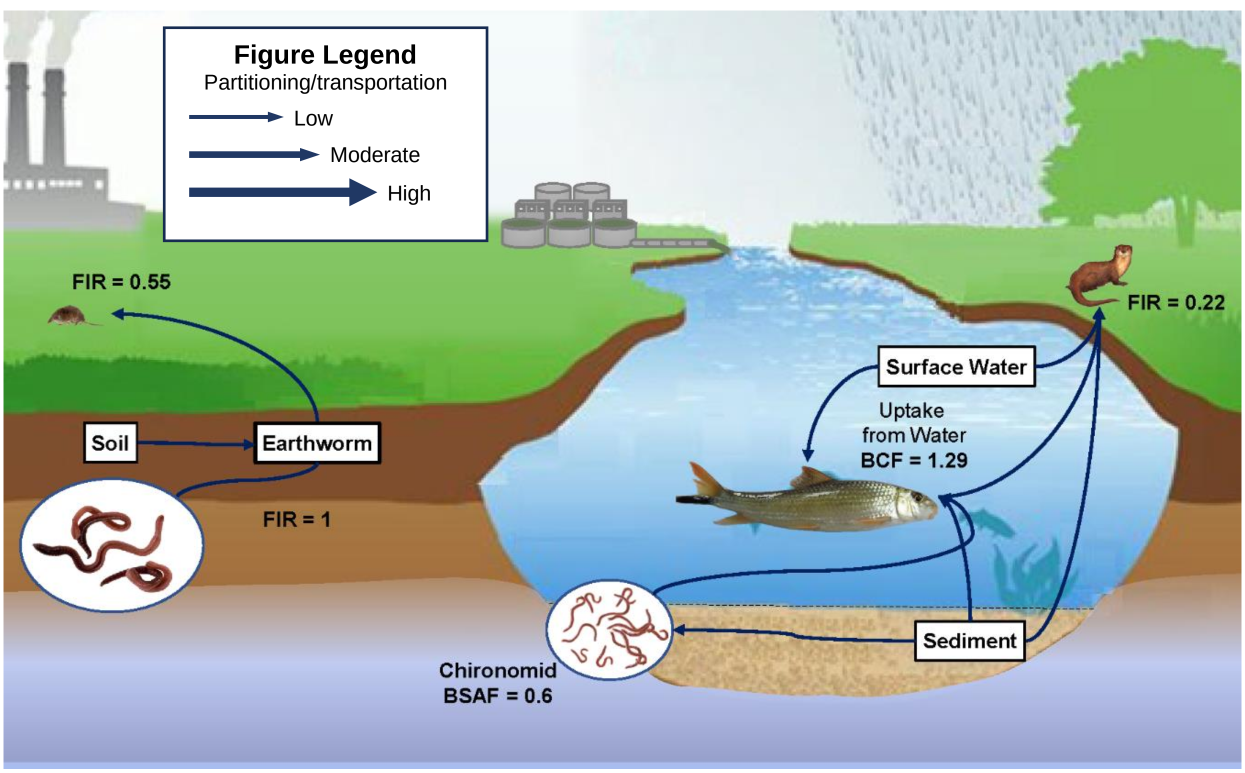

Figure 5-1. Trophic Transfer of DIDP in Aquatic and Terrestrial Ecosystems

At the screening level, the conservative assumption is that the invertebrate diet for the short-tailed shrew is comprised on entirely earthworms from contaminated soil. The screening level analysis for trophic transfer of DIDP to the short-tailed shrew used the highest calculated soil contaminate concentration to determine if a more detailed assessment is required. The highest concentration of DIDP in soil from modeled air to soil deposition at 1,000 m from a hypothetical release site is from the PVC plastics compounding OES at 0.051 mg/kg per day. Comparatively, the highest reported soil concentration of DIDP reported within the reasonably available literature is from Tran et al. (2015), reporting a DIDP concentration of 0.013 mg/kg in rural soil (Doue, Seine-et-Marne, France; population 1,029).

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, 2017b). 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, 2017b). For the purposes of the current screening level trophic transfer analysis using the blacktail redhorse, EPA has used a geometric mean of 0.32 for P_s as the proportion of total food intake that is sediment (kg sediment/kg food) from previously detailed 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, 2017b). As a conservative assumption, the American mink's diet is comprised of fish as a prey item while the fish diet is comprised of chironomids as a prey item. Similarly, the short-tailed shew was assumed to have diet comprised of entirely earthworms.

