Annex 15 report

Proposal for identification of a substance of very high concern (SVHC)

1,4-Dioxane

EC Number: 204-661-8

CAS Number: 123-91-1

November 2026

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List of abbreviations

ATP	Adenosine triphosphate
BOD	Biological oxygen demand
CAS	Chemical Abstracts Service
CLP	Classification, Labelling and Packaging
CREED	Criteria for reporting and evaluating exposure datasets
CTD	Characteristic travel distance
DF	Detection frequency
DFOP	Double first order in parallel
DOC	Dissolved organic carbon
DegT$_{50}$	Degradation half-life or transformation half-life (days)
dw	Dry weight
DWI	Drinking Water Inspectorate
DWTP	Drinking water treatment plant
ECHA	European Chemicals Agency
EC	European Community
EC$_{50}$	50% effect concentration
ECB	European Chemicals Bureau
EU	European Union
FOMC	First order multi-component
GAC	Granulated activated carbon
GB	Great Britain
GC-FID	Gas chromatography – flame ionisation detector
GLP	Good laboratory practice
HLC	Henry's law constant
HS	Hockey stick
IUPAC	International Union of Pure and Applied Chemistry
K$_{AW}$	Air-water partition coefficient
K$_{OC}$	Organic carbon normalised adsorption coefficient

K_{OW}	n-Octanol–water partition coefficient
LC_{50}	50% lethal effect concentration
LoQ	Limit of quantification
LRTP	Long-range transport potential
MCL	Mandatory classification and labelling
MSC	Member State Committee
NOEC	No observed effect concentration
OECD	Organisation for Economic Cooperation and Development
P	Persistent
P_{ov}	Overall half-life in the environment
QSAR	Quantitative structure-activity relationship
REACH	Registration, Evaluation, Authorisation and restriction of Chemicals
SFO	Single first order
SMILES	Simplified Molecular Input Line Entry System
SVHC	Substance of very high concern
TCA	1,1,1-Trichloroethane
TG	Test guideline
UK	United Kingdom
vP	Very persistent
WWTP	Wastewater treatment plant

1 Proposal

Substance name: 1,4-Dioxane

EC number: 204-661-8

CAS number: 123-91-1

1,4-Dioxane has been identified as a substance of very high concern (SVHC) in accordance with the requirements set out in Annex 15 of EU REACH (Regulation (EC) No 1907/2006). This is based on the substance meeting the following criteria:

- Article 57(a) owing to its classification in the hazard class carcinogenicity category 1B (H350: 'May cause cancer')[1].
- Article 57(f) as a substance for which there is scientific evidence of probable serious effects to human health and the environment which give rise to an equivalent level of concern to those of other substances listed in paragraphs (a) to (e) of Article 57.

This technical report documents an independent scientific assessment by the Agency on whether 1,4-dioxane should be identified as a SVHC under UK REACH. The report only considers studies presented in the equivalent document produced by the European Chemicals Agency (ECHA), the EU Member State Committee (MSC) support document (ECHA, 2021a) unless stated otherwise. Relevant observations on studies made in the EU MSC support document have been summarised and Agency comments have been added where appropriate. Unpublished study reports were not available and have not been examined, unless stated otherwise. A comprehensive literature search was not undertaken for this report. However, through previous evidence reviews of persistent and potentially mobile substances, the Agency was aware of a number of studies reporting 1,4-dioxane concentrations in different water matrices. Results from these studies are presented where relevant. These references have been used as supporting evidence in the overall weight-of-evidence assessment of the widespread environmental detection of 1,4-dioxane.

[1] Classification in accordance with section 3.6 of Annex I to the retained Regulation (EC) No 1272/2008 as amended for Great Britain (hereinafter referred to as GB CLP).

Summary of how the substance meets the criteria set out in Article 57 of the UK REACH Regulation

Carcinogenic – Article 57(a)

1,4-Dioxane is identified as a SVHC in accordance with Article 57(a) owing to it being classified under GB CLP as carcinogenic category 1B (H350: 'May cause cancer').

Equivalent level of concern – Article 57(f)

1,4-Dioxane is proposed to be identified as a SVHC in accordance with Article 57(f) of UK REACH as there is scientific evidence of possible serious effects to human health and the environment which give rise to an equivalent level of concern to those of other hazards listed in points (a) to (e) of Article 57 of UK REACH. The properties of 1,4-dioxane that lead to this conclusion can be summarised as follows:

- There is no evidence for abiotic degradation of 1,4-dioxane. Modelling results are inconclusive, but the substance screens as potentially persistent (P) and very persistent (vP) based on the lack of ready biodegradation in screening tests, even where tests were extended beyond 28 days. There was no notable degradation of 1,4-dioxane in surface water during an OECD test guideline (TG) 309 study, so the half-life is much longer than 60 days. There was no significant degradation in two non-standard studies where 1,4-dioxane was introduced into a soil suspension with a high nutrient concentration. It is therefore concluded that degradation in the environment is likely to be slow. 1,4-Dioxane fulfils the criteria for P and vP under Annex 13 of UK REACH for freshwater (half-life > 40 and > 60 days, respectively).
- Estimated and experimental log K_{OC} values for 1,4-dioxane ranged from -0.5 to 0.85, indicating a relatively low adsorption potential. It is miscible with water and has only a slight tendency to volatilise from water (the experimental Henry's law constant (HLC) is 0.486 $Pa.m^3/mol$). 1,4-Dioxane will remain in the aqueous phase and as it has limited adsorption potential it will be mobile in the aqueous environment.
- 1,4-Dioxane has a mandatory classification under GB CLP for carcinogenicity category 1B (H350: "May cause cancer"). The substance therefore meets the toxicity (T) criterion under Annex 13 of UK REACH.

These properties lead to the following concerns if 1,4-dioxane is released to the environment:

- *Widespread presence in the environment*

  The combination of persistence and mobility gives rise to the potential for 1,4-dioxane to travel considerable distances from the source of emission via water and to migrate between and through environmental compartments such as from soil to groundwater, leading to widespread presence in the environment. Environment Agency monitoring data for England provide evidence of contamination, with 1,4-dioxane detected in 10.2

to 16.8% of surface waters and in 0.5 to 7.1% of groundwater samples between 2019 and 2022. Additional evidence from national monitoring programmes and academic studies indicates that it is present in surface water, including drinking water resources, and groundwater in multiple countries.

- *Difficulty in removal from drinking water sources*

  Part 3 of the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (UK Government, 2017) requires that for water bodies used for abstraction, measures are implemented “with the aim of avoiding deterioration in water quality, in order to reduce the level of purification treatment required for the production of drinking water”.

  The ability of 1,4-dioxane to persist and its tendency to remain in the aqueous environment, together with its relatively low adsorption potential to organic matter, indicate that it is likely to be difficult to remove through conventional drinking water treatment processes. Evidence from peer-reviewed studies outside the UK suggest incomplete removal even when using advanced treatment technologies. 1,4-Dioxane has been shown to be present in drinking water sources including groundwater. 1,4-Dioxane has been detected in drinking water in different countries, including Germany, Spain, the United States, and Japan.

- *Potential for toxic effects*

  There is potential for long-term exposure of humans and wildlife to 1,4-dioxane from its presence and likely slowly increasing concentrations in the environment. Given its hazard profile, this indicates a potential to cause harm.

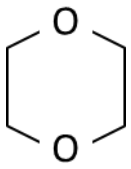
This combination of concerns gives rise to the potential for long-term impacts that are difficult to reverse. 1,4-Dioxane is therefore proposed to be identified as a SVHC in accordance with Article 57(f) of the UK REACH Regulation as there is scientific evidence of possible serious effects to the environment and human health which give rise to an equivalent level of concern to those of other hazards listed in points (a) to (e) of Article 57 of the Regulation.

2 Justification

2.1 Identity of the substance and physical and chemical properties

2.1.1 Name and other identifiers of the substance

Table 1: Substance identity

EC number:	204-661-8
EC name:	1,4-Dioxane
SMILES[a]:	O(CCOC1)C1
CAS number:	123-91-1
IUPAC[b] name:	1,4-Dioxane
Index number in GB Mandatory Classification and Labelling (MCL) List[c]:	603-024-00-5
Molecular formula:	$C_4H_8O_2$
Molecular weight:	88.12 g/mol
Synonyms:	-
Structure:	

[a] SMILES: Simplified Molecular Input Line Entry System
[b] IUPAC: International Union of Pure and Applied Chemistry
[c] GB MCL list in accordance with the retained Regulation (EC) No 1272/2008 as amended for Great Britain

2.1.2 Composition of the substance

Substance type: Mono-constituent

Table 2: Constituents other than impurities/additives

Constituents	Typical concentration
1,4-dioxane	≥ 80% w/w

2.1.3 Identity and composition of degradation products/metabolites relevant for the SVHC assessment

No transformation products were considered in ECHA (2021). It is not necessary to consider transformation products since there are adequate data for 1,4-dioxane.

