European Chemicals Bureau

Institute for Health and Consumer Protection

European Chemicals Bureau

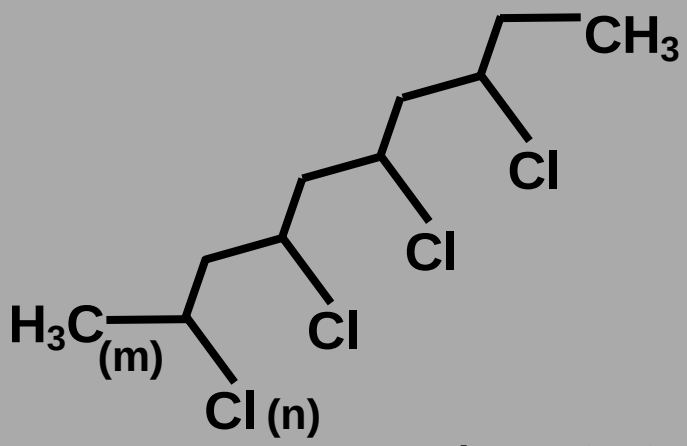
Existing Substances

European Union Risk Assessment Report

CAS No: 85535-84-8

EINECS No: 287-476-5

alkanes, C_{10-13}, chloro



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The mission of the IHCP is to provide scientific support to the development and implementation of EU polices related to health and consumer protection. The IHCP carries out research to improve the understanding of potential health risks posed by chemical, physical and biological agents from various sources to which consumers are exposed.

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UPDATED RISK ASSESSMENT

OF

ALKANES, C_{10-13}, CHLORO

CAS Number: 85535-84-8

EINECS Number: 287-476-5

Final Report August 2008

(Updating Previous Report Published in October 1999)

Introduction

A risk assessment of alkanes, C_{10-13}, chloro (short-chain chlorinated paraffins or SCCPs) produced in accordance with Council Regulation (EEC) 793/93[1] was published in October 1999[2]. Subsequent marketing and use restrictions for two uses (metal working and use for fat liquoring of leather) have come into force in the European Union through Directive 2002/45/EC[3]. This Directive also states that all remaining uses of short-chain chlorinated paraffins will be reviewed by the European Commission before 1st January 2003, in cooperation with Member States and the OSPAR Commission, in light of any relevant new scientific data on risks posed by short-chain chlorinated paraffins to health and the environment.

The UK has voluntarily updated the original risk assessment on behalf of the Commission, reviewing the new data on the environmental exposure, fate and effects of short-chain chlorinated paraffins that have become available since the original risk assessment was completed, and re-assessing the risks from the uses other than those already subject to marketing and use restrictions. The opinions of the European Commission's Scientific Committee for Toxicity, Ecotoxicity and the Environment (CSTEE) have also been considered. The assessment uses the latest version of the Technical Guidance Document, which was revised after the original report's publication. It also takes into account other information and techniques that have been used in the assessments of other substances (e.g. medium-chain chlorinated paraffins and phthalate plasticizers) to produce a more complete and conservative assessment of the risks from the remaining uses of short-chain chlorinated paraffins. In particular, the assessment now considers in detail the emissions of short-chain chlorinated paraffins over the lifetime of products.

The format of the report is broadly in line with that of the original risk assessment. Significant new information is summarised in this updated risk assessment and a comment is added to indicate how this affects the findings from the original risk assessment. In some areas, particularly the sections on release of the substance, entirely new sections have been produced to take into account the new information. To protect commercial confidentiality, the tonnage figures and calculation methods are presented in a separate confidential annex, rather than Section 2 and 3.1.1. This can be made available to regulatory authorities on request.

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The scientific work on the environmental sections was carried out by the Building Research Establishment Ltd (BRE), under contract to the rapporteur.

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[1] O.J. No. L 084, 05/04/1993 p. 0001 - 0075

[2] European Union Risk Assessment Report: Alkanes, C_{10-13}, chloro-. 1st Priority List, Volume 4. European Commission Joint Research Centre, EUR 19010 EN.

[3] O.J. No. L 177, 06/07/2002, p. 0021-0022

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0 OVERALL RESULTS OF THE RISK ASSESSMENT

CAS Number: 85535-84-8
EINECS Number: 287-476-5
IUPAC Name: Alkanes, C_{10-13}, chloro[4]

Environment

Conclusion (i) There is a need for further information and/or testing.

The worst-case PEC/PNEC ratios indicate a possible risk to:

- sediment (from the formulation and use (application) of backcoatings for textiles);
- soil (from compounding and conversion in rubber, formulation of backcoatings, application of backcoatings to textiles, and also possibly from regional sources of "waste remaining in the environment" (it is difficult to draw a clear conclusion in relation to "waste remaining in the environment" due to the uncertainties in the calculation methods used);
- marine water and sediments (from all uses of short-chain chlorinated paraffins, except for production, formulation and use in sealants/adhesives, and formulation of paints); and
- secondary poisoning via earthworm-based food chains for rubber compounding (also for several other uses, but these also lead to aquatic food chain risks).

There is some uncertainty over the PNECs for both sediment and soil. If a more conservative interpretation of the data were taken, possible risks would also be identified for the local sediment compartment for production, compounding and conversion of rubber and industrial application of paints and coatings. Possible risks would also be identified for the local terrestrial compartment for industrial use of paints. Further long-term toxicity testing with sediment- and soil-dwelling organisms could reduce this uncertainty in the PNECs. In addition, consideration could be given to carrying out further biodegradation testing of short-chain chlorinated paraffins in soil. However, given that a risk has already been identified for surface water from some of these applications, together with the concern for other end-points (e.g. secondary poisoning in the aquatic food chain, and the marine PBT assessment) it is not recommended that this be pursued further at this stage.

It is recognised that the PECs are based on a number of assumptions. Despite a legal requirement to supply emissions data for several life cycle stages under European Commission Regulation (EC) No 642/2005 [Official Journal of the European Union L 107 28.4.2005], Industry has indicated that it is unable to comply. Consequently, the PEC estimates cannot be refined further and so are considered to be the best that are achievable based on present knowledge.

Additional toxicity data would also allow the PNEC for both marine water and marine sediment to be revised, although the only uses for which there is not also a risk for secondary poisoning in the marine environment are rubber compounding and rubber conversion. It is therefore not recommended that toxicity testing be pursued.

[4] It should be noted that there are possibly other substances (such as chlorinated alkenes) that could have the same properties and hence risks as short-chain chlorinated paraffins. This is considered in Appendix A.

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

This conclusion applies to the assessment of:

- the local surface water compartment for production, compounding and conversion of rubber, formulation and use of sealants, the formulation and use of paints and coatings, and at the regional level;
- the local sediment compartment for production, compounding and conversion of rubber, formulation and use of sealants, the formulation and use of paints and coatings, and at the regional level (it should be noted that there are some uncertainties in the PNEC for this endpoint and, if a more conservative interpretation of the data were taken, possible risks would be identified for production, compounding and conversion of rubber and industrial application of paints and coatings);
- the local terrestrial compartment for production, formulation and use of sealants and formulation and use of paints, and the regional agricultural soil compartment (it should be noted that there are some uncertainties in the PNEC for this endpoint and, if a more conservative interpretation of the data were taken, possible risks would be identified for industrial use of paints);
- wastewater treatment processes and the atmospheric compartment for production and all uses;
- the risk of secondary poisoning via both the aquatic and terrestrial food chains from production, formulation and use of sealants/adhesives and formulation of paints/coatings; and
- the marine ecosystem from production, formulation and use of sealants/adhesives and formulation of paints/coatings.

Conclusion (iii) There is a need for limiting the risks; risk reduction measures which are already being applied shall be taken into account.

This conclusion applies to the:

- local assessment for surface water from the formulation of backcoatings and application of backcoatings to textiles;
- assessment of secondary poisoning via the aquatic food chain for conversion and combined conversion/compounding of rubber, formulation and processing of textile backcoatings, and from the industrial use of paints and coatings; and
- marine secondary poisoning assessment for combined compounding and conversion of rubber, formulation and processing of textile backcoatings, and industrial application of paints/coatings.

Assessment of PBT/vPvB Properties

Conclusion (iii) There is a need for limiting the risks; risk reduction measures which are already being applied shall be taken into account.

It is concluded that the substance meets the criteria for a PBT substance. Biodegradation simulation studies have demonstrated that the mineralisation half-life in both freshwater and

marine sediment is >180 days (vP), the experimentally determined BCF in fish is 7,816 l/kg (vB) and the lowest chronic NOEC in aquatic organisms is 0.005 mg/l (T).

Measurements indicate that the substance is widely distributed in the environment. The trend in levels is unknown, and they could be related to former uses that are now controlled. In addition, a clear risk has not been identified on the basis of these measurements. Nevertheless, the occurrence of short-chain chlorinated paraffins in the Arctic and in marine predators means that these findings remain a concern. In addition, the substance appears to meet the screening criteria for consideration as a candidate persistent organic pollutant (POP) under international conventions.

Note for risk managers: Sales have declined significantly since 2001 (the baseline year for this assessment), and it is no longer a high production volume substance in the EU. In the absence of any legal driver to this decline, it has to be assumed that market conditions might change and that sales could increase again in future. Therefore the overall conclusions of this assessment will continue to be based on consumption levels in 2001. However, the level of risk associated with the lower supply level is considered in Appendix C. Based on data for 2004, the following scenarios would no longer pose a risk based on the PEC/PNEC approach:

- Textile backcoating formulation sites for surface water, freshwater sediment, the terrestrial compartment and secondary poisoning.
- Industrial application of paints for secondary poisoning (including marine scenarios).
- The regional assessment for the terrestrial compartment for industrial soil.

Human Health

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

This conclusion applies to the assessment of human infants exposed via milk.

CONTENTS

TABLES

A separate confidential annex can be made available to regulatory authorities on request, containing details of the tonnage and calculation methods used in this assessment.

1 GENERAL SUBSTANCE INFORMATION

1.1 IDENTIFICATION OF THE SUBSTANCE

There has been no change in the identity of the commercial substance since the original assessment (chlorinated n-paraffins with a carbon chain length of 10-13). However, it should be noted that around 40 CAS numbers have been used to describe the whole chlorinated paraffin family at one time or another. Some of these are now historical, and others may be in use for the sole purpose of compliance with national or regional chemical inventories. It is possible that some cover the short-chain chlorinated paraffin group, and those that might are listed in **Table 1.1** (the list is not meant to be exhaustive).

Table 1.1 Substances that might contain short-chain chlorinated paraffins

Substance	CAS no.	EINECS no.
Alkanes, C6-18, chloro	68920-70-7	272-924-4
Alkanes, C10-12, chloro	108171-26-2	-
Alkanes, C10-14, chloro	85681-73-8	288-211-6
Alkanes, C10-21, chloro	84082-38-2	281-985-6
Alkanes, C10-26, chloro	97659-46-6	307-451-5
Alkanes, C10-32, chloro	84776-06-7	283-930-1
Alkanes, C12-13, chloro	71011-12-6	-
Alkanes, C12-14, chloro	85536-22-7	287-504-6
Paraffins (petroleum), normal C>10, chloro	97553-43-0	307-202-0
Alkanes, chloro	61788-76-9	263-004-3

This illustrates a problem in using CAS numbers to describe complex substances. From comments made in BUA (1992), it may be that some refer to products derived from feedstocks other than n-paraffins, or are monochlorinated. Such substances might therefore not have suitable properties for the uses considered in this assessment. From the way that n-paraffin fractions are made, the CAS numbers referring to wide ranges of chain length (e.g. 68920-70-7, 84082-38-2, 84776-06-7 and 97659-46-6) may fall into this category.

The CAS number that is listed in IUCLID (85535-84-4) is taken to represent the commercial substance.

It is possible that related substances called chloroalkenes are still in production. These are considered further in Appendix A.

1.2 PURITY/IMPURITY, ADDITIVES

It is understood that there have been no changes to the purity of short-chain chlorinated paraffins since the original assessment.

1.3 PHYSICO-CHEMICAL PROPERTIES

1.3.1 Summary of original risk assessment

The original risk assessment uses the following key physico-chemical properties for short-chain chlorinated paraffins.

Water solubility	0.47 mg/l (range 0.15-0.47)
Vapour pressure	0.0213 Pa at 40^{o}C
Log Kow	6.0 (range ~4.5-8.5)
Henrys law constant	17.1 Pa m^{3}/mole

1.3.2 Updated information

New data are available on the vapour pressure, water solubility, partition coefficient and Henry's Law constant. These are summarised in the following sections. The new physico-chemical property data are in line with those used in the original assessment. The new data do allow some better speciation of the individual components that may be present in the available short-chain chlorinated paraffin products. However, in terms of the risk assessment, a single value has to be chosen for the physico-chemical properties as it is not possible to carry out the environmental modelling for the individual components of the commercial products (due to the large number involved). **Therefore the key physico-chemical properties for environmental modelling are the same as in the original assessment.**

For some uses of chlorinated paraffins, especially for rubber and textiles, it has been confirmed that only specific types of chlorinated paraffins are generally used. For these applications, it has been possible to estimate the emissions using physico-chemical properties (notably vapour pressure) that are appropriate for the specific types of chlorinated paraffins used. This is discussed, where appropriate, in the following Sections.

1.3.2.1 Vapour pressure

Drouillard et al. (1998b) determined the subcooled-liquid vapour pressures of a series of short-chain chlorinated paraffins at 25^{o}C using a vapour pressure - gas-liquid chromatography technique. They found that vapour pressures of the short-chain chlorinated paraffins decreased with both increasing carbon chain length and degree of chlorination within the range of chlorine contents tested. The results are summarised in **Table 1.2.** Using these data, the authors derived the following equation relating vapour pressure (in Pa at 25^{o}C) to the number of carbon and chlorine atoms present in a molecule.

$$\log (\text{vapour pressure}) = -(0.353 \times \text{no. of C atoms}) - (0.645 \times \text{no. of Cl atoms}) + 4.462$$

The data in **Table 1.2** show that the vapour pressure at 25^{o}C for short-chain chlorinated paraffins with chlorine contents in the range 45-52% wt. Cl is generally in the range 0.0035-0.028 Pa. This vapour pressure range is consistent with the vapour pressure of 0.0213 Pa at 40^{o}C assumed in the original risk assessment report, and so this value is maintained in this assessment for short-chain chlorinated paraffins in general as a realistic worst case.