The highest concentrations of DIDP in soil are reported as the highest daily deposition rate from air to soil in mg/kg per day which originate from the PVC plastics compounding OES (Section 4.2). Sediment concentrations modeled via VVWM-PSC were used to represent DIDP 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 DIDP. 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 5-3 for trophic transfer to shrew from the maximum and minimum concentrations modeled from AERMOD. Table 5-4 and Table 5-5 for trophic transfer from surface water release of DIDP to fish consuming chironomids and mink consuming fish, respectively. Table 5-6 and Table 5-7 represent calculated dietary exposure values from air deposition to surface water and sediment to fish consuming chironomids and mink consuming fish, respectively. Chironomid concentrations (mg/kg) were calculated using sediment concentrations of DIDP, respectively, from VVWM-PSC and are previously reported in Section 3.2.

Table 5-3. Dietary Exposure Estimates Using EPAs Wildlife Risk Model for Eco-SSLs for Screening Level Trophic Transfer of DIDP (Air Deposition to Soil) to Short-Tailed Shrew

COU (Life Cycle Stage/ Category/ Sub-category)	OES	Earthworm DIDP Concentration (mg/kg bw) [a]	DIDP Dietary Exposure Rate (mg/kg bw/day) [b]
Processing/ Incorporation into formulation, mixture, or reaction product/ Plastic material and resin manufacturing	PVC plastics compounding	0.051	0.03
Processing/ Incorporation into formulation, mixture, or reaction product/ Other (part of the formulation for manufacturing synthetic leather)			
Published literature [c]			
Tran et al. (2015)		0.013	7.47E–03

[a] Estimated DIDP concentration in representative soil invertebrate, earthworm, assumed equal to aggregated highest calculated soil via air deposition to soil (Section 4.2).
[b] Dietary exposure (Equation 5-1) to DIDP includes consumption of biota (earthworm), incidental ingestion of soil, and ingestion of water.
[c] The highest concentration of DIDP reported in rural soil within reasonably available published literature is 0.013 mg/kg (Tran et al., 2015).

Table 5-4. Dietary Exposure Estimates Using EPA's Wildlife Risk Model for Eco-SSLs for Screening Level Trophic Transfer of DIDP (Releases to Surface Water) to Fish

COU (Life Cycle Stage/ Category/ Sub-category)	OES	Flow Rate (m^3/day)	DIDP in Sediment Ingestion Rate (mg/kg bw/day) [a]	DIDP in Chironomids Ingestion Rate (mg/kg bw/day) [b]	Fish DIDP Dietary Exposure Rate (mg/kg bw/day) [c]
Processing/ Incorporation into formulation, mixture, or reaction product/ Plastic material and resin manufacturing	PVC plastics compounding	P50 7Q10: 17,616	70.65	331	401
Processing/ Incorporation into formulation, mixture, or reaction product/ Other (part of the formulation for manufacturing synthetic leather)		P75 7Q10: 178,012	7.04	33.0	40.0
		P90 7Q10: 3.01E07	4.0E–02	1.9E–01	2.3E–01
Published literature					
Sample collection conditions/ location	Reference (overall quality determination)				
Maximum concentration of DIDP within sediments/ Industrialized harbor, Kaohsiung Harbor, Taiwan	(Chen et al., 2016) (Medium)		9.47E–03	4.44E–02	5.39E–02
Maximum concentration of DIDP within sediments/ urban	(Cousins et al., 2007) (Medium)		8.7E–03	4.08E–02	4.95E–02

COU (Life Cycle Stage/ Category/ Sub-category)	OES	Flow Rate (m^3/day)	DIDP in Sediment Ingestion Rate (mg/kg bw/day) [a]	DIDP in Chironomids Ingestion Rate (mg/kg bw/day) [b]	Fish DIDP Dietary Exposure Rate (mg/kg bw/day) [c]
areas in Sweden collected by the Swedish National Screening Program, Swedish Environmental Research Institute					
Maximum concentration of DIDP within sediments/ urbanized ecosystem, False Creek Harbor, Vancouver, British Columbia, Canada	(Mackintosh et al., 2006) (High)		1.48E–03	6.96E–03	8.44E–03
[a] Calculated from Equation 5-2 with factors representing: concentration of DIDP in sediment, proportion of food intake that is sediment, food intake rate, and absorbed fraction of DIDP from sediment [b] Calculated from Equation 5-2 with factors representing: concentration of DIDP in prey, proportion of prey in diet, feed intake rate, and absorbed fraction of DIDP from prey [c] Dietary exposure (Equation 5-2) to DIDP includes consumption of biota (chironomids) and ingestion of sediment during feeding					