2.1.4 Identity and composition of structurally related substances (used in grouping or read-across approach)

No structurally related substances were considered in ECHA (2021). It is not necessary to consider structurally related substances since there are adequate data for 1,4-dioxane.

2.1.5 Physicochemical properties

Physicochemical properties of 1,4-dioxane presented in ECHA (2021) are summarised in Table 3. The values for melting point, boiling point, vapour pressure, and density quoted by the support document are similar to those in the EU REACH registration dossier (ECHA, 2010). The values in ECHA (2021) are the same as experimental values quoted by MPBPVPWIN v1.44 in the EPISuite™ v4.1 (US EPA, 2026). The references for the water solubility assumption of miscibility and the log K_{OW} value are also both quoted by the relevant component models of EPISuite™ v4.1. As 1,4-dioxane is miscible with water, the support document assumes a water solubility of 1000 g/L at 25°C.

ECHA (2021) did not comment on the reliability of the data. It is not possible to comment on the experimental values as there are no details of the studies available. The estimated log K_{OW} value quoted is similar to the value obtained by the Agency from KOWWIN v1.69 (log K_{OW} = -0.32) where the structure appears to be adequately represented by -CH_2- (aliphatic carbon) and -O- (aliphatic attach) fragments and is within the molecular weight range of the validation and training sets.

Table 3: Overview of physicochemical properties of 1,4-dioxane

Property	Description/value	Source
Physical state at 20°C and 101.3 kPa	Colourless liquid	-
Melting/freezing point (°C)	11.8 (at 1013 hPa)	Handbook data[a]
Boiling point (°C)	101.1 (at 1013 hPa)	Handbook data[a]
Vapour pressure (Pa at 25°C)	47.5 hPa	Handbook data[a]
Density	Relative density: 1.03	Handbook data[a]
Water solubility (mg/L at 20°C)	Miscible with water	Handbook data[a]
n-Octanol–water partition coefficient (as log K_{OW})	-0.27 (temperature not known)	Estimated value[a]
Air-water partition coefficient (as log K_{AW})	-3.69 (at 12°C)	Calculated (see Section 0)

[a] References are presented in the Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profile for 1,4-dioxane (ATSDR, 2012)

2.2 Mandatory classification and labelling

Table 4: Mandatory classification in the GB MCL list

Index No	International Chemical Identification	EC No	CAS No	GB MCL list Classification		Aligned with EU CLH[a]
				Hazard Class and Category Code(s)	Hazard statement code(s)	Yes/No
603-024-00-5	1,4-dioxane	204-661-8	123-91-1	Flam. Liq. 2 Carc. 1B Eye Irrit. 2 STOT SE 3	H225 H350 H319 H335	Yes

[a] EU CLH is harmonised classification and labelling in accordance with Regulation (EC) 1272/2008

2.3 Human health hazard assessment

1,4-Dioxane possesses the following hazards: carcinogenicity, irritancy to eyes and irritancy to the respiratory tract.

2.4 Environmental fate properties

2.4.1 Degradation

2.4.1.1 Abiotic degradation

Hydrolysis: ECHA (2021) quoted Kollig *et al.* (1993) and Wolfe and Jeffers (2000) who stated that 1,4-dioxane does not hydrolyse because there are no hydrolysable functional groups. HYDROWIN v2.00 of EPISuite™ v4.1 cannot estimate a hydrolysis rate for 1,4-dioxane because it is not within the chemical structure classes that the model recognises as hydrolysable. Hydrolysis is not a likely route of degradation for 1,4-dioxane.

Oxidation: No information on oxidation is presented in ECHA (2021).

Phototransformation in air: ECHA (2021) presented a half-life of 13.7 hours (24-h day, 0.5×10^6 OH/cm^3). The Agency repeated the estimation for a 12-h day and 1.5×10^6 OH/cm^3 and the calculated half-life is 9.2 hours (0.38 days). ECHA (2021) also reported a half-life of 22.4 hours in the presence of 1.0×10^6 OH/cm^3. 1,4-Dioxane is not expected to be susceptible to direct photolysis under environmental conditions as it lacks functional groups that absorb light at visible-ultraviolet (UV) light wavelengths.

Phototransformation in water: There are no experimental or calculated data available. ECHA (2021) reported that the photo-oxidation half-life in water via hydroxyl radicals ranged between 67 days and 9.1 years, depending on the degree of light penetration (Mohr, 2010). Due to the weak absorption of UV light, 1,4-dioxane is unlikely to undergo direct photolysis in water.

Phototransformation in soil: No experimental or calculated data are available.

2.4.1.2 Biodegradation

2.4.1.2.1 Biodegradation in aqueous media or aqueous environment

2.4.1.2.1.1 Estimated data

Estimated biodegradation data from the BIOWIN v4.11 models of EPISuite™ v4.1 are summarised as follows:

- BIOWIN 2: 0.0061 (does not biodegrade fast)
- BIOWIN 3: 2.9871 (ultimate degradation within weeks)
- BIOWIN 6: 0.5539 (readily biodegradable)

The results from BIOWIN 3 and 6 suggest that 1,4-dioxane is likely to degrade in the environment. However, BIOWIN 2 suggests that 1,4-dioxane does not degrade rapidly. ECHA (2021) commented on the inconsistent results and suggests that it could reflect the different ratings of the substance fragments within the models. The BIOWIN 6 model includes two aliphatic ether fragments and four CH_2 fragments, the latter having a strong influence on the conclusion of ready biodegradability. BIOWIN 2 and 3 are based on the

same aliphatic ether fragment and molecular weight but come to different conclusions on degradability. It is not clear why this is the case. In conclusion, the results from predictive models do not provide consistent evidence for biodegradation potential or persistence.

2.4.1.2.1.2 Screening tests

ECHA (2021) briefly described four standard and non-standard ready biodegradability tests (summarised in Table 5**Error! Reference source not found.**):

- There is limited information in the EU REACH registration dossier (ECHA, 2010) for the unpublished studies dated 1979 and 1996 and therefore the Agency cannot comment on their reliability.
- The unpublished study (2010) conducted to OECD TG 310 included blank controls and vessels to check for an inhibitory effect of the test substance. The guideline appears to have been followed, and the validity criteria met although the study was not carried out to GLP. The study is considered to be reliable with restrictions (Klimisch score 2) based on the information available.
- Another study by Sei *et al.* (2010) provided supporting evidence that 1,4-dioxane does not degrade under the conditions of screening tests.

In conclusion, there is no evidence from these studies that 1,4-dioxane is readily biodegradable.

Table 5: Summary of screening test results for 1,4-dioxane

Reference	Study type	Results
Unpublished report (1996)	29-d study to OECD TG 301F (not to GLP) Inoculum source: activated sludge 1,4-dioxane (100 mg/L) Reference substance: aniline Reliability of data stated as high	Degradation by biological oxygen demand (BOD) after 29 days: 1,4-dioxane: < 10% Aniline: 92% 1,4-dioxane had no inhibitory effect on aniline degradation
Unpublished report (2010)	60-d OECD TG 310 (to GLP) Inoculum source: non-adapted activated sludge 1,4-dioxane (37.1 mg/L) Reference substance: aniline Reliability of data stated as high	Degradation by CO_2 formation: 1,4-dioxane: < 5% (after 60 days) Aniline: 74% (after 14 days)
Unpublished report (1979)	10-d OECD TG 302B (not to GLP) Inoculum source: industrial activated sludge, non-adapted 1,4-dioxane (400 mg/L) Reliability of data stated as limited	Degradation by dissolved organic carbon (DOC) removal: 1,4-dioxane: 40%
Sei *et al.* (2010)	29-d study, no guideline, not to GLP 3 different river waters Activated sludge 1,4-dioxane (100 mg/L) Reliability of data stated as high	Degradation of 1,4-dioxane (method of analysis not stated in the support document): River water: No degradation Activated sludge: No degradation

2.4.1.2.1.3 Biodegradation studies (simulation tests)

There is one study conducted to OECD TG 309 discussed in ECHA (2021), summarised in Table 6.

Table 6: Summary of aquatic biodegradation data

Reference	Study type	Results
Hofman-Caris and Claßen (2020)	60-day OECD TG 309 aerobic mineralisation study Sub-surface spring water 1,4-dioxane at 100 µg/L Reliability considered to be high.	1,4-dioxane: little degradation after 60 days. Reference substance aniline: > 98% degradation after 30 days.