Table 1.2 Measured vapour pressures for short-chain chlorinated paraffins (Drouillard et al., 1998b)

Substance	No. of C atoms	No. of Cl atoms	Chlorine content by weight	Subcooled-liquid vapour pressure at 25°C (Pa)
1,10-Dichlorodecane	10	2	33.6%	0.50
1,2,9,10-Tetrachlorodecane	10	4	50.7%	0.028
Pentachlorodecane	10	5	56.4%	0.0040-0.0054
Hexachlorodecane	10	6	61.0%	0.0011-0.0022
1,2,10,11-Tetrachloroundecane	11	4	48.3%	0.010
Pentachloroundecane	11	5	54.0%	0.0013-0.0020
Hexachloroundecane	11	6	58.7%	0.00024-0.00049
1,12-Dichlorododecane	12	2	29.7%	0.068
1,2,11,12-Tetrachlorododecane	12	4	46.1%	0.0035
Pentachlorododecane	12	5	51.8%	0.00070-0.0019
Mixture of penta- and hexachlorododecane	12	5-6	51.8-56.5%	0.00014-0.00052

The measured vapour pressure range for more highly chlorinated paraffins (e.g. 55-61% wt. Cl) is lower, at around 1.4×10^{-4}-5.4×10^{-3} Pa at 25°C, and a vapour pressure of 5.4×10^{-3} Pa will be used in the exposure assessment when considering these types of products specifically (for example this type of short-chain chlorinated paraffin is used in textile applications (see Section 2.2.2.6)).

Products with very high chlorine contents (around 70% by weight) are used for applications as a flame retardant/plasticiser in rubber (see Section 2.2.2.2). The equation above has been used to extrapolate/estimate a more realistic vapour pressure for these high chlorine content chlorinated paraffins as follows.

Formula	**Chlorine content**	**Estimated vapour pressure at 25°C**
$C_{10}H_{13}Cl_9$	70.5%	1.34×10^{-5} Pa
$C_{11}H_{14}Cl_{10}$	70.9%	1.35×10^{-6} Pa
$C_{12}H_{15}Cl_{11}$	71.1%	1.35×10^{-7} Pa
$C_{13}H_{16}Cl_{12}$	71.2%	1.36×10^{-8} Pa

Based on these estimates a vapour pressure of 1.34×10^{-5} Pa at 25°C will be considered in the release estimation for the highly chlorinated (>70% wt. Cl) products.

1.3.2.2 Water solubility

The water solubility of several short-chain chlorinated paraffins has been determined using a generator column method (Drouillard et al., 1998a and Friesen et al., 1995). The results are shown in **Table 1.3**. Douillard et al. found the water solubility to increase with increasing degree of chlorination within the range of chlorine contents tested; the data from Friesen et al. appear to show the opposite trend.

Table 1.3 Measured water solubilities for short-chain chlorinated paraffins

Substance	No. of C atoms	No. of Cl atoms	Chlorine content by weight	Water solubilities at 25°C (μg/l)	Reference
1,10-Dichlorodecane	10	2	33.6%	257	Drouillard et al., 1998a
				236	Friesen et al., 1995
1,2,9,10-Tetrachlorodecane	10	4	50.7%	328	Drouillard et al., 1998a
Tetrachlorodecane	10	4	50.7%	141	Friesen et al., 1995
Pentachlorodecane	10	5	56.4%	692-975	Drouillard et al., 1998a
				27.7-30.6	Friesen et al., 1995
Hexachlorodecane	10	6	61.0%	1.6-4.0	Friesen et al., 1995
1,12-Dichlorododecane	12	2	29.7%	22.4	Drouillard et al., 1998a

Based on these data, there is no clear trend in water solubility with either chlorine content or carbon chain length. The available data are generally consistent with the water solubility value used in the original risk assessment report (0.15-0.47 mg/l) and so this value will be retained in this update for all short-chain chlorinated paraffins. It is not clear, however, if this value would be appropriate for short-chain chlorinated paraffins with very high (>70% wt.) chlorine contents.

1.3.2.3 Partition coefficient

Fisk et al. (1998b) determined the octanol-water partition coefficients of two ^{14}C-labelled short-chain chlorinated paraffins of single carbon chain length (C_{12}). The two compounds used were $C_{12}H_{20.1}Cl_{5.9}$, 55.9% wt. Cl and $C_{12}H_{16.2}Cl_{9.8}$, 68.5% wt. Cl. The mean log Kow values determined by a HPLC method were reported to be 6.2 for the 55.9% wt. Cl substance (range of log Kow was 5.0 to 7.1 for the main components of this substance) and 6.6 for the 68.5% wt. Cl substance (range of log Kow was 5.0 to 7.4). These are consistent with the other values determined previously (range ~4.5 to 8.5) and so a log Kow of 6.0 (as used in the original risk assessment report) will be used in this update for the environmental modelling.

1.3.2.4 Henry's Law constant

Drouillard et al. (1998b) and Friesen et al. (1995) determined the Henry's Law constants for several short chain chlorinated paraffins using a gas-sparging technique. These values are shown in **Table 1.4**. The Henry's Law constant was found to decrease with increasing degree of chlorination within the range of chlorine contents tested.

The Henry's Law constant used in the original risk assessment report was 17.1 Pa m^3/mole, which is consistent with the new data available for short-chain chlorinated paraffins with around 50% wt. chlorine contents. This value will be used again here for environmental modelling as a worst case.

Table 1.4 Measured Henry's Law constants for short-chain chlorinated paraffins

Substance	No. of C atoms	No. of Cl atoms	Chlorine content by weight	Henry's Law constant at 23°C (Pa m³/mol)	Reference
1,10-Dichlorodecane	10	2	33.6%	499[a]	Drouillard et al., 1998b
1,2,9,10-Tetrachlorodecane	10	4	50.7%	17.7	Drouillard et al., 1998b
Tetrachlorodecane	10	4	50.7%	1.8-12.7 (mean 5.4)	Friesen et al., 1995
Pentachlorodecane	10	5	56.4%	2.62-4.92	Drouillard et al., 1998b
				1.8-4.6 (mean 3.4)	Friesen et al., 1995
1,2,10,11-Tetrachloroundecane	11	4	48.3%	6.32	Drouillard et al., 1998b
Pentachloroundecane	11	5	54.0%	0.68-1.46	Drouillard et al., 1998b
1,12-Dichlorododecane	12	2	29.7%	648[a]	Drouillard et al., 1998b
Mixture of penta- and hexachlorododecane	12	5-6	51.8-56.5%	1.37	Drouillard et al., 1998b

a) Henry's law constant estimated from vapour pressure and water solubility (Drouillard et al., 1998b)

For short-chain chlorinated paraffins with chlorine contents around 55-56% wt. Cl, the measured Henry's Law constant is around 1-5 Pa m^3/mole at 23°C.

As discussed in Section 1.3.2.1, short-chain chlorinated paraffins with very high chlorine contents (e.g. >70% wt. Cl) may be significantly less volatile than indicated by the above figures. Using the estimated vapour pressure for this type of chlorinated paraffin (1.34×10^{-5} Pa), a water solubility of around 0.14-0.47 mg/l (assuming that this water solubility range is appropriate for this type of chlorinated paraffin) and a molecular weight of around 355 g/mole (corresponding to $C_{11}H_{14}Cl_{10}$; 70.9% wt. Cl), the Henry's law constant for short chain chlorinated paraffins with chlorine contents >70% by weight can very approximately be estimated to be around 0.010-0.034 Pa m^3/mole.

2 GENERAL INFORMATION ON EXPOSURE

2.1 PRODUCTION

Short-chain chlorinated paraffins are still produced in the EU. To avoid revealing confidential information, data on production have been removed to a confidential annex. This can be made available to regulatory authorities on request.

2.2 USE

2.2.1 Summary of original risk assessment report

The original risk assessment was based on 1994 data as follows.

Metal working lubricants	9,380 tonnes/year
Rubber	1,310 tonnes/year
Paint	1,150 tonnes/year
Sealants	695 tonnes/year
Leather	390 tonnes/year
Textiles	183 tonnes/year
Other	100 tonnes/year
Total	13,208 tonnes/year

2.2.2 Updated information

Information on the trends in use of short-chain chlorinated paraffins since 1994 (the base year for the original risk assessment (RAR, 1999)) have been provided (Euro Chlor, 2002) but the details are considered to be confidential owing to the limited number of companies now supplying in the EU. The information is presented in a confidential annex to this report.

Manufacturers of chlorinated paraffins exist in Asia and North America, as well as other parts of Europe (e.g. Slovakia, which is now part of the EU). For example, CSTEE (2002a) indicate that large volumes of chlorinated paraffins are being produced in China and so there is a possibility of imports of short-chain chlorinated paraffins in finished products from this area. The possible importation of preparations and articles containing short-chain chlorinated paraffins from these sources into the EU has not been quantified. Euro Chlor have indicated that, in their view, the imports of short-chain chlorinated paraffins into the EU from sources in the United States and Asia are very small in comparison with domestic production.

This updated assessment is based on the amounts of short-chain chlorinated paraffins used in the EU in 2001[5]. These data show that the use of short-chain chlorinated paraffins in metal working lubricants and leather fat liquors has reduced markedly compared with the 1994 use.

[5] Euro Chlor (2004 and 2005) has indicated that there has been a further decrease in the use of short-chain chlorinated paraffins in all applications since 2001. The EU consumption in textiles and rubber had decreased by a factor of three in 2003 compared to the 2001 level, with further decreases occurring (particularly in use in textiles, paints and sealants and adhesives) in 2004. The consumption in paints and sealants/adhesives also decreased by a factor of two over the same time period. Some use in metal working fluids was still occurring in 2003, but this use was expected to cease by 2004. The overall amount of short-chain chlorinated paraffins used in the remaining applications was less than 1,000 tonnes in 2003 and less than 600 tonnes in 2004.

Of the other applications covered in the original risk assessment, short-chain chlorinated paraffins are currently used as a flame retardant in textiles and rubber, in paint and in sealants and adhesives.

There was also a small use in PVC reported during the late 1990s. This is considered further in Section 2.2.2.7. A further use of short-chain chlorinated paraffins reported in the late 1990s was in lava lamps. This use is now thought to be very small. Given the nature of this type of product (an enclosed lamp) the potential of release from this use appears to be very small. The "other" uses of short-chain chlorinated paraffins are now very minor and have essentially almost completely ceased. Industry indicated that they were not aware of any new applications of short-chain chlorinated paraffins that were not covered in the original risk assessment report (Euro Chlor, 2002).

The use of short-chain chlorinated paraffins in Sweden has reduced by 56% over the period 1998 to 2001 (KEMI, 2002). The major use in Sweden in 2001 (accounting for around 75% of the total) was in paints and coatings. The use in metal working fluids has decreased to around 15% of the total and there was no reported use in leather fat liquors in 2001. The use in sealants, lubricants, mortars and rust removing agents were reported to be at a low but stable level.

The use of short-chain chlorinated paraffins in Norway has reduced from 16 tonnes/year in 1998 to 4 tonnes/year in 2001 (75% reduction). The current (2001) uses were reported to be in metal working fluids/lubricants and paints and rust inhibitors (SFT, 2002a).

CSTEE (2002a) indicated that it is possible that the use of short-chain chlorinated paraffin as a flame retardant could increase in the future due to possible restrictions in the use of certain other halogenated flame retardants. However, as the measures that may be necessary to reduce any risk from these other flame retardants have yet to be discussed and agreed it is not possible to speculate what effect, if any, any future restrictions on the use of other flame retardants may have on the use pattern for short-chain chlorinated paraffins.

2.2.2.1 Metal cutting/working fluids

In this updated risk assessment it will be assumed that there is no longer any use of short-chain chlorinated paraffins in metal cutting/working fluids in the EU. It is expected that this use will cease entirely by 6th January 2004 at the latest, in line with the marketing and use restrictions.

2.2.2.2 Rubber industry

Chlorinated paraffins with high chlorine contents (e.g. 70% wt. Cl) can be used as flame retardants in natural and synthetic rubbers (Zitko and Arsenault, 1974). Chlorinated paraffins with lower chlorine contents may also be used in rubber. Here they have a plasticising and flame retarding function. An important use for flame retarded rubber appears to be in conveyor belts for mining applications, but the rubber is also used in other applications.

The amount of chlorinated paraffin added is generally in the range 1-4% by weight (Zitko and Arsenault, 1974), but can be up to 15% by weight for some applications (BUA, 1992).

A survey of the use of chlorinated paraffins amongst members of the British Rubber Manufacturers' Association Ltd. has been carried out (BRMA, 2001). The survey included

three main sectors within the rubber industry: the new tyre sector; the general rubber goods sector; and the polyurethane foam sector. In all, responses were received from 25 companies (around 30% of the membership). Of these, 15 companies reported using chlorinated paraffins of one type or another. The main area of use of chlorinated paraffins in general was in the general rubber goods sector. The results of the survey are summarised in **Table 2.1**. No use of chlorinated paraffins in car tyres was found in the survey.

Table 2.1 Results of survey of chlorinated paraffin use in rubber in the United Kingdom

Chlorinated paraffin type	Application	Amount of chlorinated paraffin present in rubber	Amount of chlorinated paraffin used at a site
Short-chain (C_{10-13})	Conveyor belting	10.1-16.8%	48-51 tonnes/year
Medium-chain (C_{14-17})	Cable cover	3.8%	25 tonnes/year
	Rubber hose	6.2%	1 tonne/year
	Pipe seals	4%	35 tonnes/year
	Industrial roller coverings	up to 20%	2 tonnes/year
	Flame retardant items for railway use	7.2%	4.2 tonnes/year
Long-chain ($C_{>20}$)	Various fire resistant rubber products	10%	4.8 tonnes/year
	Manufacture of flexible ducting	7%	1.5 tonnes/year
	Rubber belting	4.6%	0.1 tonnes/year
Unidentified (probably short-chain (C_{10-13})	Shoe soles	6.5%	6 tonnes/year
	Industrial sheeting	13%	1.2 tonnes/year

The amount of chlorinated paraffin present in the rubber products from the survey is in the general range 4-17%, with a maximum of 20%. These figures agree well with those reported in the literature above. The short-chain chlorinated paraffins appear to be used at loadings of around 10-17% in conveyor belts.