Table 5-5. Dietary Exposure Estimates Using EPAs Wildlife Risk Model for Eco-SSLs for Screening Level Trophic Transfer of DIDP (Releases to Surface Water) to Mink-Eating Fish

COU (Life Cycle Stage/ Category/ Sub-category)	OES	Flow Rate (m^3/day)	DIDP in Sediment Ingestion Rate (mg/kg bw/day) [a]	DIDP in Water Intake rate (mg/kg bw/day) [b]	DIDP in Fish Ingestion Rate (mg/kg bw/day) [c]	Mink DIDP Dietary Exposure Rate (mg/kg bw/day) [d]
Processing/ Incorporation into formulation, mixture, or reaction product/ Plastic material and resin manufacturing	PVC Plastics Compounding	P50 7Q10: 17,616	3.24	0.779	88.4	92.4
Processing/ Incorporation into formulation, mixture, or reaction product/ Other (part of the formulation for manufacturing synthetic leather)		P75 7Q10: 178,012	3.2E–01	3.6E–02	8.80	9.16
		P90 7Q10: 3.01E07	1.9E–03	5.6E–01	5.2E–02	6.1E–01
Published literature						
Sample collection conditions/ location	Reference (overall quality determination)					
Maximum concentration of DIDP within sediments/ Industrialized harbor, Kaohsiung Harbor, Taiwan	(Chen et al., 2016) (Medium)		4.36E–04	1.78E–05	1.19E–02	1.23E–02
Maximum concentration of DIDP within sediments/	(Cousins et al., 2007) (Medium)		4.00E–04	1.78E–05	1.09E–02	1.13E–02

COU (Life Cycle Stage/ Category/ Sub-category)	OES	Flow Rate (m^3/day)	DIDP in Sediment Ingestion Rate (mg/kg bw/day) [a]	DIDP in Water Intake rate (mg/kg bw/day) [b]	DIDP in Fish Ingestion Rate (mg/kg bw/day) [c]	Mink DIDP Dietary Exposure Rate (mg/kg bw/day) [d]
urban areas in Sweden collected by the Swedish National Screening Program, Swedish Environmental Research Institute						
Maximum concentration of DIDP within sediments/ urbanized ecosystem, False Creek Harbor, Vancouver, British Columbia, Canada	(Mackintosh et al., 2006) (High)		6.83E–05	1.78E–05	1.86E–03	1.94E–03

[a] Calculated from Equation 5-1 with factors representing: concentration of DIDP in sediment, proportion of food intake that is sediment, food intake rate, and absorbed fraction of DIDP from sediment
[b] Calculated from Equation 5-1 with factors representing: water intake rate, concentration of DIDP in surface water, and absorbed fraction of DIDP from water
[c] Calculated from Equation 5-1 with factors representing: concentration of DIDP in prey, proportion of prey in diet, feed intake rate, and absorbed fraction of DIDP from prey
[d] Dietary exposure (Equation 5-1) to DIDP includes consumption of biota (fish), incidental ingestion of sediment, and ingestion of water

Table 5-6. Dietary Exposure Estimates Using EPAs Wildlife Risk Model for Eco-SSLs for Screening Level Trophic Transfer of DIDP (Air Deposition to Surface Water and Sediment) to Fish

COU (Life Cycle Stage/ Category/ Sub-category)	OES	DIDP in Sediment Ingestion Rate (mg/kg bw/day) [a]	DIDP in Chironomids Ingestion Rate (mg/kg bw/day) [b]	Fish DIDP Dietary Exposure Rate (mg/kg bw/day) [c]
Processing/ Incorporation into formulation, mixture, or reaction product/ Plastic material and resin manufacturing	PVC Plastics Compounding	9.06E–04	4.25E–03	5.15E–03
Processing/ Incorporation into formulation, mixture, or reaction product/ Other (part of the formulation for manufacturing synthetic leather)				