- Hofman-Caris and Claßen (2020)

This is an aerobic mineralisation study conducted to OECD TG 309 that investigated the degradation of 1,4-dioxane as well as a number of other substances in water from a sub-surface spring used as a drinking water source (no added suspended sediment). The test substance was non-radiolabelled (purity 100%) and added at 100 µg/L to test vessels containing 300 mL of water. The vessels were incubated in the dark at 13 ± 1°C and duplicate samples were taken after 0, 7, 15, 30, 45, and 60 days. The microbial activity of the water was investigated using aniline (1 µg/L) as a reference substance and by determination of adenosine triphosphate (ATP) present.

Degradation of aniline was 52% after 15 days and > 98% after 30 days of incubation. ATP concentration was 86 ± 1.2 pg/mL at day 0 in the surface water (no 1,4-dioxane added) and 100 ± 5.6 pg/mL at day 2 in the presence of 1,4-dioxane, indicating no loss of microbial activity and no negative effect from 1,4-dioxane in that early timeframe. The concentration of 1,4-dioxane at each sampling time is summarised in Figure 1.

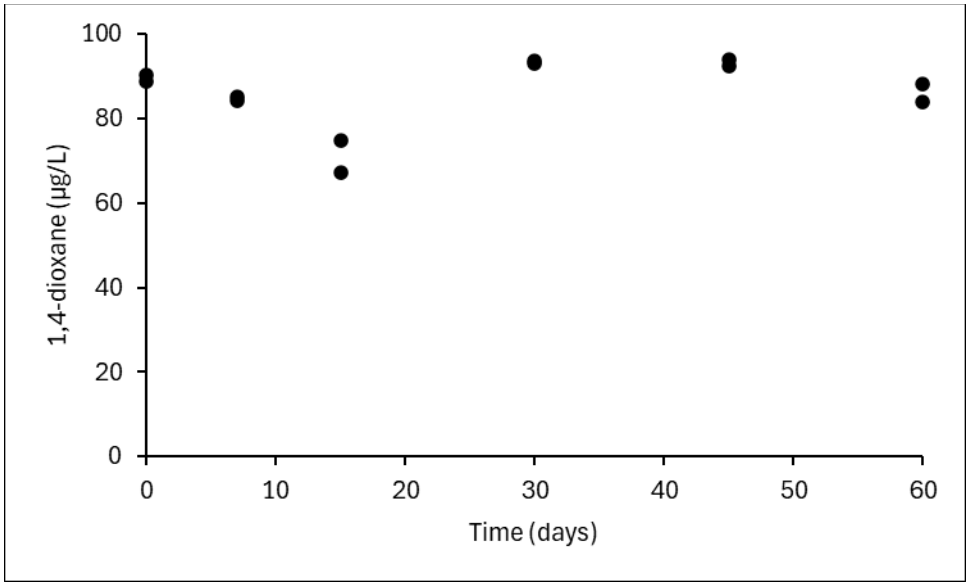


Figure 1: Concentration of 1,4-dioxane (µg/L) in surface water with sampling time

A kinetic assessment was carried out as part of the study by fitting the data with single first order (SFO), double first order in parallel (DFOP), hockey stick (HS), and first order multi-component (FOMC) kinetics. However, it is clear that no notable degradation occurred and degradation rate constants were not statistically different from zero (where available). The study is well described but it is not stated whether it is conducted to GLP. In conclusion, the study is reliable with restrictions (Klimisch score 2) and that the half-life of 1,4-dioxane in this sub-surface spring water is much longer than 60 days at 13°C.

2.4.1.2.2 Biodegradation in soil

ECHA (2021) considered two non-standard soil degradation studies, details of which are presented in Table 7.

Table 7: Summary of soil biodegradation data

Author / year	Study	Results
Kelley *et al.* (2001)	120-d non-guideline study of a soil suspension (20 g soil in 200 mL solution) 1,4-dioxane (100 mg/L) Reliability not stated	No significant degradation after 120 days
Sei *et al.* (2010)	39-d incubation of a garden soil suspension 1,4-dioxane (100 mg/L) Degradation monitored using gas chromatography with flame ionisation detection (GC-FID) Reliability not stated	No degradation after 39 days

- Kelley *et al.* (2001)

This study examined the degradation of 1,4-dioxane (100 mg/L) in a suspension of soil (20 g) in basal salt medium (200 mL). The temperature of this part of the study is not stated. There was no significant degradation after 120 days. There was degradation of approximately 60% of 1,4-dioxane in 120 days when a known dioxane-degrading actinomycete was added to the suspension. In an additional experiment under the same conditions but at a 1,4-dioxane concentration of 25 mg/L, it was shown that degradation of 1,4-dioxane was further enhanced by the addition of poplar tree root extracts. The study is well reported and is considered reliable with restrictions (Klimisch score 2), but it is noted that non-standard methodology using a soil suspension was used, with addition of nutrients and a high test substance concentration. An experiment was also included where ^{14}C-labelled 1,4-dioxane (approximately 10 mg/kg of soil) was added to soil (185 g) mixed with nutrient solution (90 mL). Mineralisation of 1,4-dioxane was 8% (based on CO_2 formation) in unplanted soil and 3% in the presence of planted poplar tree cuttings.

- Sei *et al.* (2010)

This study monitored the degradation of 1,4-dioxane (100 mg/L) in a garden soil suspension (3 g of soil dissolved in 100 mL basal salt media). No degradation was detected within 39 days of incubation. The Agency has not accessed this study and so cannot comment on its quality and reliability. As the ECHA support document notes, the

conditions of this study included addition of nutrients and high test substance concentrations and so there are doubts about its environmental relevance.

ECHA (2021) mentioned several non-standard studies with isolated bacterial species in pure or mixed culture from different locations (soil, sediment, aquifer). These studies show some indication of degradation of 1,4-dioxane under specific conditions. The ECHA support document also discussed two studies that have reported the co-metabolic transformation of 1,4-dioxane in pure or mixed cultures in the presence of primary substrates such as tetrahydrofuran (Zenker *et al.*, 2002) and ethane (Hatzinger *et al.*, 2017). Again, this type of study only shows biodegradability of 1,4-dioxane under specific conditions which are not clearly environmentally relevant.

2.4.1.3 Field data

ECHA (2021) discussed a study of 1,4-dioxane attenuation at contaminated groundwater sites (Adamson *et al.*, 2015). There was evidence of attenuation at many sites, and where it was well established, half-lives for 1,4-dioxane in the order of 2 to 5 years were estimated. It should be noted that although there were some positive correlations with factors that promoted biodegradation (e.g. dissolved oxygen concentration), the measurements are of different dissipation processes and not solely degradation.

Gedalanga *et al.* (2016) developed a multiple-lines-of-evidence framework to evaluate the biodegradation potential of 1,4-dioxane based on a former landfill site in the United States which accepted industrial waste from 1968 to 1979. It was concluded that 1,4-dioxane attenuation was occurring across the groundwater plume and that non-destructive physical processes alone did not account for the observed 1,4-dioxane attenuation.

2.4.1.4 Summary and discussion of degradation

Abiotic degradation of 1,4-dioxane by hydrolysis or phototransformation is not expected to be a relevant pathway based on its chemical structure.

Predicted data from the BIOWIN v4.11 model of EPISuite™ are inconsistent. There is no evidence that the substance is readily biodegradable based on a limited number of screening tests.

There was no notable degradation of 1,4-dioxane in sub-surface spring water during an OECD TG 309 study. The half-life of 1,4-dioxane was much longer than 60 days at 13°C.

There was no significant degradation in two non-standard studies where 1,4-dioxane was introduced into a soil suspension with a high nutrient concentration. Degradation only occurred in the presence of a known dioxane-degrading actinomycete.

Although there is some evidence that biodegradation can occur alongside dissipation processes in contaminated groundwater, half-lives of 2 to 5 years indicate that any degradation under these conditions is slow.

In conclusion, 1,4-dioxane is likely to degrade slowly in the aqueous environment and there is no evidence for rapid degradation in soil under environmentally relevant conditions.

2.4.2 Environmental distribution

2.4.2.1 Adsorption/desorption

ECHA (2021) included five organic carbon normalised adsorption coefficient (K_{OC}) values (presented as log K_{OC} values in Table 8). Although at least one of these values is reported as experimental, the provenance of the reported log K_{OC} values cannot be verified because the original sources are not available for review. For example, Arp and Hale (2019) report an experimental log K_{OC} value of -0.5 without providing a specific reference, while DiGuiseppi *et al.* (2016) report a log K_{OC} value of 0.54 without identifying its source.