Information provided by Industry (Euro Chlor, 2003b) has confirmed that, in the EU, short-chain chlorinated paraffins with chlorine contents of around 70-71% only are supplied for use in rubber, and this will be taken into account in the exposure assessment. Uses of the treated rubber include conveyor belts for use in mines where specific safety requirements need to be met.

2.2.2.3 Paint industry

A survey of the use of chlorinated paraffins in paints and coatings in the United Kingdom has been carried out (BCF, 1999). A total of 141 companies were contacted and initial responses were obtained from 106 of these. The survey was focused on obtaining information on the use of medium-chain chlorinated paraffin but information was also provided on the use of short- and long-chain chlorinated paraffins. Of the companies responding, 22 (~21%) indicated that they used medium-chain chlorinated paraffins or other chlorinated paraffins. More detailed information on the use of chlorinated paraffins was obtained from 12 (~55%) of the 22 companies. The chlorine content of the short-chain chlorinated paraffins used was generally around 65-70% wt. Cl. The types of paint/coating and the typical (total) chlorinated paraffin contents are shown in **Table 2.2**.

Euro Chlor (1999) reported that the typical level of a chlorinated paraffin in the formulated paint would be 4-15% by weight. After drying (evaporation of solvent) the chlorinated paraffin content of the coating would be around 5-20% by weight.

Table 2.2 Chlorinated paraffin content of paints (BCF, 1999)

Coating type	Chlorinated paraffin content (% by weight)
Organic solvent borne chlorinated rubber primers and topcoats	1-5
Organic solvent borne chlorinated rubber systems for swimming pools/fishponds	5-20
Organic solvent borne zinc rich (epoxy) primers	2-5
Organic solvent borne acrylic container coatings	2-10
Organic solvent borne chemical and water resistant coatings	5-20
Organic solvent borne vacuum metallising lacquers	1-5
Organic solvent borne flame retardant coating for wood	1-5
Organic solvent borne intumescent coating for structural steel	20-30
Organic solvent borne floor paints	5-10
Organic solvent borne water-proofing coatings for walls	5

In tonnage terms, the amount of chlorinated paraffins used in the United Kingdom in paints/coatings appears to be small, with a total of up to around 34 tonnes/year being identified in the BCF survey (it is not possible to extrapolate this figure to give the total United Kingdom or EU usage). Further, it was found that paints containing chlorinated paraffins make up only a very small proportion of the total paint manufactured at a site (typically <1-2% of the total, up to 5% in some cases). The total number of sites in the United Kingdom manufacturing paints and coatings containing chlorinated paraffins is estimated at around 30 (BCF, 1999).

The BCF (1999) survey also tried to identify the number of sites where coatings containing chlorinated paraffins might be used in the United Kingdom, but this did not prove to be possible. The major users of the paints are professional painters and specialist applicators, but some DIY paints containing chlorinated paraffins may be used by the general public. In the United Kingdom, it was estimated that there would be around 40,000 users of coatings containing chlorinated paraffins for water proofing of walls, with around 1,000-1,500 users of paints and coatings for other uses.

2.2.2.4 Sealing compounds

Chlorinated paraffins, including short-chain ones, are used as plasticisers/flame retardants in adhesives and sealants. Examples include polysulphide, polyurethane, acrylic and butyl sealants used in building and construction and in sealants for double and triple glazed windows. The chlorinated paraffins are typically added at amounts of 5-14% wt. of the final sealant but could be added at amounts up to 20% wt. of the final sealant in exceptional cases.

The difference between an adhesive and sealant can be fairly blurred in that some sealants are used as adhesives and *vice versa*. Generally, sealants are considered to be materials that are installed into a gap or joint to prevent water, wind, dirt or other contaminants from passing

through the joint or crack. Adhesives, on the other hand, are used to transfer loads and are typically designed with much higher tensile and shear strength than sealants (Palmer and Klosowski, 1997). The main use of short-chain chlorinated paraffins in this area is in sealants.

2.2.2.5 Leather industry

In this updated risk assessment it will be assumed that there is no longer any use of short-chain chlorinated paraffins in leather fat liquors in the EU, in line with the marketing and use restrictions on this use.

2.2.2.6 Textile industry

Short-chain chlorinated paraffins are mainly used as a flame retardant for backcoating of textiles. A very small amount also appears to be used for waterproofing textiles. Euro Chlor (2003b) indicates that the short-chain chlorinated paraffins with chlorine contents of around 56-60% wt. Cl are currently supplied in the EU for backcoating of textiles, and this will be taken into account in the emission estimation from this use.

2.2.2.7 Use in PVC

A small amount of short-chain chlorinated paraffins was reported to have been used in PVC in the late 1990s (e.g. figures reported to the Economic and Social Committee Review of the 20th Amendment to the Marketing and Use Directive, suggested a very small use of short-chain chlorinated paraffins in PVC in 1998). However, Industry has indicated that this was an error in the reported figures and that short-chain chlorinated paraffins were not used in this application over the period for which data have been collated (1994 to the present day) (Euro Chlor, 2003a).

CSTEE (2002a) also indicates that short-chain chlorinated paraffins were used as plasticisers in PVC and that short-chain chlorinated paraffins had been extracted in recent leaching experiments on a PVC mat. However, consultation with the author of the comment indicated that the mat was more than 30 years old (Jansson, 2003), and so the information is not relevant to current use. Furthermore it was stated that the researchers had found it difficult to obtain any new mats containing chlorinated paraffins today, and that the major Swedish manufacturers said that they were not using these chemicals in PVC.

In conclusion, although it appears that short-chain chlorinated paraffins may have been used in PVC in the EU historically (and some treated articles might still be found), there is currently no use in PVC and so this use is not considered further in the risk assessment.

2.3 EXPOSURE CONTROL

Marketing and use restrictions have come into force in the European Union through Directive 2002/45/EC amending for the twentieth time Council Directive 76/769/EEC relating to restrictions on the marketing and use of certain dangerous substances and preparations (short-chain chlorinated paraffins). Directive 2002/45/EC states that short chain chlorinated paraffins may not be placed on the market for use as substances or as constituents of other

substances or preparations in concentrations higher than 1% in metalworking and for fat liquoring of leather. These restrictions will apply from 6th January 2004 at the latest.

The current manufacturers recommend management processes for chlorinated paraffins (Euro Chlor, 2001). These are shown in **Table 2.3**. The recovery treatments are strongly recommended by the manufacturers.

Table 2.3 Treatment methods currently recommended by Euro Chlor

Type of waste	Preparation for disposal/recovery	Treatment methods
Liquid wastes e.g. oily waste from metal working, plasticiser condensates, water based mixtures and emulsions.	Water separation e.g. thermal splitting, ultrafiltration, chemical splitting.	Recovery e.g. incineration with energy recovery (limiting chlorine content to 1%), clean-up and re-use.
		Disposal e.g. incineration without energy recovery; absorb onto solids and then landfill.
Solid wastes e.g. plastics, rubber and resins, dried sludges from user processes.		Recovery e.g. incineration with energy recovery, re-process thermoplastics, grind/chip rubber.
		Disposal e.g. incineration without energy recovery; landfill.

PARCOM (Convention for the Prevention of Marine Pollution from Land-based Sources) Decision 95/1 was an agreement to phase out the use of short-chain chlorinated paraffins in paints, coatings, sealants, rubber, plastics, textiles and metal working fluids (PARCOM, 1995). The deadlines agreed for the phase-out were 31st December 2004 for use as a plasticiser in sealants in dams and use as a flame retardant in conveyor belts, and 31st December 1999 for all other uses.

Following the PARCOM Decision, some EU member states (e.g. the Netherlands) have implemented national legislation to control the uses of short-chain chlorinated paraffins identified for phase out by 31st December 1999 (i.e. in metal working; for fat liquoring of leather; as plasticisers in paints or coatings; and as flame retardants in rubber, plastics or textiles). (Note: The EU risk assessment carried out in accordance with Regulation 793/93/EEC updated the assessment that justified PARCOM Decision 95/1, and did not identify risks from all of these uses.)

Regulations governing the use of short-chain chlorinated paraffins in Norway were laid down on 13th December 2000. According to the regulations, production, import, export, sale and use of short-chain chlorinated paraffins in pure form, preparations or in finished products is prohibited. The regulations entered into force on 1st January 2001. According to the transitional provisions, the prohibition of the sale and use of short-chain chlorinated paraffins entered into force on 1st January 2002 and will come into force on 1st January 2005 for conveyor belts in the mining industry and sealing materials (SFT, 2002a).

In Germany, certain halogen-containing wastes, for example metal working fluids with >2 g halogen/kg and halogen-containing plasticisers, are classified as potentially hazardous waste and are incinerated (BUA, 1992).

The Baltic environmental protection commission Helcom has also recently completed a three-year project to identify the most cost-effective ways of eliminating certain hazardous substances in the region by 2020, which includes short-chain chlorinated paraffins. This

follows a ministerial pledge to phase-out short-chain chlorinated paraffins in a 1998 environmental declaration (along with around 70 other substances) (HELCOM, 2002).

Short-chain chlorinated paraffins have been identified as priority hazardous substances in the field of water policy under the Water Framework Directive (Directive 2000/60/EC of 23 October 2000).

Short-chain chlorinated paraffins are not currently included in the 1998 Protocol to the UNECE Convention on Long-range Transboundary Air Pollution on Persistent Organic Pollutants (POPs), which is concerned with emissions to air. However, this is due for review around 2005, and Parties are considering short-chain chlorinated paraffins as a potential new candidate. A final draft dossier on short-chain chlorinated paraffins is available (UNECE, 2003)[6]. The draft dossier was recently reviewed (Fourth meeting of the expert group on the persistent organic pollutants held in Norway 17-19 March 2003) and the expert judgement based on the information in the dossier was that short-chain chlorinated paraffins fulfil the UNECE POP characteristics in line with the Executive Body decision 1998/2[7] (SFT, 2003).

Short-chain chlorinated paraffins appear to meet the screening criteria for consideration as a POP under the Stockholm Convention (Stockholm Convention, 2001) (see Section 3.3.5.2). Under the Convention, Governments must take measures to eliminate or reduce the release of POPs into the environment.

A number of uses (including some former uses) of short-chain chlorinated paraffins will be covered under the Integrated Pollution Prevention of Control Directive (Directive 1996/61/EC). This will include (depending on the size of operation) production of short-chain chlorinated paraffins, metal working (though only large companies in the ferrous and non-ferrous metals sectors), some plastics compounding/conversion sites and leather processing sites (larger sites only) (Entec, 2004).

2.4 NATURAL SOURCES

It is impossible to say categorically that naturally occurring chlorinated paraffins do not exist. A large number of organohalogen compounds are known to be produced naturally in the environment (especially in the marine environment, where there is an abundance of chlorine and bromine), and a comprehensive review of these has been published (Gribble, 1996). This study reported around 2,570 naturally occurring organohalogen compounds (detected up to mid-1994). A number of naturally occurring compounds with carbon chains in the C_{10} to C_{13} range were identified in this study, but none were paraffinic, and all contained one or more functional groups such as acid (COOH) or ester (COOR) groups, and generally contained a relatively low number of halogen atoms (typically ≤3 chlorine atoms/molecule). Therefore although there is a possibility of natural formation, there is currently no evidence of any significant natural source of the short-chain chlorinated paraffins currently in commercial production.

[6] Available from http://www.unece.org/env/popsxg

[7] See http://www.unece.org/env/lrtap/conv/report/dec98_2.htm

2.5 IMPURITIES IN OTHER PRODUCTS

Short-chain chlorinated paraffins are present as minor impurities in medium-chain (C_{14-17}) chlorinated paraffins. The EU producers of medium-chain chlorinated paraffins (represented by Euro Chlor) have, since 1991, used paraffin feedstocks in the production process with a C_{10-13} content of <1% (the actual levels are often much lower than this) (RAR, 2002). Therefore small amounts of short-chain chlorinated paraffins could be released to the environment as a result of the use of medium-chain chlorinated paraffins. This is considered further in Appendix B.

2.6 WASTE DISPOSAL

Similar to chlorinated compounds in general, chlorinated paraffins can act as a source of chlorine radicals during disposal using incineration processes. This chlorine can then lead to the formation of polychlorinated dioxins and furans, and is a well known problem with incineration.

In most cases, controls are already in place on incinerators to minimise the formation of these dioxins and furans, and so the presence of chlorinated paraffins should not lead to increased emissions. However, other processes involving chlorinated paraffins may not be so well controlled (e.g. accidental fires).

In addition, CSTEE (2002b) indicates that other unsaturated hydrocarbon products, including aromatic products such as polychlorinated biphenyls and polychlorinated naphthalenes can also be formed from chlorinated paraffins under certain circumstances, such as under heat or in contact with alkaline substances. The basis for these comments is unknown.

There is insufficient information available on these issues to make an assessment of the significance of these processes in terms of a risk for the environment. These issues are therefore not considered further in this assessment.

3 ENVIRONMENT

3.1 EXPOSURE ASSESSMENT

3.1.1 General discussion

To avoid revealing confidential data, full details of the calculations and assumptions used to estimate releases are not presented here, but are included in a confidential annex to this report.

3.1.1.1 Release from production

No new information on releases from production sites was available and so no changes are proposed. The maximum releases of short-chain chlorinated paraffins from production sites are likely to be less than 9.9-26.7 kg/year. The production site in Slovakia has not been considered.

3.1.1.2 Release from use

Emissions from some uses were not estimated in the original assessment, since appropriate methodologies did not exist and the relative tonnages were low. This was noted as a potential data gap (for paints at least) by the CSTEE at the time (CSTEE, 1998). Recent assessments of other existing substances, notably phthalate plasticisers, have attempted to quantify emissions from plastics and paints, and so this assessment now provides release estimates for all remaining uses.

3.1.1.2.1 Use in metal working and extreme pressure lubricating fluids

The release from this use will be considered to be zero owing to the forthcoming marketing and use restrictions.