[a] Calculated from Equation 5-2 with factors representing: concentration of DIDP in sediment, proportion of food intake that is sediment, food intake rate, and absorbed fraction of DIDP from sediment
[b] Calculated from Equation 5-2 with factors representing: concentration of DIDP in prey, proportion of prey in diet, feed intake rate, and absorbed fraction of DIDP from prey
[c] Dietary exposure (Equation 5-2) to DIDP includes consumption of biota (chironomids) and ingestion of sediment during feeding

Table 5-7. Dietary Exposure Estimates Using EPAs Wildlife Risk Model for Eco-SSLs for Screening Level Trophic Transfer of DIDP (Air Deposition to Surface Water and Sediment) to Mink Eating Fish

COU (Life Cycle stage/ Category/ Sub-category)	OES	DIDP in Sediment Ingestion Rate (mg/kg bw/day) [a]	DIDP in Water Intake Rate (mg/kg bw/day) [b]	DIDP in Fish Ingestion Rate (mg/kg bw/day) [c]	Mink DIDP Dietary Exposure Rate (mg/kg bw/day) [d]
Processing/ Incorporation into formulation, mixture, or reaction product/ Plastic material and resin manufacturing	PVC Plastics Compounding	4.17E–05	9.93E–06	1.13E–03	1.19E–03
Processing/ Incorporation into formulation, mixture, or reaction product/ Other (part of the formulation for manufacturing synthetic leather)					

[a] Calculated from Equation 5-1 with factors representing: concentration of DIDP in sediment, proportion of food intake that is sediment, food intake rate, and absorbed fraction of DIDP from sediment.
[b] Calculated from Equation 5-1 with factors representing: water intake rate, concentration of DIDP in surface water, and absorbed fraction of DIDP from water.
[c] Calculated from Equation 5-1 with factors representing: concentration of DIDP in prey, proportion of prey in diet, feed intake rate, and absorbed fraction of DIDP from prey.
[d] Dietary exposure (Equation 5-1) to DIDP 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 (Appendix A, (U.S. EPA, 2024a)). This approach is in agreement with the Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances (U.S. EPA, 2021a). 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 published literature as a comparative approach. Modeled values from VVWM-PSC for surface water and sediment based on COU/OES estimated water releases from hypothetical facilities resulted in DIDP concentrations within surface water and sediment with a confidence rank of slight as reported within the *Environmental Media and General Population Exposure for Diisodecyl Phthalate (DIDP)* TSD (U.S. EPA, 2024b). A strength within this screening level trophic transfer analysis is the use of modeled sediment concentrations resulting from varying percentiles of the 7Q10 flow rates in addition to the presentation and comparison with monitored concentrations of DIDP within reasonably available literature. Modeled values from AERMOD for air deposition to soil, water, and sediment DIDP concentrations was determined to have slight confidence as reported within the Environmental Exposure Media TSD (U.S. EPA, 2024b). EPA has slight confidence in the modeled concentrations as being representative of actual releases, due to the bias toward over-estimation, but robust confidence that no surface water release scenarios exceed the concentrations presented in this evaluation. Other model inputs were derived from reasonably available literature collected and evaluated through EPA's systematic review process for TSCA risk evaluations. All monitoring and experimental data included in this analysis were from articles rated "medium" or "high" quality from this process.

6.2 Trophic Transfer Confidence

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

Measured concentrations within aquatic species were represented with empirical biomonitoring data within four studies while measured concentration within terrestrial species were limited to one avian species. Empirical biomonitoring data for aquatic organisms were reasonably available with biota concentrations represented within a variety of aquatic taxa inhabiting False Creek Harbor, Vancouver, British Columbia, Canada, a location characterized by the authors as an urbanized marine ecosystem Lin et al. (2003). Overall, there were four different publications from this same site with sampling conducted on aquatic organisms representing four different trophic levels Mackintosh et al. (2004). The highest DIDP concentration within whole fish was observed for juvenile shiner perch at 0.057 mg/kg wet weight from McConnell (2007). Within the reasonably available published literature terrestrial species were largely represented by domesticated mammals residing within agricultural and indoor environments and these mammals are not ecologically relevant. One study reported DIDP concentration within the muscle of an avian species, surf scooter, at 1,412 ng/g lipid equivalent, which represents 0.031 mg/kg within the muscle tissue with a mean lipid content of 2.2 percent (Mackintosh et al., 2004). Of note, no studies with measured DIDP in biota from the United States were identified and many of the exposure estimates were based on a single study or from studies of a single origin not within the United States. 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 moderate.