The molecular weight of 1,4-dioxane falls within the range of the training set compounds of the KOCWIN model. The fragment correction for 'ether, aliphatic' used in both the MCI and log K_{OW} models is present in 20 of the 447 compounds in the training set and there are no fragments in 1,4-dioxane that are not represented in the training set. In conclusion, 1,4-dioxane is likely to be within the applicability domain of the models. The estimated values from the KOCWIN model were independently confirmed by the Agency. ECHA (2021) also mentioned a review article of occurrence and treatment of 1,4-dioxane by Zenker *et al.* (2003), which states that sorption is not a significant attenuation mechanism owing to complete miscibility of 1,4-dioxane with water; no experimental evidence is presented.

Table 8: Summary of studies of adsorption behaviour of 1,4-dioxane

Source	Type of information	Results
Estimated value using KOCWIN v2.01 of EPISuite™ v4.10	Estimated data	0.595 (K_{OW} method) 0.421 (MCI method)
EU risk assessment report (ECB, 2002)	Estimated value based on log K_{OW} of -0.32[a]	0.85
Arp and Hale (2019)	Quoted value (no reference to source)	-0.5
DiGuiseppi et al (2016)	Quoted value (no reference to source)	0.54[b]

[a] A higher log K_{OW} of -0.27 is cited in Section 2.1.5, although this would not change the result significantly.

[b] Reported as -0.42 in ECHA (2021).

There are other sources of information, including a United States Environmental Protection Agency (US EPA) risk assessment that quotes a log K_{OC} range from 0.4 (estimated) to 1.23 but again no clear reference to any experimental value (US EPA, 2020).

In conclusion, although only one of the values is known to be from an experimental study, and it is not possible to independently assess data reliability owing to lack of information, the predicted or experimental log K_{OC} values reported are all below 1.5, and mostly below 1. This consistency indicates a low potential for adsorption to organic matter in environmental matrices such as soil, sediment and sewage sludges.

2.4.2.2 Volatilisation

ECHA (2021) used equation R.16-4 in Guidance document R.16 (ECHA, 2016) to determine the HLC for 1,4-dioxane from its vapour pressure and water solubility. However, it was observed during the EU public consultation that this method is not valid for substances that are completely miscible with water.

ECHA (2021) also reported three values obtained from the HENRYWIN v3.21 module of EPISuite™, which are summarised as follows (all at 25°C):

Experimental database match:	0.486 Pa.m^3/mol
Bond estimation method:	0.599 Pa.m^3/mol
Group estimation method:	0.011 Pa.m^3/mol

The Agency has been unable to assess the reliability of the experimental HLC value, which was reported by Park *et al.* (1987). The molecular weight of 1,4-dioxane falls within the range of the training set compounds of HENRYWIN. The bond and group descriptions adequately describe the substance. The advice of the model is that the estimation from the group model is preferred where the bond method does not use a correction factor, which is the case for 1,4-dioxane.

ECHA (2021) also estimated the air-water partition coefficient (K_{AW}) using equation R.16-5 from Guidance document R.16 (ECHA, 2016):

$$K_{AW} = \frac{HENRY}{R.T}$$

The resulting log K_{AW} of -3.69 was confirmed by the Agency. The inputs used were HENRY (HLC) = 0.486 Pa.m^3/mol, gas constant (R) = 8.314 Pa/m^3/mol/K and temperature (T) = 285 K.

It is agreed with ECHA (2021) that all values indicate 1,4-dioxane to likely remain primarily in the water phase with a slight tendency to volatilise from water. Although 1,4-dioxane has a moderately high vapour pressure it is highly soluble in water.

2.4.2.3 Modelling of distribution between environmental compartments

ECHA (2021) presented MacKay Level III modelling within EPISuite™ v4.1 (see Table 9). The results indicate that if 1,4-dioxane is released to water, it will remain in that compartment. If released to soil, much remains in the soil, but the limited potential for adsorption means that it has the potential to leach from soil to groundwater.

Table 9: Environmental distribution pattern according to MacKay Level III modelling

Environmental compartment	Mass amount (%)			
	Equal release	Release to air	Release to water	Release to soil
Air	3.46	65.3	10.16	0.53
Water (surface)	44.3	16.2	99.6	18.8
Soil	52.1	18.5	0.044	80.7
Sediment	0.086	0.031	0.19	0.036

2.4.2.4 Distribution and removal during water treatment

2.4.2.4.1 Distribution in sewage treatment plants

ECHA (2021) presented distribution modelling according to the SimpleTreat 3.0 model which shows that 99% of 1,4-dioxane entering a municipal sewage treatment works will distribute to water, 1% to air, and 0.1% to primary sludge with no degradation. It is therefore expected that standard wastewater treatment processes will result in almost all of the substance in influent being emitted to surface water. The Agency has checked the distribution using SimpleTreat v4.1 and obtained very similar results.

Stepien *et al.* (2014) examined 1,4-dioxane concentrations in influent and effluent from four wastewater treatment plants (WWTPs) in Germany which treated household sewage and indirect discharges from industries (30 to 50% of the total). Each was equipped with conventional processes such as mechanical pre-treatment with coarse particle screening, an aerated grit-removal tank, a primary clarifier and one to two biological treatment stages with activated sludge. Two also employed post-anoxic denitrification steps. There was little evidence of a reduction in 1,4-dioxane between influent and effluent in three of the treatment plants while there was a large increase in 1,4-dioxane in the effluent of one WWTP, attributed to contaminated methanol used in the denitrification process.

In a more recent report, Yang *et al.* (2026) measured 1,4-dioxane in the influent and effluent of seven industrial and seven municipal WWTPs in China. 1,4-Dioxane concentrations in industrial WWTPs ranged from 0.07 to 380.6 µg/L in influents and from 0.08 to 256.4 µg/L in effluents. For municipal WWTPs, 1,4-dioxane levels ranged from 0.13 to 5.0 µg/L in influents and from 0.10 to 3.1 µg/L in effluents. Removal of 1,4-dioxane in most WWTPs varied from 15.8 to 83.2%, with the highest removal efficiencies seen where advanced oxidation processes such as ozonation, chlorination, and UV photolysis were employed. In four WWTPs where biological treatment was the primary process, 1,4-dioxane concentrations increased in effluent relative to influent after treatment. This increase was not attributed to any specific cause.

2.4.2.4.2 Removal during drinking water treatment

Stepien *et al.* (2014) looked at the removal of 1,4-dioxane from a mixture of bank filtration water and groundwater from natural recharge in two drinking water treatment plants (DWTPs) in Germany. For the first DWTP, the raw water concentration was 0.67 µg/L, reducing to 0.49 µg/L after treatment (which was described as ozonation, aeration, and a two layer activated carbon filtration). For the second DWTP the concentration in raw water is not clearly reported but was 0.77 µg/L in the river water before bank filtration. After ozonation, aeration and gravel filtration the concentration reduced to 0.65 µg/L, and then 0.60 µg/L after another filtration step with activated carbon. This suggests the advanced treatments used at these sites can achieve overall removal efficiencies of around 25%.

Carrera *et al.* (2019) investigated the removal of dioxanes over four seasons in 2015 from a DWTP in Catalonia, Spain that supplies an average of 450,000 m^3 of water each day to more than 3 million people. The treatment process included ozonation and granulated activated carbon (GAC) filtration. The total removal efficiency for 1,4-dioxane was 57 ± 17% (n = 4). For advanced treatment involving ultra-filtration and reverse osmosis, total removal efficiency was 77 ± 5% (n = 4).

Yang *et al.* (2026) investigated the removal efficiency of 1,4-dioxane at five DWTPs in China. All DWTPs included treatment with activated carbon and either chlorination (four DWTPs) or ozonation (one DWTP). There was approximately a 30% reduction in 1,4-dioxane at two of the plants but either no removal or some increase in concentration after treatment in the other three.

A report for the Drinking Water Inspectorate (DWI, 2023) modelled the removal of a number of persistent and potentially mobile substances in different drinking water treatment scenarios. Estimated 1,4-dioxane removal efficiencies varied between 15 and 90% (Table 10).

Table 10: Modelled 1,4-dioxane removal for different drinking water processes

Drinking water source	Treatment process	Description	1,4-dioxane removal (%)
Surface water	Conventional	Coagulation/flocculation/filtration and chlorination	15
	Advanced	Coagulation/flocculation/filtration, ozonation, activated carbon and chlorination	90
Groundwater	Filtration	Sand filtration plus disinfection	15
	Membrane	Ultrafiltration plus disinfection	15

2.4.2.5 Field data

ECHA (2021) discussed several studies that have found 1,4-dioxane in drinking water, groundwater, and surface water in various parts of the world. Data from these studies are presented in this section. A few studies could not be accessed or were not available in the English language, so have not been included here. There are additional studies that report 1,4-dioxane concentrations in different waters. Results from these studies are presented where relevant.