3.1.1.2.2 Use as a flame retardant in rubber formulations

Summary of original release estimate

The estimated emissions from use as a flame retardant in rubber formulations in the original risk assessment report were as follows.

Local release = <0.004 kg/day over 300 days
Regional release = <1.3 kg/year
Total EU release = <13 kg/year

Updated estimate

Since the original risk assessment was completed, further information on exposure from use in rubber/other polymers has been obtained for the risk assessment reports of medium- and

long-chain chlorinated paraffins (RAR (2003) & Environment Agency (2001)). This has been used along with the updated use pattern information to obtain the revised emission estimates.

The details of the updated estimate are considered confidential but the estimates have been based on the information in the Use Category Document on plastics additives (UCD, 1998)[8]. The emission factors in the Use Category Document have been modified to take into account the relevant physico-chemical properties for short-chain chlorinated paraffins. Industry has indicated that short-chain chlorinated paraffins with chlorine contents of 70-71% by weight are the dominant grades used in rubber (Euro Chlor, 2003b), and so a vapour pressure of 1.34×10^{-5} Pa at 25^{o}C appropriate for this type of short-chain chlorinated paraffin has been used in the estimates. The amount of rubber containing short-chain chlorinated paraffin processed on a local site has been estimated using the information given in Section 2.2.

The estimates consider liquid loss through spillage and volatile release from compounding and conversion. Volatile losses are thought to occur initially to air, but the possibility exists that as the gases cool, the short-chain chlorinated paraffin could condense out and eventually enter into waste water during cleaning, etc. To take this into account in the PEC calculations, it has been assumed that 50% of the releases initially to air will enter into waste water and 50% will remain in the air.

In addition to these estimates, the calculations in the original risk assessment have been changed to take account of the revised quantity used in this area. These calculations appear in the tables as the alternate estimate.

3.1.1.2.3 Use as a plasticizer in paints and sealing compounds

Summary of original release estimate

The releases from paints and sealants were thought to be low. Volatilisation/leaching from the paint/sealant was thought to be a possibility but insufficient data were available to estimate the releases.

Updated estimate

Paints

An estimate of releases from formulation and processing (application) has been made using information provided by industry, a recent Emission Scenario Document (ESD) on coatings (Environment Agency, 2003a) and Appendix I of the Technical Guidance Document. Some details of the updated estimate are considered confidential.

[8] Industry has recently carried out workplace monitoring for medium-chain chlorinated paraffins at four PVC processing (conversion) plants in the EU (MCCP User Forum, 2003). The plants represented 21.7% of the total use in this area and used a variety of emission treatment methods (e.g. thermal oxidisers or vapour recovery) prior to release into the atmosphere. The emissions to air from the process vents were found to be much lower than estimated using the methods in UCD (1998). This indicates that the methods presented in UCD (1998) may overestimate the actual emissions from plastic and rubber processing in general, particularly at well controlled sites. However, the study only considered air emissions of medium-chain chlorinated paraffins from a limited number of sites processing PVC and so it is difficult to extrapolate these results to the "realistic worst case" situation in the EU for short-chain chlorinated paraffins used in plastics and rubber.

For formulation, the ESD indicates that emissions to air and water should be minimal for solvent-borne paints and coatings. Any solvent-borne paint/coating left in the manufacturing equipment at the end of the formulation of a batch is washed out with organic solvents and either recycled back to the process or disposed of (by incineration or disposed of as hazardous waste) and hence little or no release to the environment occurs from this process. Packaging waste will be similarly disposed of. The emission factors given in the ESD for formulation of solvent-borne coatings are summarised below.

		Standard size batch (~1,000 litres)	Large size batch (~10,000 litres)
Waste generation	equipment leftovers	0.5% recycled 0.5% to disposal	0.25% recycled 0.25% to disposal
	packaging waste	0.5% to disposal	0.5% to disposal
Emissions to air		0% for low volatility liquids	0% for low volatility liquids
Emissions to water		0% for liquids	0% for liquids

The main source of emission to water identified in the ESD is from wash-off of dust from workshop areas. Since short-chain chlorinated paraffins are liquids at room temperatures, such sources of emission are not relevant.

On this basis, the local and regional emissions to waste water and air during the formulation of solvent-borne paints and coatings containing short-chain chlorinated paraffins can be assumed to be negligible, and this assumption will be considered in the risk assessment.

For processing (application of paints), immediate losses of short-chain chlorinated paraffins to air should be minimal as a result of the low vapour pressure of the substance (losses over extended time periods are considered later). Losses to water are also expected to be low (owing to the low water solubility of the substance) from industrial application of paints. This is also indicated in the ESD.

In the absence of information on the actual magnitude of releases to the environment from the use of paints containing short-chain chlorinated paraffins, the default release estimates from Appendix I of the Technical Guidance Document have been used as the basis for the PEC calculations. These estimates have been supplemented with information reported in the ESD. In particular this latter source indicates that a considerable amount of paint/coatings containing short-chain chlorinated paraffins may be disposed of during the application process (estimates range from 2.5% to 60.8% depending on the coating type and the mode of application), and this is taken into account in the estimate of lifetime losses from painted articles.

Sealants

The main function of the short-chain chlorinated paraffin is as a plasticiser and/or flame retardant additive. It is thought that the short-chain chlorinated paraffins are used at a typical concentration of 5-14%, with a maximum of around 20% by weight of the sealant/adhesive.

Sealants are produced by mixing the required additives with a viscous liquid polymer. Both low and high shear mixers may be used, depending on the surface area of the filler used in the formulation (Palmer and Klosowski, 1997). As most sealants are moisture sensitive (particularly the one-part sealants), no water use is likely in the process and so releases to waste water are likely to be very low.

A survey of chlorinated paraffin use in sealants in the United Kingdom was carried out at the end of 1998. Of the twenty two companies contacted, responses were received from ten. Not all companies reported using short-chain chlorinated paraffins but where they were used, a consistent picture of the industry was obtained. Only minor amounts of short-chain chlorinated paraffins appear to be used in adhesives.

Short-chain chlorinated paraffins are used in both 1-part and 2-part sealants, and similar methods are used to produce both types. Typically, sealants are made in a batch process of around 1,000 kg at a time. The process is simple mixing, sometimes under gentle heat (e.g. up to around 40^{o}C) and is usually carried out under vacuum to avoid moisture entering the process. A typical short-chain chlorinated paraffin content of the sealant would be 5-20% by weight and typically up to 1-2 tonnes of a sealant containing the chlorinated paraffin may be manufactured at a site per week. The amount of chlorinated paraffins used on a site is typically of the order of 5-30 tonnes/year.

Once formulated, the sealant is pumped directly from the mixing vessel to fill cartridges (e.g. for 1-part sealants) or tins (e.g. 2-part sealants).

Losses to waste water during the manufacture of sealants are reported to be low or zero as water is not used in the process (most sealants are moisture sensitive). Scrap material and machine cleaning can account for up to 5% solid waste. Cleaning between batches is minimised by the use of dedicated equipment or by starting with light coloured product and progressing through to darker coloured products. Generally, solid material is removed from the equipment by hand. Solvent cleaning of the equipment can also occur. These solvents are collected and disposed of at the end of their useful life by registered waste contractors. As a result of its physico-chemical properties, the chlorinated paraffin is likely to be associated with the solid waste phases during the cleaning of equipment and so releases to waste water from the process are likely to be very low (the releases to water owing to leaching from the sealant are considered in Section 3.1.0.2.7).

Some sealants (e.g. 1-part) are supplied in the form of cartridges typically containing around 500 g of sealant. In use, around 2-3 cm^3 of sealant are estimated to remain in the nozzle and tube when the cartridge has been emptied. This will quickly skin over and be protected inside the packaging. The final destination of these discarded cartridges will be as waste to landfill.

Other sealants (e.g. 2-part) are supplied in tins. Immediately before use, a curing agent is added to the tin and mixed with the sealant. The sealant is then filled into a cartridge on-site prior to application. Again, any unused material will quickly cure and set hard and will be disposed of in an appropriate manner. For industrial applications in the United Kingdom, the waste sealants are treated as special waste rather than general building waste.

Based on the above discussion, the major loss of sealant containing short-chain chlorinated paraffins during their production and use (application) will be as solid waste.

3.1.1.2.4 Use in leather applications

The releases from this use will be considered to be zero in this updated assessment as a result of the marketing and use restrictions.

3.1.1.2.5 Use as a flame retardant in textile applications

Summary of original release estimate

Losses to the environment from backcoating of textiles were thought to be low but it was not possible to quantify the releases from this source.

Updated estimate

An estimate of releases from formulation of backcoatings (also believed to be termed compounding[9]) and processing (application of the backcoating to the textile) has been made using information provided by industry and from Appendix I of the Technical Guidance Document. The details of the updated estimate are considered confidential.

Information provided by industry indicates that the short-chain chlorinated paraffins used typically contain around 56-60% chlorine by weight (Euro Chlor, 2003b), and the properties of this type of chlorinated paraffin are taken into account in the emission estimate.

The approach taken assumes that the majority of chlorinated paraffins used in this area are applied by backcoating. Other processes may have been used in the past (e.g. for water-proofing textiles), but the current extent of these is small. Some of these processes, particularly if the chlorinated paraffin is applied directly to the textile from an aqueous solution/emulsion, could potentially lead to a local release of short-chain chlorinated paraffins.

In backcoating, the chlorinated paraffin is applied to the back of the material in a viscous polymer latex, which is then cured, usually by heating to 130-140^{o}C for a few seconds to drive off water. Once cured, the additive is incorporated in a polymer matrix which should minimise losses due to volatilisation and leaching. These losses are considered later in Section 3.1.0.2.7.

Losses to the environment during the backcoating process are thought to be very low, and are mainly associated with the cleaning out of the formulation vessels and the application machinery. The losses from these operations are likely to be mainly in the form of a polymer containing the chlorinated paraffin and are likely to be collected for disposal rather than sent to sewer, which should minimise the actual release of chlorinated paraffin to the environment.

The major sources of release during the formulation (compounding) of flame retardant formulations for textile treatments are thought to be dust formation (from solid additives only) during the emptying of the flame retardant powder into the pre-mixer and washing out of the final formulation mixing tanks. At major formulation sites controls are generally in place to limit exposure to dusts. Any loose dust is likely to be collected and the area then washed down with water. Thus a small amount of the flame retardant may reach the waste water. The vast majority of the dust (>99%) that is collected is re-used. As short-chain chlorinated paraffins are liquids at or near room temperature dust is not expected to be a

[9] The producers of short-chain chlorinated paraffins do not recognise the concept of compounding in relation to textiles and have questioned whether this is a relevant scenario for short-chain chlorinated paraffins. However they do not have any further information on the releases from use of short-chain chlorinated paraffins in textiles as a whole and so a separate formulation and processing step is considered in the assessment in the absence of more specific information.

source of release during their use. With regard to washing out of vessels, around 0.5% of the formulation is estimated to be lost, of which the flame retardant will make up a percentage.

The actual form of the flame retardant formulation at this stage is as a viscous mixture with the polymer. Large sites are likely to have a solids extraction system in place before the effluent is discharged from the site. This system is likely to remove this as a "paint-like" film, and so the actual releases of short-chain chlorinated paraffins to sewer are likely to be very small. The solid residue will be disposed of. The actual efficiency of such a solid extraction system for the removal of short-chain chlorinated paraffin is unknown, and it is not known if such a system will be fitted at all sites in the EU. As a worst case approach it will be assumed that all the release at the generic large site is directed to a standard waste water treatment plant as defined in the TGD. This approach will overestimate the resulting concentrations in the environment from sites where a solids extraction system is present.

Release of flame retardant formulation could also occur during the backcoating operation. The losses are thought to be as a result of initial set-up and washing down of the coating equipment between batches (although it is also possible that a small loss to the atmosphere could occur during the curing process). The estimated likely loss is around 1 kg of formulation between each batch. This equates to a loss of around 0.15-0.2 kg of short-chain chlorinated paraffin, assuming that it makes up 15-20% of the wet formulation. The frequency of washing is dependent on the length of run, but could vary between a few hours and a few days. The waste is usually collected for suitable disposal but could be disposed of to drain. The amount of short-chain chlorinated paraffin released at a given site will depend on the number of coating machines at the site and the frequency of washing of equipment and so is not easy to quantify in general terms. However, if a figure of 0.75-1 kg/day (i.e. washing occurs 5 times/day) of short-chain chlorinated paraffin is taken to represent the daily loss (to within an order of magnitude) at a worst case facility, this would give a yearly estimated loss of 49.5-88 kg of short-chain chlorinated paraffin (using the default number of days/year of operation estimated earlier), possibly to landfill or waste water.

Little information is available on the other uses of short-chain length chlorinated paraffins in the textile industry, although it is possible that for some applications (such as water-proofing textiles) the chlorinated paraffin is applied in emulsion form and so releases could be to water. However, the quantities involved are small.

3.1.1.2.6 Release from articles over their service life

Summary of original release estimate

Releases from products containing short-chain chlorinated paraffins over their service life were not fully quantified in the original assessment owing to a lack of a suitable methodology.

Updated release estimate

Since the original risk assessment was completed this type of release has been estimated for both medium-chain (RAR, 2002) and long-chain chlorinated paraffins (Environment Agency, 2001) and a similar methodology has been used here to estimate these emissions for short-chain chlorinated paraffins.

Although short-chain chlorinated paraffins are of low vapour pressure at ambient temperatures, the vapour pressure is not so low as to preclude the possibility of volatilisation from plastics, paints, rubber, textiles and sealants during their service life. Losses have also been estimated for leaching and as a result of "waste" from the products themselves during their useful lifetime and disposal (e.g. erosion/particulate losses).

No agreed method is currently included in the Technical Guidance Document for addressing these potential sources of release. The method used to estimate these emissions follows the approach taken in the draft ESR risk assessments of various phthalate plasticisers. The accuracy of the estimates is uncertain.