Applying BCF and BSAF values for aquatic species was accomplished using predicted and empirical values, respectively. Empirical data were available for a BSAF value within chironomids from Brown et al. (1996). A predicted BCF was used to represent DIDP from surface water exposure to fishes (U.S. EPA, 2017a). Although an empirical BCF was available for earthworm from ECJRC (2003) these data were determined to have an overall quality ranking of low and were not used within this screening level trophic transfer analysis. As a result, the concentration for the earthworm was conservatively set as equivalent to the soil concentration from the AERMOD modeling of air to soil deposition of DIDP results with the highest COU/OES based estimated daily deposition rate of DIDP (Section 4.2). The confidence in quality of the database for the chronic mammalian assessment using a worm-eating mammal consuming earthworms as a prey item is moderate.

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, 2017b, 1993), thereby increasing the confidence for strength and precision, resulting in a moderate 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).

Consistency
The confidence in consistency for the chronic mammalian assessment using a worm-eating mammal consuming earthworms as a prey item is slight. Inputs for DIDP concentrations in soil displayed similarities among modeled and monitored concentrations. The highest daily deposition rate for soil concentrations modeled via AERMOD (Section 4.2) is the same orders of magnitude to the highest soil concentrations reported within published literature. The modeled concentration was represented by the PVC plastics compounding OES with deposition 1,000 m from a fugitive source, while the highest concentration within literature was collected from soil characterized as originating from ambient monitoring within a rural environment and not associated with known releases of DIDP. There is no reasonably available literature on daily deposition of DIDP from stack or fugitive emissions to soil that can serve as a comparison between modeling results and monitored soil concentrations.

The confidence in consistency for the chronic mammalian assessment using aquatic-dependent terrestrial species consuming fishes that prey on the sediment invertebrate chironomid is slight. A slight confidence ranking is due to uncertainty associated with the predicted BCF value used for fishes. In addition, differences between measured and modeled concentrations of DIDP within chironomids from an empirical BSAF value and modeled sediment DIDP concentrations for each water release based COU/OES. For example, the predicted chironomid concentrations were two to five orders of magnitude greater than the highest concentrations of DIDP reported within aquatic biota. The modeled data represent estimated concentrations near hypothetical facilities that are actively releasing DIDP to surface water, while the reported measured concentrations within biota represent sampled taxa with ambient water and sediment concentrations of DIDP. Differences in magnitude between modeled and measured concentrations within biota may be due to collections of aquatic species not being geographically or temporally close to known releasers of DIDP.

Relevance (Biological and Environmental)
The short-tailed shrew and American mink were selected as appropriate representative mammals 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 cautious approach to determining potential risk. Conversely, conservative assumptions associated with a lack of metabolic transformation within prey items such as chironomids, earthworms and fish decrease the confidence in biological relevance resulting in a slight confidence for biological relevance for the chronic mammalian assessment using an aquatic-dependent terrestrial species. The *Human Health Hazard Assessment for Diisodecyl Phthalate* (U.S. EPA, 2024d) details ADME studies with DIDP for the oral route within male and female rats indicating absorption and metabolism of this compound within Section 2 Toxicokinetics.

The screening level trophic transfer analysis investigated dietary exposure resulting from DIDP 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 DIDP absorbed from diet, and soil or sediment) all set to the most conservative values—emphasizing a cautious approach to estimating exposure of DIDP. Assumptions within the trophic transfer equations (Equation 5-1, 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 DIDP ability to transfer among the trophic levels, however, this increases confidence that risks are not underestimated. As a result, there is an overall moderate 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 moderate. 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 slight (Table 6-1).