There have been recent developments in the reliability assessment of monitoring data through the Criteria for Reporting and Evaluating Exposure Datasets (CREED; Merrington *et al.* (2024)). The Agency considered the quality and reporting of the monitoring evidence presented in this dossier for a selection of references using the CREED framework. Overall, the studies were generally well reported, relevant to the assessment, and included the required reporting elements, although some recommended elements were not consistently reported. Consequently, the monitoring evidence is considered to be broadly consistent with the CREED silver level ("usable with restrictions").

2.4.2.5.1 Drinking water

ECHA (2021) discussed a number of academic research reports for drinking water (summarised in Table 11), with 1,4-dioxane being found in drinking water in Europe, the United States, and Japan. Detection frequency (DF) varied from 21 to 100% with a maximum reported concentration of 4.36 µg/L. These studies reported sampling that took place approximately 10 or more years ago. A more recent report from China (Wang *et al.*, 2024) found 1,4-dioxane in 78% of finished drinking water samples from 31 cities, with a median of 0.15 µg/L and range from < 0.02 to 2.92 µg/L. No reports of 1,4-dioxane in drinking water in the UK were located.

2.4.2.5.2 Groundwater

ECHA (2021) discussed the use of 1,4-dioxane as a stabiliser for chlorinated solvents such as 1,1,1-trichloroethane (TCA). As a result, 1,4-dioxane has frequently been detected in groundwater at industrial and contaminated sites where such solvents were historically used. The studies reporting concentrations of 1,4-dioxane in groundwater, excluding review papers, are presented in Table 11. Concentrations and detection frequencies were generally high, reflecting the targeted investigation of groundwater suspected to be contaminated. Several additional studies identified the frequent co-occurrence of 1,4-dioxane with TCA and other chlorinated solvents at contaminated sites through the analysis of historical monitoring data (Adamson *et al.*, 2014; Anderson *et al.*, 2012), indicating that releases associated with chlorinated solvent use have been an important source of groundwater contamination. 1,4-Dioxane can occur as an unintended impurity in surfactants and that this has been identified as a potentially significant source of

environmental releases (HSE, 2025). Given the widespread use of surfactant-containing products, this source may also contribute to the occurrence of 1,4-dioxane in groundwater.

2.4.2.5.3 Surface water

ECHA (2021) referenced a number of studies that have monitored the concentration of 1,4-dioxane in the Rhine river and reports that bank filtration does not adequately remove it (e.g. Fleig *et al.*, 2017; Röden *et al.*, 2016). Three additional studies known to the Agency that have reported 1,4-dioxane concentrations in surface water are summarised briefly below:

- Bach *et al.* (2024) surveyed 300 sites across France between 2020 and 2022. Sampling focussed on water catchments producing the greatest flow of treated water, randomly selected drinking water sources (mostly groundwater), and potentially contaminated sites. They found that of 587 total samples, only 7% had 1,4-dioxane concentrations above the limit of quantification (LoQ), which was 0.15 µg/L. DF was 9% (8 out of 86 samples) for surface water and 7% for treated water (20 out of 287). The concentration above the LoQ was less than 1 µg/L in 35 out of 44 samples, and between 1 and 3 µg/L in the other 9 samples.
- Neuwald *et al.* (2022) investigated German drinking water. They found 1,4-dioxane in 11 out of 16 surface water samples (69%) in the first campaign (median = 0.54 µg/L; range: < 0.1 to 1.61 µg/L) and in 5 out of 10 surface water samples (50%) in the second campaign (median = 0.14 µg/L; range: <0.1 to 0.75 µg/L).
- A report from China (Wang *et al.*, 2024) found 1,4-dioxane in 81% of surface water samples from 31 cities, with a median of 0.17 µg/L and range from <0.02 to 7.76 µg/L.

Monitoring data are also available from the Environment Agency. The analytical method was gas chromatography-mass spectroscopy (GC-MS), the data are semi-quantitative, and the sites are distributed throughout England, including both rural and urban locations. The results are summarised in Table 12 for freshwater and groundwater. The data for 2019 to 2022 show detection in 10.2 to 16.8% of freshwater samples, and between 0.5 and 7.1% of groundwater samples; the limit of detection was stated to be 0.01 µg/L. Detection in drinking water supplies (Table 13) was 7.69 to 21.74% for surface water and 0% to 16.7% for groundwater, although this dataset is relatively small.

Table 11: Summary of field data

Reference	Study details	Concentration (µg/L) and DF (%)
Drinking water		
Magg *et al.* (2013)	Frankfurt, Germany). Drinking water samples (n = 12)	Above 0.10 µg/L in 7 samples, max = 0.58 µg/L
Karges *et al.* (2018)	Germany (2015 to 2016) Finished drinking water from aquifer recharge systems	Range: 0.03 to 2.05 DF = 80% (LoQ = 0.034)
Carrera *et al.* (2019)	Catalonia, Spain (2015 to 2018) Finished drinking water (n = 89)	Average: 1.062 ± 0.923 Maximum: 4.356 LoQ = 0.05
Adamson *et al.* (2017)	USA (2013 to 2015) Public drinking water systems (n = 4864)	DF: 21% of 4,864 public water systems (minimum reporting limit was 0.07 µg/L)
Abe (1997)	Kanagawa Prefecture, Japan (1995-1996); n = 12	0.2 to 1.5 DF = 100%
Groundwater		
Karges *et al.* (2018)	Germany (2015 to 2016) Suspected pollution influenced groundwaters n = 44 at a total of 8 sites	Range: 0.04 to 152.11 DF = 100% (LoQ = 0.036)
OVAM (2017)	Flanders, Belgium (2016 to 2017) Sites known to be contaminated with 1,1,1-trichloroethane (n = 16)	Max: 26,000 DF: 100%

<table>
<tr><th>Reference</th><th>Study details</th><th>Concentration (µg/L) and DF (%)</th></tr>
<tr><td>Carrera et al. (2017)</td><td>Lower Llobregat River basin, Spain (2015)
Groundwater from 4 areas (n =6 64)</td><td>Measured mean range: 1.68 to 50.53
Maximum: 241.09
DF -= 100%</td></tr>
<tr><td>Abe (1999)</td><td>Kanagawa Prefecture, Japan (1995 to 1998)
Groundwater from 20 wells (n = 60)</td><td>Range: < 0.1 to 94.8
DF: 80%</td></tr>
<tr><td colspan="3">Surface water</td></tr>
<tr><td>Stepien et al. (2014)</td><td>River water, Germany (2012 to 2013)
River Oder: n = 49
River Main: n = 19
River Rhine: n = 15</td><td>Concentrations:
<table>
<tr><th>River</th><th>Mean</th><th>Median</th><th>Max</th><th>Min</th></tr>
<tr><td>Oder</td><td>0.66</td><td>0.55</td><td>2.2</td><td>0.14</td></tr>
<tr><td>Rhine</td><td>0.47</td><td>0.44</td><td>0.86</td><td>0.21</td></tr>
<tr><td>Main</td><td>0.49</td><td>0.53</td><td>0.86</td><td>0.11</td></tr>
</table></td></tr>
<tr><td>Rüdel et al. (2020)</td><td>Rivers Lech and Inn (and one tributary each), Germany (2016)</td><td>River Lech: Up to 5.5
River Inn: up to 4.9
River Inn tributary: up to 100</td></tr>
</table>

Table 12: Environment Agency monitoring results for 1,4-dioxane (freshwater and groundwater)

Year	Total analyses	Total detections	% detection	Total sites detected	Concentration (µg/L)[a]			
					Min.	Max.	Mean	Median
Freshwater								
2019	2645	408	15.43	82	0.07	42.00	0.43	0.18
2020	606	72	11.88	40	0.10	0.84	0.21	0.16
2021	1474	247	16.76	89	0.03	12.00	0.35	0.20
2022	1222	125	10.23	34	0.06	2.20	0.29	0.19

Year	Total analyses	Total detections	% detection	Total sites detected	Concentration (µg/L)[a]			
					Min.	Max.	Mean	Median
Groundwater[b]								
2019	1231	22	1.79	22	0.10	13.00	1.23	0.29
2020	201	1	0.50	1	0.15	0.15	-	-
2021	61	2	3.28	2	0.15	1.90	-	-
2022	28	2	7.14	2	0.11	0.31	-	-

[a] These reported values should only be considered an approximation for actual levels
[b] Groundwater quality monitoring network data

Table 13: Environment Agency monitoring results for 1,4-dioxane (drinking water supply from surface water and groundwater)

Year	Total analyses	Total detections	% detection	Total sites detected	Concentration (µg/L)[a]			
					Min.	Max.	Mean	Median
Drinking water supply (from surface water)								
2019	224	25	11.16	11	0.10	0.66	0.23	0.19
2020	37	3	8.11	2	0.13	0.26	0.21	0.24
2021	46	10	21.74	5	0.10	1.50	0.37	0.19
2022	13	1	7.69	1	1.00	1.00	-	-
Drinking water supply (from groundwater)								
2019	213	9	4.23	9	0.10	0.42	0.26	0.29
2020	30	5	16.67	5	0.10	0.96	0.46	0.17
2021	14	1	7.14	1	0.43	0.43	-	-
2022	2	0	0.00	0	-	-	-	-

[a] These reported values should only be considered an approximation for actual levels

2.4.2.6 Summary of environmental distribution

It is not possible to evaluate the original source of the available log K_{OC} values in most cases. Despite some variability in the reported values (−0.5 to 1.23), they collectively indicate that 1,4-dioxane has limited potential to adsorb to organic matter in environmental matrices. 1,4-Dioxane is expected to have a low potential to volatilise from water.