The estimates depend to some extent on the vapour pressure of the substance in question. A vapour pressure at room temperature of around 0.021 Pa has been assumed in the calculations for short-chain chlorinated paraffins in general where several different types of short-chain chlorinated paraffins could be used. However, for rubber and textiles a single type of short-chain chlorinated paraffin dominates each use, and a vapour pressure appropriate to the main type of chlorinated paraffin used has been assumed (i.e. 5.4×10^{-3} Pa for the 55-61% wt. Cl types used in textiles and 1.3×10^{-5} Pa for the 70-71% wt. Cl types used in rubber).

The details of the updated release estimates are considered confidential.

3.1.1.3 Summary of release estimates

3.1.1.3.1 Summary from original risk assessment

The total emission of short-chain chlorinated paraffins was estimated as 39.29 kg/year to air and 204,100 kg/year to water in the region and 393.9 kg/year to air and 1,784,000 kg/year to water in the EU as a whole. These emissions (particularly to water) were dominated by the use of short-chain chlorinated paraffins in metal working and in leather fat liquors. The emissions did not, however, include the contribution from articles over their lifetime and during disposal.

3.1.1.3.2 Summary of updated release estimates

The release estimates are summarised in **Table 3.1**. The actual release estimates are subject to a large uncertainty. They show an increased regional emission to air and a reduced regional emission to water when compared with the estimates in the original risk assessment report. In addition, a significant emission to urban/industrial soil is now predicted. The estimates are based on the amounts of short-chain chlorinated paraffins used in the EU in 2001. Euro Chlor (2004) indicate that the use of short-chain chlorinated paraffins in the EU in 2003 was around three times lower than in 2001. This reduction in use will lead to a reduction in the regional and continental emissions.

Table 3.1 Summary of environmental release estimates for short-chain chlorinated paraffins

Use	Comment	Estimated local release	Estimated regional release (kg/year)	Estimated continental release[a] (kg/year)
Production sites	Site specific information	<0.089 kg/day to waste water over 300 days	Confidential	Confidential
Use in rubber[b]	Compounding site (formulation)	7.5 kg/year (0.038-0.063 kg/day) to waste water; 2.5 kg/year (0.0125-0.021 kg/day) to air, over 118-200 days	Confidential	Confidential
	Conversion site (processing)	2.5-12.5 kg/year (0.0125-0.106 kg/day) to waste water; 2.5-12.5 kg/year (0.0125-0.106 kg/day) to air, over 118-200 days		
	Combined compounding and conversion site	10-20 kg/year (0.050-0.169 kg/day) to waste water; 5-15 kg/year (0.025-0.127 kg/day) to air, over 118-200 days		
Use in textiles	Formulation (compounding)	165 kg/year (0.55 kg/day) to waste water, over 300 days	Confidential	Confidential
	Processing (backcoating)	49.5-88.0 kg/year (0.75-1 kg/day) to waste water, over 66-88 days	Confidential	Confidential
Sealants/ adhesives	Formulation/use	Negligible	Confidential	Confidential
Paints and coatings	Formulation	Negligible	Confidential	Confidential
	Industrial application of paints (Processing)	6.48-13.0 kg/year (0.022-0.075) kg/day to waste water, over 300 days	Confidential	Confidential
	Application by general public (private use)	Negligible		

Table 3.1 continued overleaf

Table 3.1 continued Summary of environmental release estimates for short-chain chlorinated paraffins

Use	Comment	Estimated local release	Estimated regional release (kg/year)	Estimated continental release[a] (kg/year)
Volatile and leaching loss from products containing short-chain chlorinated paraffins over life-time	Volatile loss over life-time		286-1,057 kg/year to air	2,576-9,516 kg/year to air
	Leaching loss over life-time		4,363-11,878 kg/year to waste water	39,269-106,903 kg/year to waste water
"Waste remaining in environment" over life-time and disposal			3,276-6,492 kg/year to urban/industrial soil 1,088-2,155 kg/year to surface water 4.4-8.7 kg/year to air	29,484-58,429 kg/year to urban/industrial soil 9,788-19,398 kg/year to surface water 39.2-77.9 kg/year to air
Total			299-1,092 kg/year to air 3,732-9,789 kg/year to wwtp[c] 2,021-4,602 kg/year to surface water[c] 3,276-6,492 kg/year to urban/industrial soil	2,695-9,832 kg/year to air 33,213-87,486 kg/year to wwtp[c] 18,091-41,270 kg/year to surface water[c] 29,484-58,429 kg/year to urban/industrial soil

a) Continental release = total EU release-regional release .
b) Estimates based on a worst case approach assuming release from rubber processing is similar to that from plastic processing. Other information is available which indicates that the total release from the processes may be much lower at <0.0042 kg/day over 118 days, probably to waste water. This figure will also be considered in the risk assessment.
c) Releases to waste water assume a 80% connection rate to wwtp, with 20% going directly to surface water, as recommended in the Technical Guidance Document.

These differences arise for a number of reasons. For example, the regional emission to water in the original report was dominated by the contribution from use in metal working/finishing fluids and leather fat liquoring. In the current assessment, it is assumed that these regional sources have now been effectively controlled, and so the regional emission to water is dominated by the contribution from the leaching loss over the lifetime of products and from the contribution from "waste remaining in the environment". It was not possible to estimate the emissions from these sources in the original report and so they were not included in the original total.

For the regional emissions to air and urban/industrial soil, the increased regional emissions estimated in the current assessment compared with those in the original assessment arise mainly from the contribution of the lifetime and disposal emissions. Again it was not possible to estimate the contribution from these sources in the original report.

In addition to the sources outlined in **Table 3.1**, short-chain chlorinated paraffins are also present as minor impurities in medium-chain (C_{14-17}) chlorinated paraffins. However, the EU producers of medium-chain chlorinated paraffins (represented by Euro Chlor) have, since 1991, used paraffin feedstocks in the production process with a C_{10-13} content of <1% (the actual levels are often much lower than this) (RAR, 2002). Based on the total amount of medium-chain chlorinated paraffins estimated to be released in the EU (~ 3,076-3,338 tonnes based on 1997 figures), the approximate upper limit for the amount of short-chain chlorinated paraffins present is 30.8-33.4 tonnes/year. This corresponds to around 11-28% (at most) of the total amount of short-chain chlorinated paraffins estimated to be released from current normal use. It should also be noted that risk reduction is required for many of the uses of medium-chain chlorinated paraffins. The contribution of this source has therefore not been taken into account in the regional and continental release estimates for this assessment, to avoid complicating the interpretation of the results. Appendix B carries out an assessment of the significance at the local level of the short-chain chlorinated paraffin impurity present in medium-chain chlorinated paraffins.

As noted in Section 2.2.2, a significant reduction in the amounts of short-chain chlorinated paraffins used in the EU has occurred since 2001 (the base-line year for the above emission estimates). The effect of this reduction in use on the resulting emissions and PEC/PNEC ratios is considered in Appendix C.

3.1.1.4 Degradation

3.1.1.4.1 Abiotic degradation

Summary of original risk assessment report

Short-chain chlorinated paraffins were assumed to be photochemically and hydrolytically stable in the environment. The half-life for atmospheric degradation by reaction with hydroxyl radicals was estimated to be 7.2 days.

Updated information

Koh and Thiemann (2001) showed that several chlorinated paraffins, including two short-chain chlorinated paraffins (C_{10-13}, 56% wt. Cl and C_{10-13}, 62% wt. Cl commercial products) were rapidly degraded by UV light (254 nm) in aqueous solutions containing either

0.01% acetone (half-life 3.8 and 0.7 hours respectively), 0.02% hydrogen peroxide (half-life 8.0 and 5.8 hours respectively) or 0.002% hydrogen peroxide (half-life 9.2 and 6.9 hours respectively). The half-life in pure water was longer than in the solutions containing either acetone or hydrogen peroxide (the half-lives for the two short-chain chlorinated paraffins were not determined). The photodegradation reaction lead to the release of chloride ions into solution and some indications for the formation of long-chain length paraffins were found in some experiments (e.g. n-alkanes with chain lengths $>C_{25}$ were identified in experiments carried out with a $C_{12\text{-}18}$ chlorinated paraffin), possibly as a result of re-combination reactions of smaller alkyl fragments formed during the reaction.

As the conditions used in this test were not directly relevant to the environment (UV-light of wave-length 254 nm was used in the experiment but only light of wavelength >290 nm is relevant to exposure in the lower atmosphere and earth's surface), it is not possible to estimate a rate for photodegradation in the environment from the data.

3.1.1.4.2 Biodegradation

Summary of original risk assessment report

Short-chain chlorinated paraffins are not readily biodegradable (no degradation was observed in a test for ready biodegradability (OECD 301C, Modified MITI I Test), and only up to 16% degradation was observed in a test for inherent biodegradability (OECD 302B, Modified Zahn-Wellens Test), although conducted at a concentration two orders of magnitude above water solubility and therefore there is some uncertainty over the interpretation of the results). There are some indications that some short-chain chlorinated paraffins of low chlorine content (e.g. <50% wt. Cl) may biodegrade slowly in the environment, particularly in the presence of adapted micro-organisms. Certain bacteria have also been shown to dechlorinate short-chain chlorinated paraffins with high chlorine contents in a cometabolic process and so under certain conditions, biodegradation of these compounds might also be expected to occur slowly in the environment. Short-chain chlorinated paraffins were assumed to be not readily biodegradable for environmental modelling purposes.

Updated information

Fisk et al. (1998b) estimated half-lives for biodegradation of 13 days for ^{14}C-labelled $C_{12}H_{20.1}Cl_{5.9}$ (55.9% wt. Cl) and 30 days for $C_{12}H_{16.2}Cl_{9.8}$ (68.5% wt. Cl) in an aerobic sediment system containing oligochaetes (*Lumbriculus variegatus*). The extent of degradation was determined at day 0 and day 14 of the experiments based on the difference between toluene-extractable ^{14}C measurements (taken to represent unchanged chlorinated paraffin) and total ^{14}C measurements. However, the results of this test should be treated with caution as the identity of the ^{14}C present in the samples was not determined, and it was assumed that the non-extractable ^{14}C represented metabolites.

Allpress and Gowland (1999) identified a bacterium (*Rhodococcus* sp.) that was able to grow using various chlorinated paraffins as the sole source of carbon and energy. The bacterium was isolated from stream water from an industrial area of the United Kingdom using a minimal salts medium containing 1% by volume of a $C_{14\text{-}17}$, 45% wt. Cl chlorinated paraffin product. The ability of this bacterium to utilise short-chain chlorinated paraffins was investigated by inoculating minimal salts medium containing one of two short-chain chlorinated paraffins (a $C_{10\text{-}13}$, 49% wt. Cl product and a $C_{10\text{-}13}$, 63% wt. Cl product) at a

concentration of 1% by volume and determining the chloride release compared with controls over 71 days incubation at 20°C. The test media also contained anti-bumping granules to aid dispersion of the test substance within the media. Only the C_{10-13}, 49% wt. Cl product was utilised by the bacterium with 49% of the chlorine present in the chlorinated paraffins being released as chloride after 71 days. The C_{10-13}, 63% wt. Cl product showed little or no increase in chloride ion levels above the control values during the experiment. Several other chlorinated paraffins were tested using this system and it was concluded that the *Rhodococcus* sp. identified in the study was able to utilise chlorinated paraffins as sole source of carbon and energy, but little or no utilisation occurred with chlorinated paraffins with high degrees of chlorination (at or above around 59-60% wt. Cl).

Further studies investigating the biodegradation of short-chain chlorinated paraffins in both freshwater and marine sediments under aerobic and anaerobic conditions have been carried out by Thompson and Noble (2007). Two substances were used in the tests, a ^{14}C-labelled n-decane, 65% wt. Cl product and a ^{14}C-labelled n-tridecane, 65% wt. Cl product. The test substances were synthesised by chlorination of the respective uniformly ^{14}C-labelled n-alkanes mixed with the appropriate unlabelled n-alkanes. The purity of the chlorinated products was >98% and the two test substances had average molecular formulas of $C_{10}H_{14.9}Cl_{7.1}$ (65.0% wt. Cl) and $C_{13}H_{18.8}Cl_{9.2}$ (64.9% wt. Cl) respectively.

The freshwater sediment was collected from the Grand Western Canal in Devon (UK) and the marine sediment was collected from the Dart Estuary in Devon. Both sampling sites were considered to be remote from sources of significant industrial contamination. The samples were collected through the water column using a grab sampler. The marine sediment samples were separated into the superficial aerobic sediment and the subsurface anaerobic sediment. This separation was not possible for the freshwater sediment and so a single sediment sample was collected and used for both the aerobic and anaerobic experiments. Samples of overlying water were collected from the same locations as the sediments. The sediments were sieved (2 mm) to remove stones and other debris and stored for between six and seven days under refrigeration prior to use in the tests.

The freshwater sediment had a pH of 7.1, a redox potential of 231 mV (Eh; at the time of collection), an organic carbon content of 4.5-4.8% and consisted of 56% sand, 21% silt and 23% clay. The overlying water from the freshwater sediment sampling site had a pH of 8.6 and a redox potential of 460 mV (Eh; at the time of collection). The aerobic layer of the marine sediment had a pH of 7.5, a redox potential of 279 mV (Eh; at the time of collection), an organic carbon content of 4.1% and consisted of 8% sand, 51% silt and 41% clay. The anaerobic layer of the marine sediment had a pH of 7.8, a redox potential of 216 mV (Eh; at the time of collection), an organic carbon content of 4.1% and consisted of 8% sand, 51% silt and 41% clay. The overlying water from the marine sediment sampling site had a pH of 7.8, a redox potential of 356 mV (Eh, at the time of sampling) and a salinity of 26.5‰.