Table 6-1. DIDP 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
Chronic Mammalian Assessment (worm eating)	++	++	+	++	Moderate
Chronic Mammalian Assessment (fish consumption)	++	++	+	+	Moderate

[a] Relevance includes biological and environmental relevance.
+ + + Robust confidence suggests thorough understanding of the scientific evidence and uncertainties. The supporting weight of the scientific evidence outweighs the uncertainties to the point where it is unlikely that the uncertainties could have a significant effect on the hazard estimate.
+ + Moderate confidence suggests some understanding of the scientific evidence and uncertainties. The supporting scientific evidence weighed against the uncertainties is reasonably adequate to characterize hazard estimates.
+ Slight confidence is assigned when the weight of the scientific evidence may not be adequate to characterize the scenario, and when the assessor is making the best scientific assessment possible in the absence of complete information. There are additional uncertainties that may need to be considered.

7 CONCLUSION OF ENVIRONMENTAL EXPOSURE AND SCREENING LEVEL TROPHIC TRANSFER ANALYSIS

Dietary exposure estimates were calculated based on water and air releases from the COU/OES with the highest modeled environmental releases as reported within the Environmental Media and General Population Exposure Technical Support Document (U.S. EPA, 2024b). The PVC plastics compounding OES—which encompasses two COUS: Processing/incorporation into formulation, mixture, or reaction product/plastic material and resin manufacturing, and Processing/incorporation into formulation, mixture, or reaction product/other (part of the formulation for manufacturing synthetic leather)—resulted in the highest environmental releases from the following media of release/exposure pathway: (1) surface water or wastewater/surface water, sediment; (2) fugitive or stack air release/air deposition to surface water and sediment; and (3) fugitive or stack air release/air deposition to soil. Although terrestrial hazard data for DIDP were not available for mammalian wildlife species, studies in laboratory rodents were used to derive hazard values for mammalian species (U.S. EPA, 2024a). Specifically, empirical toxicity data for rats were used to estimate a toxicity reference value (TRV) for terrestrial mammals at 128 of mg/kg-bw/day (U.S. EPA, 2024a) based on *Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)* (U.S. EPA, 2003).

Results for calculated dietary exposures of DIDP 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-dependant mammals with exposure pathways for surface water/sediment and air deposition to surface water/sediment are presented within Table 7-1. Maximum concentrations of DIDP reported within the reasonably available literature were also used to calculate dietary exposure estimates, describing no intersection of exposure of DIDP with 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 releases of DIDP from air and subsequent deposition to soil also resulted in dietary exposure concentrations below the TRV (Table 7-2). Comparative maximum soil concentrations of DIDP within rural and agricultural soils at 1.3×10^{-2} and 4.0×10^{-2} mg/kg, respectively, also resulted in dietary exposure concentrations below the TRV (Tran et al., 2015). Exposure pathways with aquatic-dependant mammals and terrestrial mammals as receptors were not examined further since, even with conservative assumptions, dietary DIDP exposure concentrations from this analysis are not equal to or greater than the TRV. These results align with previous studies indicating that DIDP is not bioaccumulative and will not biomagnify, as summarized within U.S. EPA (2024c).

The screening level trophic transfer analyses were conducted with both modeled DIDP concentrations from COU/OESs for different media of release and exposure pathways in addition to maximum values reported within reasonably available literature for soil and sediment. Modeled concentrations of DIDP within surface water and sediment from hypothetical facility surface water releases have a confidence rank of slight as reported within the *Environmental Media and General Population Exposure for Diisodecyl Phthalate (DIDP)* TSD (U.S. EPA, 2024b). Maximum concentrations from published literature should be considered to represent DIDP concentrations from ambient monitoring within industrialized and urban ecosystems and not direct releases. The inclusion of modeled sediment concentrations of DIDP from varying percentile 7Q10 flow rates allowed for this analysis to demonstrate an array of dietary exposure rates of DIDP for a representative mammal based on low flow conditions across the distribution of flow data from NAICS codes comprising the COU/OES with the highest release to surface water and sediment. Conservative approaches within both environmental media modeling (*e.g.*, AERMOD, VVWM-PSC) and the screening level trophic transfer analysis likely overrepresent DIDP ability to transfer among the trophic levels; however, this increases confidence that risks are not underestimated. The utilization of these different sources of information as a comparative approach with similar results ensures, with a high degree of confidence, that dietary exposure of DIDP does not approach concentrations to cause hazard within mammals.