Fugacity modelling indicates that after release to water, it is likely to remain in that compartment. After release to soil there is potential for movement through the soil to groundwater.

Available monitoring data indicate that 1,4-dioxane is present with a high detection frequency in waters where industrial contamination has been known or suspected to occur. In more general monitoring in France, Germany and England, 1,4-dioxane is present in a much lower but still significant percentage of samples. Detection frequency was much higher in monitoring of surface water in China.

2.4.3 Data indicating potential for long-range transport

1,4-Dioxane has an estimated half-life in air of 13.7 hours (see Section 2.4.1.1) and so does not screen for long-range environmental transport via the air (half-life > 2 days) according to the Stockholm Convention (UNEP, 2025). 1,4-Dioxane volatilisation from water is expected to be low and therefore long-range transport is more likely to occur via the water phase.

ECHA (2021) reported the use of the OECD P_{OV} and a Long-Range Transport Potential (LRTP) screening tool (v2.2) to evaluate the LRTP of 1,4-dioxane, using a log K_{OW} of -0.27 and air-water distribution coefficient log K_{AW} of -3.69. There are no specific $DegT_{50}$ values available for soil and water and so ECHA (2021) presented three sets of modelling based on ‘best case’ (inherently biodegradable), ‘pragmatic worst case’ (not biodegradable), and ‘upper limit’ (not biodegradable in soil) values. Although there was little degradation seen in the aerobic mineralisation study, the study duration was only 60 days and determination of half-lives beyond the length of the study introduces considerable uncertainty

As a definitive bound experimental half-life in water is not available, the results of any LRTP modelling will not be reliable and so no further consideration is given to long-range transport modelling as part of this assessment.

2.4.3.1 Summary of long-range transport potential

It is possible that 1,4-dioxane could be subject to long-range transport as it is persistent in water with limited potential for removal by either volatilisation or adsorption.

2.4.4 Bioaccumulation

ECHA (2021) presented a very brief assessment to conclude that 1,4-dioxane is not bioaccumulative. However, this endpoint is not relevant to this assessment.

2.4.5 Ecotoxicity information

ECHA (2021) briefly reported a range of studies that are used to assess the environmental hazard of 1,4-dioxane but does not comment on their reliability. Given the very low level of toxicity observed, the Agency has also not assigned a reliability score.

2.4.5.1 Aquatic compartment (including sediment)

The studies presented in ECHA (2021) are summarised in Table 14. That document also stated that there are seven more fish acute toxicity tests listed in the EU risk assessment report performed under the Existing Substances Regulation (ECB, 2002), some with test durations shorter than 96 hours and LC_{50} values all > 100 mg/L. There were no studies for sediment organisms.

Table 14: Summary of aquatic toxicity studies

Study type	Study details	Results
Fish		
Short term toxicity	96-h test (no guideline specified with *Menidia beryllina* (Tidewater Silverside)	LC_{50} not reached at the highest test concentration of 320 mg/L
	Test similar to OECD TG 203 with *Pimephales promelas* (Fathead Minnow)	LC_{50} = 13,000 mg/L (nominal concentrations)
	96-h test according to special acute fish toxicity test system by the Center for Lake Superior Environmental Studies (University of Wisconsin-Superior) with *Pimephales promelas* (Fathead Minnow)	LC_{50} = 10,800 mg/L (nominal concentrations)
	96-h test (same methodology as above)	LC_{50} = 9,850 mg/L (nominal concentrations)
Long term toxicity	32-d flow through test to guideline equivalent to OECD TG 210. Test species: embryos of *Pimephales promelas* (Fathead Minnow) Mean measured concentrations were: 0, 27.6, 40.3, 65.3, 99.7, and 145 mg/L	NOEC reported in EU REACH registration dossier: 145 mg/L (stated to be based on initial measured concentration) NOEC reported in ECB (2002) was: > 103 mg/L
Aquatic invertebrates		
Short term toxicity	Semi-static 48-h OECD TG 202 Test species: *Daphnia magna*	EC_{50} > 1,000 mg/L (based on nominal, analytically verified)

Study type	Study details	Results
Long term toxicity	7-d study according to EPA-600/4-85-014. Test species: *Ceriodaphnia dubia* Test concentrations: 625; 1,250; 2,500; 5,000; 10,000 mg/L	Based on nominal concentrations (no measured concentrations were reported): NOEC = 625 mg/L LOEC = 1,250 mg/L
	21-d OECD TG 211 Test species: *Daphnia magna* (No other information available)	NOEC = 1,000 mg/L
Algae and aquatic plants		
	72-h OECD TG 201 with *Pseudokirchneriella subcapitata* No information on test concentrations available.	E_rC_{50} > 1,000 mg/L NOE_rC ≥ 1,000 mg/L
	8-h algal toxicity test according to ISO 8692 with *Scenedesmus quadricauda*	EC_{50} = 5,600 mg/L (not specified if growth rate or biomass) – reported as a toxic threshold concentration
	8-h test (no guideline specified) with *Scenedesmus quadricauda*	EC_{50} = 575 mg/L for biomass (based on nominal concentrations) – reported as a toxic threshold concentration

2.4.6 Terrestrial compartment

ECHA (2021) briefly considered studies discussed in ECB (2002):

- A three-day toxicity test on seed germination/root elongation using *Lactuca sativa* (lettuce) resulted in an EC_{50} of 1,450 mg/L (equivalent to 2,175 mg/kg soil dry weight (dw)). This is not a standard test design, so the results are difficult to interpret in a REACH context.
- A test where 1,4-dioxane (5 µL) was applied topically to the pupal cuticle of the flesh fly *Sarcophaga crassipalpis* resulted in 32% terminating the diapause prematurely and 56% developing normally to adult insects. This is not a standard test species or design, so the results are difficult to interpret in a REACH context.

2.4.7 Microbial activity in sewage treatment systems

ECHA (2021) reported a 16-h NOEC for *Pseudomonas putida* of 2,700 mg/L and a short-term respiration inhibition test with industrial activated sludge in which no effects were found up to a concentration of 2,000 mg/L.

2.4.8 Summary and discussion of the ecotoxicity information

It is agreed with ECHA (2021) that toxic effects on aquatic organisms were only observed at high concentrations (> 100 mg/L). However, as no standard tests were available, it is not possible to draw a meaningful conclusion about terrestrial toxicity.

2.5 Conclusions on the SVHC properties

2.5.1 CMR assessment

1,4-Dioxane is covered by the entry with Index number 603-024-00-5 in the GB MCL list and is assigned the hazard class Carcinogenicity category 1B (H350: May cause cancer). Therefore, 1,4-dioxane satisfies the criterion in Article 57(a) of UK REACH.

2.5.2 Equivalent level of concern under Article 57(f)

1,4-Dioxane is proposed to be identified as a SVHC in accordance with Article 57(f) of UK REACH as there is scientific evidence of possible serious effects to human health and the environment which give rise to an equivalent level of concern to those of other hazards listed in points (a) to (e) of Article 57 of UK REACH. The properties of 1,4-dioxane that lead to the very high concern can be summarised as follows:

- There is no evidence for abiotic degradation of 1,4-dioxane. Modelling results are inconclusive, but the substance screens as potentially P and vP based on the lack of ready biodegradation in screening tests, even where tests were extended beyond 28 days. There was no notable degradation of 1,4-dioxane in surface water during an OECD TG 309 study, so the half-life of 1,4-dioxane in freshwater is much longer than 60 days. There was no significant degradation in two non-standard studies where 1,4-dioxane was introduced into a soil suspension with a high nutrient concentration. It is therefore concluded that degradation in the environment is likely to be slow. In particular, 1,4-dioxane fulfils the P and vP criteria for freshwater under Annex 13 of UK REACH (half-life > 40 and > 60 days, respectively).
- Estimated and experimental log K_{OC} values for 1,4-dioxane ranged from -0.5 to 0.85, indicating a relatively low adsorption potential. It is miscible with water and has only a slight tendency to volatilise from water (the experimental Henry's law constant (HLC) is 0.486 $Pa.m^3/mol$). 1,4-Dioxane will remain in the aqueous phase and as it has limited adsorption potential it will be mobile in the aqueous environment.
- 1,4-Dioxane has a mandatory classification under GB CLP for Carcinogenic category 1B (H350: "May cause cancer"). Therefore, the substance meets the toxicity (T) criterion under Annex 13 of UK REACH.