The test method used was based on the OECD 308 Test Guideline (Aerobic and anaerobic transformation in aquatic sediment systems). The sediments were acclimated to the test conditions for twenty two days prior to addition of the test substance. During the acclimation the test chambers (1 litre glass bottles) each contained an equivalent dry weight of 75 g freshwater sediment or 65 g marine sediment and 525 ml of the overlying water and the chambers were incubated at 16°C. Air was supplied to the aerobic chambers at a rate of 20-30 ml/min (air was provided via glass tubing located centrally above the water surface). The headspace of the anaerobic chambers was continually purged with nitrogen at a similar rate during the acclimation period. To start the biodegradation phase of the test, the relevant

test substance was added to the chambers adsorbed onto 5 g of dry sediment. The spiked dry sediment was prepared by adding 0.5 ml of a stock solution of the relevant chlorinated paraffin in acetone to 5 g of dry sediment and allowing the acetone to evaporate. The spiked dry sediment was then mixed into the bulk sediment using a magnetic stirring bar. The final depth of sediment in the test chambers was 22 mm and depth of the overlying water was 90 mm (water/sediment volume ratio of approximate 3.1). Control sediments were prepared in the same manner but using acetone without the test substance. A total of 156 test vessels were prepared (sixteen vessels each for the eight combinations of test substance (C_{10}/C_{13}), sediment (marine/freshwater) and conditions (aerobic/anaerobic) and twenty eight control vessels). During the biodegradation phase, the headspace of the aerobic chambers was continually purged with air (as during the acclimation phase) and volatile organic products and $^{14}CO_2$ were collected from the exhaust air. The anaerobic chambers were operated as static closed systems during the biodegradation phase of the test (no trapping systems for methane were available that would be effective if the headspace was continually purged), with the chambers being flushed with nitrogen overnight only following the initial addition of the test substance. The initial concentrations of the test substance were in the range 6.2 to 8.7 mg/kg dry weight. The duration of the tests were 98 days (aerobic conditions) and 86-100 days (anaerobic conditions) and the test chambers were again incubated at 16°C throughout the duration of the tests.

The microbial biomass present in the test systems was determined both at the start and end of the test. The microbial biomass at the start of the test was determined to be 268 µg C/g in the freshwater aerobic sediment, 286 µg C/g in the freshwater anaerobic sediment, 220 µg C/g in the marine aerobic sediment and 216 µg C/g in the marine anaerobic sediment. At the end of the study the microbial biomass in the control sediments was 400 µg C/g in the freshwater aerobic sediment, 380 µg C/g in the freshwater anaerobic sediment, 250 µg C/g in the marine aerobic sediment and 160 µg C/g in the marine anaerobic sediment. The corresponding microbial biomass in the treated sediments was 420, 440, 280 and 160 µg C/g respectively in the experiments with the chlorinated decane and 400, 400, 250 and 160 µg C/g respectively in the experiments with the chlorinated tridecane. These data indicate that neither test substance was toxic to the microbial biomass at the concentrations used.

At various timepoints during the test, duplicate vessels from each treatment group were sacrificed and analysed to determine the distribution of total ^{14}C and the overall mass balance. The results of the experiments are summarised in **Table 3.2**.

For the experiments carried out under aerobic conditions, $^{14}CO_2$ was found to be evolved over the 98 day test period. The cumulative formation of $^{14}CO_2$ (as a percentage of the total radiolabel added to the test system) is shown graphically in **Figure 1**. Both substances showed a higher rate of mineralisation in the marine sediment than in the freshwater sediment, and the chlorinated decane was mineralised at a faster rate than the chlorinated tridecane. The highest amount of $^{14}CO_2$ evolved was around 13% in the experiments with the chlorinated decane in the marine sediment.

Table 3.2 Biodegradation of short-chain chlorinated paraffins in freshwater and marine sediment

Conditions	Test substance	Sediment	Time (days)	% Distribution of ^{14}C-label (as a percentage of the applied dose)						
				Volatiles	CO_2 (cumulative)	Methane	Overlying water	Sediment	Vessel surfaces[a]	Total mass balance
Aerobic	C_{10}, 65% wt. Cl	Freshwater	0	-	-	-	<0.35	82.2	0.58	83.1
			14	0.29	0.20	-	0.90	108	0.55	110
			35	0.72	0.61	-	1.20	89.8	0.10	92.4
			56	0.36	2.14	-	1.40	106	0.07	110
			77	0.22	3.21	-	1.32	96.9	0.23	102
			98	0.18	3.88	-	1.07	83.6	0.12	88.8
		Marine	0	-	-	-	<0.29	69.2	1.16	70.7
			14	0.024	0.35	-	2.06	81.8	2.27	86.5
			35	0.054	2.64	-	5.17	56.3	1.61	65.7
			56	0.071	5.78	-	4.42	77.7	0.84	88.8
			77	0.12	9.51	-	5.33	69.8	0.46	85.2
			98	0.073	13.4	-	4.49	63.9	1.55	83.4
	C_{13}, 65% wt. Cl	Freshwater	0	-	-	-	<0.30	98.2	1.33	99.8
			14	0.0048	0.25	-	0.57	94.2	0.56	95.5
			35	0.0058	0.42	-	0.53	74.8	0.19	75.9
			56	0.0072	0.90	-	0.59	95.6	0.12	97.2
			77	0.0053	1.08	-	0.62	99.6	0.17	101
			98	0.0037	3.33	-	0.63	102	0.08	106

Table 3.2 continued overleaf

Table 3.2 continued Biodegradation of short-chain chlorinated paraffins in freshwater and marine sediment

Conditions	Test substance	Sediment	Time (days)	% Distribution of ^{14}C-label (as a percentage of the applied dose)						
				Volatiles	**CO_2** (cumulative)	Methane	**Overlying water**	**Sediment**	**Vessel surfaces[a]**	**Total mass balance**
		Marine	0	-	-	-	<0.25	101	1.49	103
			14	0.0044	0.08	-	1.00	59.2	2.43	62.7
			35	0.0044	1.32	-	2.00	63.7	0.93	67.9
			56	0.0013	3.30	-	2.50	57.4	1.85	65.0
			77	0.0044	4.62	-	2.46	78.0	0.18	85.3
			98	0.0033	5.81	-	2.34	71.2	1.56	80.9
Anaerobic	C_{10}, 65% wt. Cl	Freshwater	0	-	-	-	0.22	87.8	1.4	89.5
			77	0.0030	0.66	0.14	1.49	81.0	0.090	83.3
			78	0.0036	0.77	0.084	1.74	76.3	0.090	78.9
			86	0.0030	0.062	0.10	1.79	94.8	0.090	96.9
			87	0.0030	0.85	0.090	1.89	101	0.23	104
		Marine	0	-	-	-	0.28	46.9	2.38	49.5
			82	0.0036	0.50	0.069	10.8	81.5	0.42	93.3
			83	0.0057	0.79	0.072	10.1	76.9	0.094	87.9
			97	0.0062	2.00	0.063	11.6	64.6	0.41	78.7
			98	0.0057	1.86	0.066	11.0	64.1	0.19	77.2

Table 3.2 continued overleaf

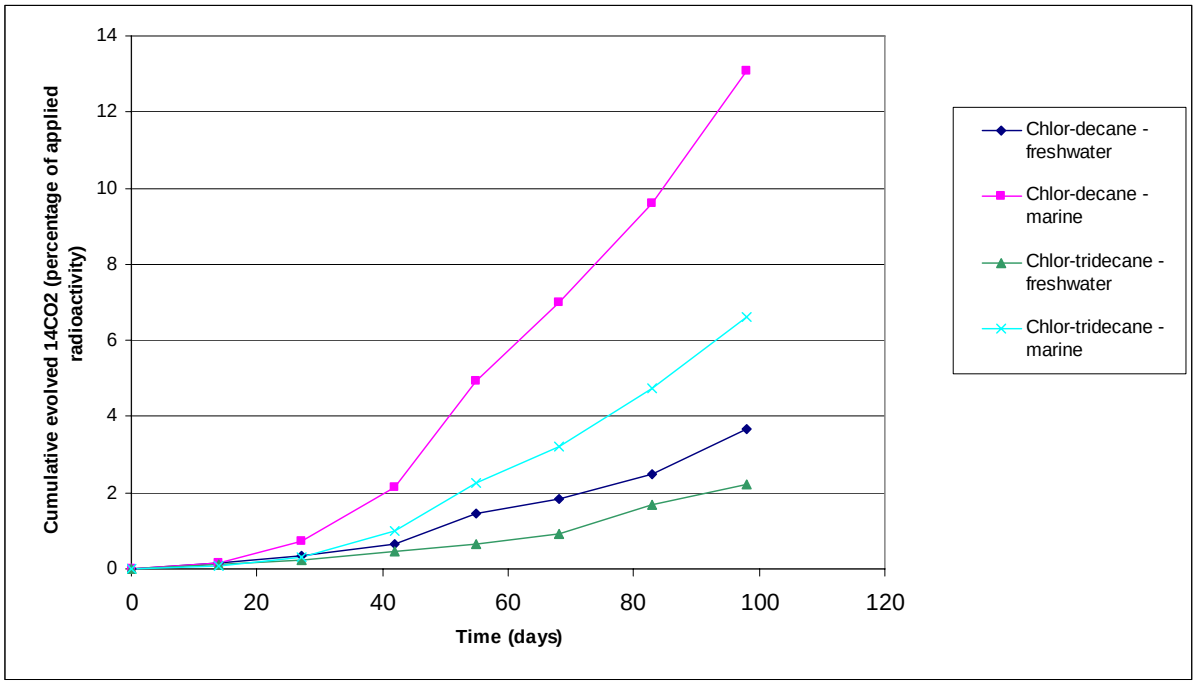
Table 3.2 continued Biodegradation of short-chain chlorinated paraffins in freshwater and marine sediment

Conditions	Test substance	Sediment	Time (days)	% Distribution of ^{14}C-label (as a percentage of the applied dose)						
				Volatiles	**CO_2** (cumulative)	Methane	**Overlying water**	**Sediment**	**Vessel surfaces[a]**	**Total mass balance**
	C_{13}, 65% wt. Cl	Freshwater	0	-	-	-	0.25	74.8	0.57	75.6
			79	0.0026	0.17	0.053	0.54	74.9	0.20	75.9
			80	0.0027	0.054	0.068	0.68	90.6	0.15	91.5
			92	0.0032	0.20	0.090	0.88	90.0	0.37	91.6
			93	0.0026	0.41	0.069	0.87	100	0.95	102
		Marine	0	-	-	-	0.19	41.2	5.38	46.7
			84	0.0044	0.073	0.054	5.64	69.6	0.46	75.9
			85	0.0035	0.046	0.056	4.80	76.4	0.12	81.5
			99	0.0022	1.19	0.055	5.69	89.8	3.10	99.8
			100	0.0035	1.35	0.054	6.46	61.9	1.38	71.1

- Not determined

a) Analysis of solvent extracts from the walls of the test vessels after emptying

Figure 1.1 Mineralisation of ^{14}C-labelled short-chain chlorinated paraffins in aerobic sediments



First order rate constants and half-lives for mineralisation were estimated from the $^{14}CO_2$ evolution data. The estimated half-lives were around 1,340 days for the chlorinated decane in freshwater sediment, 335 days for the chlorinated decane in marine sediment, 1,790 days for the chlorinated tridecane in freshwater sediment and 680 days for the chlorinated tridecane in marine sediment. The mean half-live (average of the two substance; this could be assumed to be representative of a $C_{10\text{-}13}$, 65% wt. Cl product) was determined to be around 1,630 days in freshwater sediment and 450 days in marine sediment. It should be noted, however, that there was a considerable lag phase before mineralisation commenced (around 40-50 days; see **Figure 1**) and these half-lives were calculated after the lag phase. In addition, it should be noted that the actual extent of mineralisation seen in some experiments was relatively small and in all cases was <50% and so the calculated half-lives are extrapolated beyond the available data.

Under anaerobic conditions, no significant formation of ^{14}C-labelled methane was noted during the test (the amount of methane formed was <0.1% of the applied radioactivity). In addition only a limited amount of ^{14}C-labelled CO_2 was formed (≤ 1.3% of the applied radioactivity). Therefore it was concluded that there was insufficient degradation under the anaerobic conditions with which to estimate the rate constant for the reaction.

The mean mass balance determined in this study was around 90-98% in the experiments with freshwater sediments and 78-84% in the experiments with marine sediments. The mass balance in the freshwater sediment studies was generally satisfactory. Thompson and Noble (2007) thought that it was probable that the generally lower mass balance seen in the marine sediments reflected an underestimate of the amount of radioactivity present in the sediment by the analytical method used. As low mass balances were apparent in the marine sediment at the start of the study, a further experiment was carried out to investigate if there was any systematic loss of the test substance during the spiking procedure. This revealed no source of loss prior to addition of the test substance to the sediment.

The dissolved oxygen concentration in the overlying water of the control vessel was generally in the range 30-70% of the air saturation value during the test for both sediments

under aerobic conditions (a few, isolated values were outside this range). For the anaerobic sediments, the dissolved oxygen levels of the overlying water in the control sediments were generally lower, but more variable, than found under aerobic conditions, with values of 1-25% and 0.6-65% of the air saturation value being found in the freshwater and marine sediments respectively. It was thought that these values were affected by the need to open the bottles periodically in order to make pH and oxygen readings, and this inevitably allowed oxygen to be introduced into the test system (the higher values for the dissolved oxygen readings were generally associated with such sampling times).

The redox potentials of the aerobic freshwater sediment systems during the test (after the acclimated phase) was in the range 269 to 957 mV (Eh) in the overlying water and -188 to -31 mV (Eh) in the sediment. The ranges in the aerobic marine system were 413 to 605 mV (Eh) in the overlying water, but somewhat higher in the sediment (-161 to 44 mV (Eh)). For the anaerobic sediment systems, the redox potentials for the overlying water were in the range -146 to 671 mV (Eh) in the freshwater system and -22 to 614 mV (Eh) in the marine system. The corresponding redox potentials in the anaerobic sediment phase were in the range -234 to -216 mV (Eh) in the freshwater system and -172 to 98 in the marine sediment system.

As relatively high levels of dissolved oxygen were present in the water phase of the anaerobic tests at various points during the incubation, it is likely that the actual conditions in this test cycled between aerobic and anaerobic conditions. It is also interesting to note that the redox potentials of the bulk sediment phase were generally similar (predominantly negative values for the redox potential) under both aerobic and anaerobic conditions. This is not necessarily surprising as the OECD 308 test guideline is designed to simulate an aerobic water column over an aerobic sediment layer that is underlain with an anaerobic gradient.

No parent compound analysis was carried out in this test and so the extent of primary degradation was not determined. Overall the results show that although mineralisation of the test substance occurred under aerobic conditions, the rate of mineralisation was low, with a mean half-life under aerobic conditions of around 1,630 days in freshwater sediment and around 450 days in marine sediment. Little or no mineralisation was evident under anaerobic conditions over the timeframe of this study.