Table 7-1. Dietary Exposure Estimates for Mammals Representing the Highest Modeled Environmental Releases to Surface Waters and DIDP in Sediment, Soil from Air Deposition, and within Published Literature

COU (Life Cycle Stage [a]/ Category [b]/ Sub-category [c])	OES	Media of Release/ Exposure Pathway [d]	Mink DIDP Dietary Exposure (mg/kg bw/day) [e]	DIDP TRV for Mammals (mg/kg-bw/day) [f]
Processing/ Incorporation into formulation, mixture, or reaction product/ Plastic material and resin manufacturing	PVC plastics compounding	Surface water/ Surface water, sediment (P50 7Q10: 17,616 m^3/day)	92.4	128
Processing/ Incorporation into formulation, mixture, or reaction product/ Other (part of the formulation for manufacturing synthetic leather)		Surface water/ Surface water, sediment (P75 7Q10: 178,012 m^3/day)	9.16	
		Surface water/ Surface water, sediment (P90 7Q10: 3.01E07 m^3/day)	6.1E–01	
Processing/ Incorporation into formulation, mixture, or reaction product/ Plastic material and resin manufacturing	PVC plastics compounding	Fugitive air/ Air deposition to surface water, sediment	1.19E–03	
Processing/ Incorporation into formulation, mixture, or reaction product/ Other (part of the formulation for manufacturing synthetic leather)				
Published literature				
Sample collection conditions/ location	Reference (overall quality determination)			
Maximum concentration of DIDP within sediments/ Industrialized harbor, Kaohsiung Harbor, Taiwan	(Chen et al., 2016) (Medium)		9.61E−05	
Maximum concentration of DIDP within sediments/ urban areas in Sweden collected by the Swedish National Screening Program, Swedish Environmental Research Institute	(Cousins et al., 2007) (Medium)		8.84E−05	
Maximum concentration of DIDP within sediments/ urbanized ecosystem, False Creek Harbor, Vancouver, British Columbia, Canada	(Mackintosh et al., 2006) (High)		1.52E−05	

COU (Life Cycle Stage [a]/ Category [b]/ Sub-category [c])	OES	Media of Release/ Exposure Pathway [d]	Mink DIDP Dietary Exposure (mg/kg bw/day) [e]	DIDP TRV for Mammals (mg/kg-bw/day) [f]

[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 COU appear in the life cycle diagram, reflect CDR codes, and broadly represent conditions of use of DIDP in industrial and/or commercial settings.
[c] These subcategories reflect more specific conditions of use of DIDP.
[d] Sediment concentrations for screening level trophic transfer analysis represented with median, 75th, and 90th percentile 7Q10 flow rates.
[e] RQ values calculated for aquatic-dependent terrestrial receptors based on DIDP releases to water, wastewater, and/or wastewater to onsite treatment or discharge to POTW (with or without pretreatment).
[f] Toxicity Reference Value (TRV) for mammals calculated using empirical toxicity data for rats as detailed within the *Environmental Hazard Assessment for Diisodecyl Phthalate (DIDP)* (U.S. EPA, 2024a).

Table 7-2. Dietary Exposure Estimates for Terrestrial Mammal Representing the Highest Modeled Environmental Releases of Air and DIDP in Soil from Published Literature

COU (Life Cycle Stage [a]/Category [b]/ Sub-category [c])	OES	Media of Release/ Exposure Pathway	Shrew DIDP Dietary Exposure (mg/kg bw/day) [d]	DIDP TRV for Mammals (mg/kg-bw/day) [e]
Processing/ Incorporation into formulation, mixture, or reaction product/ Plastic material and resin manufacturing	PVC plastics compounding	Fugitive air/ air deposition to soil	0.03	128
Processing/ Incorporation into formulation, mixture, or reaction product/ Other (part of the formulation for manufacturing synthetic leather)				
Published literature				
Sample collection conditions/location	Reference (overall quality determination)			
Non-agricultural Rural soil collected in Doue, Seine-et-Marne, France (population 1,029)	Tran et al. (2015)		7.47E–03	

[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 DIDP in industrial and/or commercial settings.
[c] These subcategories reflect more specific conditions of use of DIDP.
[d] RQ values calculated for terrestrial receptors based on DIDP releases to fugitive or stack air and air deposition to soil
[e] Toxicity Reference Value (TRV) for mammals calculated using empirical toxicity data for rats as detailed within the *Environmental Hazard Assessment for Diisodecyl Phthalate (DIDP)* (U.S. EPA, 2024a).

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