These properties lead to the following concerns if 1,4-dioxane is released to the environment:

- *Widespread presence in the environment*

The combination of persistence and mobility gives rise to the potential for 1,4-dioxane to travel considerable distances from the source of emission via water and to migrate between and through environmental compartments such as from soil to groundwater, leading to widespread presence in the environment. Environment Agency monitoring data for England provide evidence of contamination, with 1,4-dioxane detected in 10.2 to 16.8% of surface waters and in 0.5 to 7.1% of groundwater samples between 2019 and 2022. Additional evidence from national monitoring programmes and academic studies indicates that it is present in surface water, including drinking water resources, as well as in groundwater in multiple countries.

- *Difficulty in removal from drinking water sources*

  Part 3 of the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (UK Government, 2017) requires that, for water bodies used for abstraction, measures are implemented ‘with the aim of avoiding deterioration in water quality, in order to reduce the level of purification treatment required for the production of drinking water’.

  The ability of 1,4-dioxane to persist and its tendency to remain in the aqueous environment, together with its relatively low adsorption potential to organic matter, indicate that it is likely to be difficult to remove through conventional drinking water treatment processes. Evidence from peer-reviewed studies suggest incomplete removal even when using advanced treatment technologies. 1,4-Dioxane has been shown to be present in drinking water sources including groundwater. 1,4-Dioxane has been detected in drinking water in different countries, including Germany, Spain, the United States, and Japan.

- *Potential for toxic effects*

  There is potential for long-term exposure of humans and wildlife to 1,4-dioxane from its presence and likely slowly increasing concentrations in the environment. Given its hazard profile, this indicates a potential to cause harm.

This combination of concerns gives rise to the potential for long-term impacts that are difficult to reverse. 1,4-Dioxane is therefore proposed to be identified as a SVHC in accordance with Article 57(f) of the UK REACH Regulation as there is scientific evidence of possible serious effects to the environment and human health which give rise to an equivalent level of concern to those of other hazards listed in points (a) to (e) of Article 57 of the Regulation.

3 Information on use, exposure and alternatives

3.1 UK and EU REACH registration status and tonnage

Under UK REACH, the substance is registered in the range of 10 to 100 tonnes per annum (tpa).

A total of 343 Downstream User Import Notifications (DUINs[2]) have been submitted under UK REACH.

Under EU REACH, the substance is registered with an estimated aggregated tonnage of 1,000–10,000 tonnes per annum (13 active EU registrants).

3.2 General description of uses and exposure

1,4-Dioxane is used as a solvent and laboratory reagent. However, it is also generated as an unintended by-product during the synthesis of other substances (e.g. ethoxylated substances that are used as surfactants) and may consequently occur as a residual impurity in products formulated with these other substances. This includes in products such as personal care products, cosmetics, detergents, surface cleaners (including household cleaning products) and paints. It may also be generated during the manufacture of polyethylene terephthalate (PET), resulting in residual amounts in plastics. Historically, 1,4-dioxane was used as a stabiliser for the chlorinated solvent 1,1,1-trichloroethane before its phase-out under the Montreal Protocol in the 1990s (ECHA, 2021b and HSE, 2025).

Exposure and release to the environment may occur during formulation and other industrial uses of the substance, as well as through its presence as a residual impurity in other substances and products (including consumer products) (ECHA, 2021b and HSE, 2025).

3.3 Alternatives

No information on specific alternatives is available (ECHA, 2021 and HSE, 2025).

[2] GB-based companies who imported substances from EU-based suppliers before UK REACH became law on 1 January 2021 had no EU REACH registration obligations as they were classed as Downstream Users (DUs). As they are now importers from outside of GB, they may have registration obligations under UK REACH. However, a transitional measure allows former DUs to suspend the registration until one of three deadlines (depending on tonnage and hazard). Where the identity of these imported substances was known, they could be included in a Downstream User Import Notification (DUIN) submitted to the Agency.

References

Abe, A. (1997). Determination method for 1,4-dioxane in water samples by solid phase extraction GC/MS. *Journal of Environmental Chemistry (in Japanese),* 7, 95-100.

Abe, A. (1999). Distribution of 1,4-dioxane in relation to possible sources in the water environment. *Science of The Total Environment,* 227(1), 41-47. https://doi.org/10.1016/S0048-9697(99)00003-0

Adamson, D. T., Anderson, R. H., Mahendra, S. & Newell, C. J. (2015). Evidence of 1,4-dioxane attenuation at groundwater sites contaminated with chlorinated solvents and 1,4-dioxane. *Environmental Science & Technology,* 49(11), 6510-6518. https://doi.org/10.1021/acs.est.5b00964

Adamson, D. T., Mahendra, S., Walker, K. L., Rauch, S. R., Sengupta, S. & Newell, C. J. (2014). A multisite survey to identify the scale of the 1,4-dioxane problem at contaminated groundwater sites. *Environmental Science & Technology Letters,* 1(5), 254-258. https://doi.org/10.1021/ez500092u

Adamson, D. T., Pina, E. A., Cartwright, A. E., Rauch, S. R., Hunter Anderson, R., Mohr, T. & Connor, J. A. (2017). 1,4-Dioxane drinking water occurrence data from the third unregulated contaminant monitoring rule. *Science of The Total Environment,* 596-597, 236-245. http://dx.doi.org/10.1016/j.scitotenv.2017.04.085

Anderson, R. H., Anderson, J. K. & Bower, P. A. (2012). Co-occurrence of 1,4-dioxane with trichloroethylene in chlorinated solvent groundwater plumes at US Air Force installations: Fact or fiction. *Integrated Environment Assessment and Management,* 8(4), 731-737. https://doi.org/10.1002/ieam.1306

Arp, H. P. H. & Hale, S. E. (2019). REACH: Improvement of guidance and methods for the identification and assessment of PMT/vPvM substances. German Environment Agency (UBA). Available at: https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2019-11-29_texte_126-2019_reach-pmt.pdf

ATSDR (2012). Toxicological profile for 1,4-dioxane. Atlanta, Georgia. Available at: https://www.atsdr.cdc.gov/toxprofiles/tp187.pdf

Bach, C., Boiteux, V. & Dauchy, X. (2024). France-wide monitoring of 1,4-dioxane in raw and treated water: Occurrence and exposure via drinking water consumption. *Archives of Environmental Contamination and Toxicology,* 87(2), 95-104. https://doi.org/10.1007/s00244-024-01078-6

Carrera, G., Vegue, L., Boleda, M. R. & Ventura, F. (2017). Simultaneous determination of the potential carcinogen 1,4-dioxane and malodorous alkyl-1,3-dioxanes and alkyl-1,3-dioxolanes in environmental waters by solid-phase extraction and gas chromatography

tandem mass spectrometry. *Journal of Chromatography A,* 1487, 1-13. https://doi.org/10.1016/j.chroma.2017.01.015

Carrera, G., Vegue, L., Ventura, F., Hernandez-Valencia, A., Devesa, R. & Boleda, M. R. (2019). Dioxanes and dioxolanes in source waters: Occurrence, odor thresholds and behavior through upgraded conventional and advanced processes in a drinking water treatment plant. *Water Research,* 156, 404-413. https://doi.org/10.1016/j.watres.2019.03.026

DiGuiseppi, W., Walecka-Hutchison, C. & Hatton, J. (2016). 1,4-Dioxane Treatment Technologies. *Remediation Journal,* 27(1), 71-92. https://doi.org/10.1002/rem.21498

DWI (2023). Persistent, mobile and toxic substances - Risk to drinking water in England and Wales (Phase 2). [DWI 70/2/341]. Drinking Water Inspectorate. https://dwi-content.s3.eu-west-2.amazonaws.com/wp-content/uploads/2023/01/18144553/DWI70_2_341.pdf

ECB (2002). European Union risk assessment report: 1,4-dioxane. Available at: https://echa.europa.eu/documents/10162/a4e83a6a-c421-4243-a8df-3e84893082aa

ECHA (2010). EU REACH registration for 1,4-dioxane; last updated April 2026. Available at: https://chem.echa.europa.eu/100.004.239/dossier-list/reach/dossiers/active?searchText=123-91-1

ECHA (2016). Chapter R.16: Environmental Exposure Assessment. *Guidance on Information Requirements and Chemical Safety Assessment.* European Chemicals Agency. Helsinki, Finland. https://data.europa.eu/doi/10.2823/515110

ECHA (2021a). Member State Committee support document for identification of 1,4-dioxane as a substance of very high concern. Available at: https://chem.echa.europa.eu/api-activity-list/v1/svhcIdentification/documents?name=f27b3fafd6505faaacfdab22b557e53b_svhc_supdoc_1,4-dioxane_en.pdf

ECHA (2021b). PROPOSAL FOR IDENTIFICATION OF A SUBSTANCE OF VERY HIGH CONCERN ON THE BASIS OF THE CRITERIA SET OUT IN REACH ARTICLE 57. Available at: https://chem.echa.europa.eu/api-activity-list/v1/svhcIdentification/documents?name=f27b3fafd6505faaacfdab22b557e53b_ec_204-661-8_1,4-dioxan_svhc_annex_xv_pub_en.pdf

Fleig, M., Brauch, H.-J. & Schmidt, K. C. (2017). Wesentliche Ergebnisse aus dem ARW Untersuchungsprogramm.