The new data generally confirm the previous findings that short-chain chlorinated paraffins degrade only slowly in the environment. It will therefore be assumed that short-chain chlorinated paraffins are not readily biodegradable in this updated assessment.

3.1.1.5 Accumulation

3.1.1.5.1 Summary of original risk assessment report

Short-chain chlorinated paraffins were found to accumulate in fish (whole body bioconcentration factor (BCF) up to 7,816 l/kg) and molluscs (whole body bioconcentration factor (BCF) up to 40,900 l/kg). Uptake into fish via food was also shown to occur, with accumulation factors up to 1-2 being determined on a lipid basis for short-chain chlorinated paraffins with high chlorine contents for this route of exposure, based on experiments with ^{14}C-labelled compounds.

3.1.1.5.2 Updated information

Fisk et al. (1999) studied the uptake of two ^{14}C-labelled short-chain chlorinated paraffins by eggs and larvae of Japanese medaka (*Oryzias latipes*) as part of a 20-day embryo-larval toxicity study. The substances tested had average formulas of $C_{10}H_{15.3}Cl_{6.7}$, 63.7% wt. Cl and $C_{12}H_{19.5}Cl_{6.5}$, 58.5% wt. Cl. The measured exposure concentrations used were 4.7, 50, 370, 2,200 and 5,100 µg/l for the C_{10} chlorinated paraffin and 0.7, 9.6, 55 and 270 µg/l for the C_{12} chlorinated paraffin. The resulting concentrations in the larvae at approximately 3-days post hatch were 12, 100, 1,000, 3,000, and 3,500 mg/kg respectively for the C_{10} chlorinated paraffin and 0.74, 7.1, 62 and 460 mg/kg respectively for the C_{12} chlorinated paraffin. The resulting BCF values were 690-2,700 l/kg for the C_{10} chlorinated paraffin and 740-1,700 for the C_{12} chlorinated paraffin, with the BCF for the C_{10} chlorinated paraffin appearing to increase with decreasing exposure concentrations. The two highest measured exposure concentrations for the C_{10} chlorinated paraffin appear to be higher than the experimental water solubility of short-chain chlorinated paraffin (typically 150-470 µg/l) and so the results at these higher exposure concentrations may have been affected by the presence of undissolved test substance (the BCFs for these two concentrations are 690-1,364 l/kg compared with BCFs of 2,000-2,700 l/kg at the three lower concentrations). Similar results were found for the eggs. Further details of this study are given in Section 3.2.1.1. The exposure period in this experiment is relatively short and no indication is available as to whether equilibrium was reached.

Muir et al. (2000) estimated bioaccumulation factors for short-chain chlorinated paraffins based on field measurements of the concentrations in water and in lake trout (*Salvelinus namaycush*) from western Lake Ontario. The average lipid content of the fish was 22%. The analytical method used was able to quantify C_{10}, C_{11}, C_{12} and C_{13} chlorinated paraffins. The concentrations found in the water phase were 0.16, 0.48, 0.98 and 0.09 ng/l for these four groups respectively (total short-chain chlorinated paraffin concentration 1.8 ng/l) and the concentrations in fish were 3.4, 18.3, 33.6 and 10.3 µg/kg wet weight for the four groups respectively (total short-chain chlorinated paraffin concentration 65.7 µg/kg wet weight). Based on these data the authors estimated whole body bioaccumulation factors of 21,250 l/kg for C_{10} chlorinated paraffins, 38,125 l/kg for C_{11} chlorinated paraffins, 34,286 l/kg for C_{12} chlorinated paraffins and 114,444 for C_{13} chlorinated paraffins (the equivalent factor based on the total short-chain chlorinated paraffin is 36,500 l/kg).

As the factors reported by Muir et al. (2000) are based on field measurements they represent a combination of bioconcentration through water and uptake from food. It could therefore be questioned whether the concentration measured in fish should be compared directly with the concentration in water alone. It should also be noted that the values appear to be based on very few data points. There may therefore be considerable uncertainty over the actual concentrations these fish were exposed to over extended periods (i.e. the concentration in water may vary both spatially and temporally). Thus, although these data confirm that significant uptake of short-chain chlorinated paraffins occurs in fish in the environment, there is some uncertainty over the actual bioaccumulation factors obtained from this study.

A further investigation in the same area determined the levels of short-chain chlorinated paraffins in surface water and various parts of the food chain (Muir et al., 2002). The samples were collected in Lake Ontario (and northern Lake Michigan) during June and August 2001. The samples included water, zooplankton (collected above the thermocline), Mysis (collected as for zooplankton), Diporeia (benthic invertebrate; collected from Lake Ontario only), forage fish (including smelt (*Osmerus mordax*) (omnivore), slimy sculpin (*Cottus cognatus*)

(benthivore) and alewife (*Alosa pseudoharengus*) (planktivore)) and lake trout (*Salvelinus namaycush*). The results of the analysis for Lake Ontario are summarised in **Table 3.3**.

Table 3.3 Concentrations of short chain chlorinated paraffins in the Lake Ontario food web (Muir et al., 2002)

Species	Number of samples	Lipid content	Mean chlorinated paraffin concentration									
			C_{10}		C_{11}		C_{12}		C_{13}		Total C_{10-13}	
			µg/kg wet wt.	µg/kg lipid	µg/kg wet wt.	µg/kg lipid	µg/kg wet wt.	µg/kg lipid	µg/kg wet wt.	µg/kg lipid	µg/kg wet wt.	µg/kg lipid
Lake trout	6	16%	2.2	14	8.0	50	10.5	66	1.2	7.5	21.9	137
Rainbow trout smelt	2	5.5%	2.9	53	8.2	149	6.7	122	0.65	12	18.5	336
Slimy sculpin	2	4.8%	3.7	77	10.9	227	8.3	173	1.0	21	23.9	498
Alewife	2	2.7%	0.83	31	1.4	52	1.6	59	0.13	4.8	4.0	148
Diporeia	1	2.9%	1.8	62	4.1	141	4.1	141	0.55	19	10.6	366

Based on these data, Muir et al. (2002) estimated biomagnification factors (BMFs) for various steps in the food chain. These BMFs are shown in **Table 3.4**.

The estimated BMFs in **Table 3.4** indicate that the BMFs for lake trout are generally <1 for all the food sources considered. However, the BMF is 1-1.6 for the slimy sculpin when Diporeia is considered as the food source and BMFs of 1.1 and 1.5 were determined for the C_{12}- and C_{13}-chlorinated paraffins in lake trout when alewife were considered as the food source. When considering these data is should be born in mind that the sample size was very small (e.g. only one sample of Diporeia and two samples of slimy sculpin and alewife were analysed) and so it is difficult to draw any definite conclusions from the data. It should also be noted that the apparent BMF >1 for the slimy sculpin – Diporeia food chain could, in part, result from differences in the bioconcentration factors between the two species. For example the concentration of the short-chain chlorinated paraffin in slimy sculpin is a result of bioconcentration from water and the uptake from food. Similarly the concentration in Diporeia is dependent on the uptake from water/sediment and the uptake from food. Therefore, as the concentration in each organism results from a contribution from exposure via water (bioconcentration) and via food (biomagnification), differences in concentrations in organisms in this food chain could result from factors other than biomagnification through the food chain.

When considering the actual levels in the fish, it can be seen that the levels present in slimy sculpin and smelt were very similar (indicating that the apparent BMF above 1 for the slimy sculpin-Diporeia food chain is a result of the relatively lower levels present in Diporeia rather than high levels present in slimy sculpin), with the levels in alewife and rainbow trout being slightly lower. The authors concluded that the low biomagnification seen through these food chains is probably due to biotransformation by vertebrates as well as low bioavailability (i.e. strong adsorption onto sediments).

Table 3.4 Estimated biomagnification factors for short-chain chlorinated paraffins in the Lake Ontario food web (Muir et al., 2002)

Food chain	Estimated biomagnification factor (BMF) on a lipid basis[a]				
	C_{10}-chlorinated paraffin	C_{11}-chlorinated paraffin	C_{12}-chlorinated paraffin	C_{13}-chlorinated paraffin	Total C_{10-13} chlorinated paraffin
Lake trout – alewife	0.43	0.94	1.1	1.5	0.91
Lake trout – smelt	0.27	0.35	0.56	0.68	0.43
Lake trout – slimy sculpin	0.17	0.22	0.37	0.35	0.27
Slimy sculpin – Diporeia	1.3	1.6	1.2	1.1	1.4

Note: a) BMF estimated as concentration in predator/concentration in prey; all concentrations are on a lipid weight basis.

It should also be taken into account that the estimated BMFs given in **Table 3.4** assume that food for each predator consists mainly of one source. For example, the BMF for the slimy sculpin-Diporeia food chain essentially assumes that Diporeia are the sole food for slimy sculpin. This is unlikely to be the case in reality. For example, Brandt (2004) showed that the contribution of Diporeia to the slimy sculpin's diet varied geographically and seasonally (approximate range 25-97%) and that for Lake Michigan there was a decline in the Diporeia populations in recent years that contributed to this variability. Other invertebrates (e.g. *Mysis relicta*) were shown to replace Diporeia in the diet (*Mysis* samples appear to have been collected in the Muir et al. (2002) study but no results were given). Similar considerations could equally apply to the lake trout food chain in **Table 3.4**.

Fisk et al. (1998a) investigated the dietary accumulation of several short-chain chlorinated paraffins in juvenile rainbow trout (*Oncorhynchus mykiss*). The chlorinated paraffins used in the experiment were synthesised by the gas-phase free-radical chlorination of 1,9-decadiene, 1,5,9-decatriene or 1,10-undecadiene. The dominant products from these reactions were the chlorinated alkanes derived by chlorine addition to the double bonds. In the study, the mixtures of the various products from these reactions were spiked onto proprietary fish food (14% lipid content). The concentration of each isomer in the food was determined by GC analysis. The fish (initial weight 2-7 g; mean lipid content 2.7-3.0% from day 5 to the end of the study) were then exposed to the spiked food for 40 days, followed by up to 80 days depuration. At various times during the experiment, three fish were sampled and analysed for the presence of the chlorinated paraffin isomers (parent compound analysis). No significant effects on the health of the fish (growth rate, lipid content, liver somatic indices and mortality) were seen during the experiment, and no chlorinated paraffin was detected in the control fish (detection limit ~1 μg/kg).

Uptake of the chlorinated paraffins was seen to occur during the experiment, and steady state was reached for most chlorinated paraffins within the 40 days exposure. The estimated bioaccumulation factors based on kinetic measurements and the tissue concentrations (the tissue concentrations were lipid normalised and growth corrected for the kinetic measurements) after 40 days are shown in **Table 3.5**.

Table 3.5 Dietary accumulation of C_{14} chlorinated paraffins in rainbow trout (Fisk et al., 1988a)

Substance	Chlorine content (% wt. Cl)	Concentration in food (μg/kg)	Depuration half-life (days)	Assimilation efficiency - α	Bioaccumulation factor (BAF)		
					BAF_{calc}	BAF_{equil}	BAF_{ss}
$C_{10}H_{18}Cl_4$	50.7	412	8.3	23%	0.26	0.46	0.18
$C_{10}H_{17}Cl_5$ (a)	56.4	251	7.8	13%	0.14	0.43	0.10
$C_{10}H_{17}Cl_5$ (b)	56.4	737	7.1	76%	0.73	0.40	0.48
$C_{10}H_{16}Cl_6$ (a)	61.0	1,754	10	130%	1.5	0.57	1.4
$C_{10}H_{16}Cl_6$ (b)	61.0	542	10	63%	0.71	0.56	0.64
$C_{10}H_{16}Cl_6$ (c)	61.0	526	20	46%	1.1	1.1	0.66
$C_{10}H_{15}Cl_7$ (a)	64.8	106	15	100%	1.6	0.82	1.5
$C_{10}H_{15}Cl_7$ (b)	64.8	91	8.5	107%	1.0	0.48	1.1
$C_{10}H_{14}Cl_8$ (a)	67.9	183	30	41%	1.4	1.7	1.1
$C_{10}H_{14}Cl_8$ (b)	67.9	132	14	105%	1.6	0.77	0.67
$C_{11}H_{20}Cl_4$	48.3	590	11	54%	0.65	0.60	0.60
$C_{11}H_{19}Cl_5$	54.0	154	9.0	39%	0.39	0.50	0.64
$C_{11}H_{18}Cl_6$	58.7	592	17	29%	0.54	0.94	0.40
$C_{11}H_{16}Cl_8$	65.7	108	37	41%	1.7	2.0	1.0

(a), (b) and (c) denote different isomers.
BAF_{calc} is estimated from rate of uptake (α×feeding rate on lipid basis)/depuration rate. These are considered to be the most reliable values.
BAF_{equil} is estimated from rate of uptake (α×feeding rate on lipid basis)/depuration rate - assuming a value for α of 0.5.
BAF_{ss} = concentration in fish at 40 days (lipid corrected, not growth corrected)/concentration in food (lipid corrected).

The dietary accumulation of a C_{10}, 63.7% wt. chlorinated paraffin has been studied in juvenile rainbow trout (*Oncorhynchus mykiss*) (Fisk et al, 2000). The substance tested was a single carbon chain length product synthesised by the free-radical chlorination of a ^{14}C-labelled C_{10}-alkane with SO_2Cl_2. The product had an average formula of $C_{10}H_{15.3}Cl_{6.7}$, but the position of the radio-label in the carbon chain was not stated. The food used during the test was a commercial fish food (41% protein, 14% lipid and 3% fibre). The chlorinated paraffin was added to the food as a suspension in hexane followed by evaporation of the solvent. Two chlorinated paraffin concentrations were tested: 1.4 mg/kg wet wt. food and 15 mg/kg wet wt. food. During the test, groups of 36 juvenile fish in flow-through tanks (initial weight 1-5 g, final weight 23-69 g, lipid content at day 40 6.0-8.0%) were fed the contaminated food (daily feeding rate was 1.5% of mean weight of fish) over a 40-day period, followed by a 160-day depuration period using clean food. At various times during the experiment fish were sampled for ^{14}C levels in the carcass (whole fish minus liver and G. I. tract). All measured concentrations were corrected for growth dilution. At day 40 of the uptake phase and day 40 of the depuration phase the amount of non-toluene-extractable ^{14}C-label present in the carcass was also determined. This measurement was assumed to reflect the extent of biotransformation of the substance in fish. No effects on body and liver growth rates or liver somatic indices were seen between exposed and control populations during the test and no mortalities were seen.