Gedalanga, P., Madison, A., Miao, Y., Richards, T., Hatton, J., DiGuiseppi, W. H., Wilson, J., *et al.* (2016). A multiple lines of evidence framework to evaluate intrinsic biodegradation of 1,4-dioxane. *Remediation Journal,* 27(1), 93-114. https://doi.org/10.1002/rem.21499

Hatzinger, P. B., Banerjee, R., Rezes, R., Streger, S. H., McClay, K. & Schaefer, C. E. (2017). Potential for cometabolic biodegradation of 1,4-dioxane in aquifers with methane

or ethane as primary substrates. *Biodegradation,* 28(5-6), 453-468. https://doi.org/10.1007/s10532-017-9808-7

Hofman-Caris, R. & Claßen, D. (2020). Persistence of gabapentin, 1H-benzotriazole, diglyme, DTPA, 1,4-dioxane, melamine and urotropin in surface water. Testing of chemicals according to the OECD 309 guideline. [KWR 2020.118]. Available at: https://edepot.wur.nl/539038

HSE (2025). Agency Technical Report: 1,4-Dioxane. Available at: https://www.hse.gov.uk/reach/assets/docs/technical-report-1-4-dioxane.pdf

Karges, U., Becker, J. & Puttmann, W. (2018). 1,4-Dioxane pollution at contaminated groundwater sites in western Germany and its distribution within a TCE plume. *Science of The Total Environment,* 619-620, 712-720. https://doi.org/10.1016/j.scitotenv.2017.11.043

Kelley, S. L., Aitchison, E. W., Deshpande, M., Schnoor, J. L. & Alvarez, P. J. (2001). Biodegradation of 1,4-dioxane in planted and unplanted soil: effect of bioaugmentation with Amycolata sp. CB1190. *Water Research,* 35(16), 3791-3800. https://doi.org/10.1016/S0043-1354(01)00129-4

Kollig, H. P., Kitchens, B. E. & Hamrick, K. J. (1993). FATE, the environmental fate constants information database. *Journal of Chemical Information and Computer Sciences,* 33(1), 131-134. https://doi.org/10.1021/ci00011a019

Magg, K., Thomas, A. M., Stepien, D. K. & Püttmann, W. (2013). Nachweis und räumliche Verbreitung des Lösungsmittels 1,4-Dioxan im Trinkwasser der Stadt Frankfurt am Main. Available at: https://www.setac-glb.de/fileadmin/setac/tagung/2013/tagungsband_setac2013_webversion.pdf

Merrington, G., Nowell, L. H. & Peck, C. (2024). An introduction to Criteria for Reporting and Evaluating Exposure Datasets (CREED) for use in environmental assessments. *Integrated Environmental Assessment and Management,* 20(4), 975-980. https://doi.org/10.1002/ieam.4899

Mohr, T. K. G. (ed.) (2010). *Environmental Investigation and Remediation: 1,4-Dioxane and other Solvent Stabilizers.* CRC Press. https://doi.org/10.1201/EBK1566706629

Neuwald, I. J., Hubner, D., Wiegand, H. L., Valkov, V., Borchers, U., Nodler, K., Scheurer, M.*, et al.* (2022). Occurrence, distribution, and environmental behavior of persistent, mobile, and toxic (PMT) and very persistent and very mobile (vPvM) substances in the sources of German drinking water. *Environmental Science & Technology,* 56(15), 10857-10867. https://doi.org/10.1021/acs.est.2c03659

OVAM (2017). Additives of chlorinated solvents - 1,4-dioxane in Flanders. Available at: https://ovam.vlaanderen.be/c/document_library/get_file?uuid=58ea137c-dc5d-4fe3-96cf-efe202795c15&groupId=177281

Park, J. H., Hussam, A., Couasnon, P., Fritz, D. & Carr, P. W. (1987). Experimental reexamination of selected partition coefficients from Rohrschneider's data set. *Analytical Chemistry,* 59(15), 1970-1976. https://doi.org/10.1021/ac00142a016

Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC.: European Commission. Available at: http://data.europa.eu/eli/reg/2006/1907/2022-12-17

Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006 (Text with EEA relevance). European Commission. Available at: http://data.europa.eu/eli/reg/2008/1272/2026-05-01

Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006 (Text with EEA relevance). UK Government. Available at: https://www.legislation.gov.uk/eur/2008/1272/contents

Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC (Text with EEA relevance). UK Government. Available at: https://www.legislation.gov.uk/eur/2006/1907/contents

Röden, O., Lammert, C. & Schmidt, K. C. (2016). Untersuchungen zu Vorkommen und Bedeutung von 1,4-Dioxan für die Trinkwassergewinnung aus Rhein-Uferfiltrat.

Rüdel, H., Körner, W., Letzel, T., Neumann, M., Nödler, K. & Reemtsma, T. (2020). Persistent, mobile and toxic substances in the environment: a spotlight on current research and regulatory activities. *Environmental Sciences Europe,* 32(1). https://doi.org/10.1186/s12302-019-0286-x

Sei, K., Kakinoki, T., Inoue, D., Soda, S., Fujita, M. & Ike, M. (2010). Evaluation of the biodegradation potential of 1,4-dioxane in river, soil and activated sludge samples. *Biodegradation,* 21(4), 585-591. https://doi.org/10.1007/s10532-010-9326-3

Stepien, D. K., Diehl, P., Helm, J., Thoms, A. & Puttmann, W. (2014). Fate of 1,4-dioxane in the aquatic environment: from sewage to drinking water. *Water Research,* 48, 406-419. https://doi.org/10.1016/j.watres.2013.09.057

UK Government (2017). The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 [2017 No. 407]. Available at: https://www.legislation.gov.uk/uksi/2017/407/data.pdf

UNEP (2025). Stockholm Convention on persistent organic pollutants (POPS). Text and Annexes. Revision 2025. Available at: https://www.pops.int/Portals/0/download.aspx?e=UNEP-POPS-COP-CONVTEXT-2025.English.pdf

US EPA (2020). Final Risk Evaluation for 1,4-Dioxane CASRN: 123-91-1. Available at: https://www.epa.gov/sites/default/files/2020-12/documents/1._risk_evaluation_for_14-dioxane_casrn_123-91-1.pdf

US EPA (2026). EPI Suite™ - Estimation Programs Interface Suite™ for Microsoft® Windows. Version: v 4.11. Washington, DC, USA: United States Environmental Protection Agency. Available at: https://www.epa.gov/tsca-screening-tools/epi-suitetm-estimation-program-interface; accessed 13 May 2026

Wang, C., Liu, T., Qian, Y., Zhang, B., Liu, W., Zhang, Y., An, W., *et al.* (2024). Ubiquitous occurrence of 1,4-dioxane in drinking water of China and its ecological and human health risk. *Science of The Total Environment,* 921, 171155. https://doi.org/10.1016/j.scitotenv.2024.171155

Wolfe, N. L. & Jeffers, P. M. (eds.) (2000). *Hydrolysis. In: Handbook of property estimation methods for chemicals: environmental and health sciences (RS B. and D M., eds.).* MI, Lewis, Chelsea.

Yang, F., Zhang, L., Hu, X., Huang, R., Wang, C., Chen, Y., Li, A., *et al.* (2026). National-scale insights into occurrence, health risks, and potential sources of 1,4-dioxane in drinking water of China. *Environmental Pollution,* 391, 127544. https://doi.org/10.1016/j.envpol.2025.127544

Zenker, M. J., Borden, R. C. & Barlaz, M. A. (2002). Modeling cometabolism of cyclic ethers. *Environmental Engineering Science,* 19(4), 215-228. https://doi.org/10.1089/109287502760271535

Zenker, M. J., Borden, R. C. & Barlaz, M. A. (2003). Occurrence and treatment of 1,4-dioxane in aqueous environments. *Environmental Engineering Science,* 20(5), 423-432. https://doi.org/10.1089/109287503768335913

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