The results indicated that the chlorinated paraffin uptake had not reached steady state by day 40 of the uptake phase and so the bioaccumulation factor for uptake from food was determined kinetically. The assimilation efficiencies (based on lipid corrected concentrations

in fish (the fish concentrations were also adjusted for growth dilution) and food) were determined to be 9.6% at the low dose and 72% at the high dose, and the depuration rate constant was estimated to be 0.016-0.027 d^{-1} (depuration half-life ~26-43 days). There was some evidence for biotransformation of the chlorinated paraffin by the fish. Based on the measured kinetic parameters (bioaccumulation factor = assimilation efficiency×feeding rate/depuration rate constant), the bioaccumulation factor was around 0.26 at the low exposure concentration and 1.2 at the high exposure concentration. These values are based on ^{14}C measurements and so will include a contribution from any metabolites formed. It should also be noted that the fish concentrations are based on those in the carcass and so the actual concentration in whole fish (and hence bioaccumulation factor) could be higher than indicated here if the liver and G.I. tract were included. [The Fisk et al. (2000) paper also estimates bioaccumulation factors from the data outlined above assuming assimilation efficiencies of 50% and 90%. However, these are example calculations only and are not considered relevant to this assessment.]

A further study into the uptake of short-chain chlorinated paraffins by rainbow trout from food has been carried out by Cooley et al. (2001) as part of a toxicity investigation. In the study, juvenile trout were exposed to one of four short-chain chlorinated paraffins daily via food for either 21 or 85 days. The food used in the test had a lipid content of 14%. The resulting whole fish tissue concentrations and the bioaccumulation factors that can be estimated from the data are shown in **Table 3.6**. Further experimental details of this study are report in Section 3.2.1.1. Fish from several of the high exposure concentrations fed erratically during the test which means that the actual relative exposure of these fish may be lower than indicated by the concentration in food.

Table 3.6 Uptake of short-chain chlorinated paraffins by juvenile rainbow trout from food (Cooley et al., 2001)

Chlorinated paraffin	Exposure period (days)	Concentration in food (mg/kg)	Concentration in whole fish (mg/kg)	Estimated BAF[a]
$C_{10}H_{15.5}Cl_{6.5}$	85	0.87	0.10[b]	0.11
	21	12	0.84[b]	0.070
	21	62	0.92[b]	0.015
^{14}C-$C_{10}H_{15.3}Cl_{6.7}$	85	0.84	0.099[c]	0.12
	21	13	0.92[c]	0.071
	21	74	3.0[c]	0.041
$C_{11}H_{18.4}Cl_{5.6}$	85	3.7[d]	0.10[b]	0.068
	21	53[d]	5.5[b]	0.10
	21	290[d]	4.0[b]	0.014
^{14}C-$C_{12}H_{19.5}Cl_{6.5}$	85	1.9	0.14[c]	0.074
	21	14	0.79[c]	0.056
	21	58	1.1[c]	0.019

a) BAFs have been estimated in this report from the data (BAF = concentration in fish/concentration in food).
b) The concentration was determined by parent compound analysis.
c) The concentration was determined by ^{14}C analysis.
d) These concentrations are reported elsewhere in the paper as 1.8, 2.6 and 14 μg/kg respectively.

An experiment to investigate the uptake of short-chain chlorinated paraffins by oligochaetes (*Lumbriculus variegatus*) from sediment has been carried out (Fisk et al., 1998b). The

chlorinated paraffins used were synthesised by chlorination of ^{14}C-dodecane (labelled in the 1-position), and had the following average formulas: $C_{12}H_{20.1}Cl_{5.9}$ 55.9% wt. Cl and $C_{12}H_{16.2}Cl_{9.8}$ 68.5% wt. Cl. The sediment used had the following composition: 40% sand, 58% silt and 2% clay; organic carbon content 2.3-3.8% of dry weight. For each exposure concentration, 36 jars were filled with spiked sediment to provide a 100:1 organic carbon:oligochaete lipid ratio (15 animals per jar) and the jars were placed in flow-through aquaria maintained at 11.6°C. The uptake period of the experiment was 14 days and was followed by a 42 day depuration period, where the animals were placed in clean sediment. Analysis of the concentrations present in sediment, interstitial water and the oligochaetes was by ^{14}C measurements using a variety of extraction methods. Biota-sediment bioaccumulation factors were determined from the rates of uptake and depuration (equilibrium was not reached within 14 days and so the bioaccumulation factors could not be determined based on the concentrations present in the organisms at day 14). For the determination of the bioaccumulation factors, concentrations in the organisms were normalised to the lipid content and the sediment concentrations were normalised to the organic carbon content (also corrected for loss of ^{14}C (possibly by biodegradation or metabolism) as determined by the difference between toluene-extractable and total ^{14}C measurements). The results of the analysis are shown in **Table 3.7**.

Table 3.7 Uptake and accumulation of ^{14}C-labelled chlorinated paraffin by *Lumbriculus variegatus*

Substance	Sediment conc. at 14 days (dry wt)	Sediment organic carbon content[a]	Lipid conc.[b]	Uptake rate constant (g/g/d)	Depuration rate constant (d^{-1})	Depuration half-life	Kinetic BAF[c]
$C_{12}H_{20.1}Cl_{5.9}$	26.5 µg/kg	2.3%	3.7%	22×10^{-2}	5.0×10^{-2}	14 days	4.4
	106 µg/kg	3.8%	2.9%	51×10^{-2}	5.6×10^{-2}	12 days	9.1
$C_{12}H_{16.2}Cl_{9.8}$	124 µg/kg	3.6%	3.6%	9.0×10^{-2}	4.8×10^{-2}	14 days	1.9
	442 µg/kg	3.1%	3.4%	11×10^{-2}	5.8×10^{-2}	12 days	1.9

a) On a dry sediment weight basis.
b) Mean lipid concentration of exposed organisms.
c) Kinetic BAF based on rate of uptake and rate of depuration.

The interpretation of these results is complicated by the fact that the measurements are based on ^{14}C-determinations and there was evidence that biotransformation was occurring in both the sediments and oligochaetes. Therefore, the results could indicate uptake, accumulation and elimination of metabolites rather than the parent compound. This may particularly be the case with the measured depuration rates and half-life, and so the kinetic BAF probably represents the upper limit of the true bioaccumulation factor of the chlorinated paraffin. However, from the results available it can be seen that the potential for uptake by organisms from sediment is reduced as the chlorine content is increased, although both chlorinated paraffins tested show bioaccumulation factors >1. For the determination of concentrations in the worms, the organisms were not cleansed of gut contents prior to analysis and so any sediment present in the gut at the time of analysis would also have contributed to the uptake seen (however as the concentration in the organism by day 14 was in excess of that in the sediment this would probably not have significantly affected the results).

Summary and discussion

The new data confirm that short-chain chlorinated paraffins bioconcentrate in fish, and can also be taken up from food by fish. The accumulation factors for fish from dietary studies are generally in line with those obtained in previous studies (i.e. in the range 1-2).

In addition to bioconcentration, the Technical Guidance Document now provides methods to take into account biomagnification in the assessment of secondary poisoning. The method requires a biomagnification factor (BMF) for fish, preferably expressed on a lipid-normalised basis. A BMF of 10 would be appropriate for short-chain chlorinated paraffins as a default value (based on the fish BCF of 7,816 l/kg). However, the lipid-normalised accumulation factors determined for short-chain chlorinated paraffins from fish feeding studies and field measurements are generally in the region of 1-2 at most. This suggests that the actual BMF for short-chain chlorinated paraffins may be lower than the recommended default value.

It should be recognised that the assessment of bioaccumulation/biomagnification according to the methods given in the Technical Guidance Document is at a relatively early stage of development. There is a general lack of experience in addressing some of the uncertainties that are associated with the methods used, and the following important points need to be considered:

- There is a fundamental difference in biomagnification/accumulation factors obtained from field studies/measurements and those obtained from laboratory feeding studies. Field-derived factors will take into account accumulation from water and by food, whereas laboratory feeding studies only consider the food route. No distinction is made in the methods given in the Technical Guidance Document between these two types of factors (this is considered further in Section 3.1.4.1).
- Many of the data are lipid-normalised. For some of these studies (e.g. those by Fisk et al. (1996; reported in original risk assessment), Fisk et al. (1998) and Fisk et al. (2000)) the fish food used in the study had a lipid content of 14%, which was generally higher than that in the fish (e.g. 2.7-3.0% in the Fisk et al. (1998a) study and 6-8% in the Fisk et al. (2000) study). Thus if the accumulation factors were expressed in terms of a whole fish and whole food basis, the factors would be around 2-4 times lower than determined on a lipid basis and almost all accumulation factors would be below 1. In terms of the Technical Guidance Document, the methods suggest that the lipid-normalised BMFs should be used. However, conversely, it could be argued that in the environment the food for a predatory species would be generally of lower lipid content than found in laboratory fish food (and may be of lower lipid content than the predatory species itself). It is therefore not possible to infer from these results (or other laboratory-based results using proprietary food of high lipid content) that the accumulation factor on a whole body and food basis would be below 1 in the environment.
- The uptake of a chemical from food depends on many factors including the feeding rate, the digestibility of the food, the lipid content of the food, and the size of the organism (Environment Agency, 2003c; Hendriks et al., 2001). The current methods proposed in the Technical Guidance Document give little or no guidance on how these factors should be considered within the risk assessment framework. Therefore the use of data from the available feeding studies in the current methods given in the Technical Guidance Document needs careful consideration.
- Several of the studies have been corrected for growth dilution. The Technical Guidance Document is unclear on whether this is an appropriate basis on which to calculate

accumulation or biomagnification factors. It could be argued that such a correction, in some circumstances, may make it virtually impossible for a steady state to be reached in fish that are growing. For example, it is possible to conceive the situation where the actual concentrations in the fish had remained constant from one sampling period to the next (i.e. steady state may have been reached) but if the fish grew by 10% over the same sampling period then the growth corrected concentrations would appear to increase by 10% as a result only of the calculation method involved. Environment Agency (2003c) has reanalysed the growth corrected data for short-chain chlorinated paraffins from Fisk et al. (1996 (reported in original risk assessment report), 1998a, and 2000) and estimated that the non-growth corrected fish BMFs from the study would be around 0.13-0.24 on a lipid basis in the Fisk et al. (1996) study, 0.072-0.78 on a lipid basis in the Fisk et al. (1998a) study, and 0.041-0.36 on a lipid basis in the Fisk et al. (2000) study. It should be noted, however, that since the original raw concentration – time data were lacking in the papers (they generally reported only the derived kinetic parameters) the reanalysis is only approximate and may be subject to large errors.

- Several of the studies investigating the kinetics of uptake have, in some cases, calculated relatively high accumulation factors when assuming assimilation efficiencies higher than those found in the experiment. These are, however, hypothetical calculations only as the actual assimilation efficiency was determined in almost all of these studies. Thus, the kinetic data most relevant to this assessment from these studies are those based on the actual assimilation efficiencies measured.
- Many of the studies measuring the accumulation factor based on the concentration in fish at the end of the exposure period do not appear to have reached steady state. These data may consequently underestimate the actual accumulation factor or alternatively may be an artefact of correction for growth dilution. Accumulation factors determined by kinetic methods generally do not suffer from this problem (although again correction for growth dilution has been carried out in a number of the available kinetic studies and the appropriateness of this is unclear). Despite this, there are some accumulation factors in the range 1-1.5 on a lipid basis based on measurements of the non-steady-state concentration in fish after 40 days' exposure.
- The available data indicate that the accumulation factor from food may increase with increasing chlorination for short-chain chlorinated paraffins. The highest accumulation factors (on a lipid basis) are generally obtained for short-chain chlorinated paraffins with >60% chlorination.
- Many of the results have been obtained using ^{14}C-measurements and will include contributions from metabolites and so overestimate the accumulation of short-chain chlorinated paraffins themselves. However, the data of Fisk et al. (1998a) were generated based on parent compound analysis, and accumulation factors up to 1.7 on a lipid basis were determined in this study.
- In feeding studies the rate of uptake of the chemical is dependent on the feeding rate. This is assumed to be a function of the amount of food given to the fish each day but in some studies (e.g. Cooley et al., 2001) it is clear that the spiked food had some effects on the actual feeding of the fish and may mean that the actual exposure in some studies could be lower (and hence accumulation factor higher) than indicated by the nominal feeding rate.
- The Swedish Environmental Protection Agency (1998) found no evidence for biomagnification in the herring-to-seal food chain for chlorinated paraffins based on the

results of Jansson et al. (1993) reported in the original risk assessment (the concentrations found in herring were higher than those found in seals). However, recent field studies by Muir et al. (2002) appear to show BMFs in the range 1-2 for certain types of short-chain chlorinated paraffins in some food chains (particularly a fish-invertebrate food chain but also a predatory fish-fish food chain), although it should be noted that there are some uncertainties in these data.

In summary, the measurement of the accumulation/biomagnification factor is very difficult for complex substances such as short-chain chlorinated paraffins and so there are some uncertainties associated with many of the determinations. Taking into account all of the factors described above, it is not possible to determine reliable BMF values suitable for use in the risk assessment based on current understanding of the methods used in the available studies. Indeed many of the points outlined above are not specific to short-chain chlorinated paraffins. Rather they refer to how such data in general should be generated and treated within the current framework for secondary poisoning outlined in the Technical Guidance Document and this is an area that is probably best addressed outside of this specific assessment.

The available data for short-chain chlorinated paraffins do show that uptake into fish from food does occur in the laboratory. However, although this uptake can be significant in some cases, it does not appear to be appropriate to use a BMF as high as 10 (i.e. the default value in the Technical Guidance) as a worst case.

For the updated assessment, the fish BCF value will be taken to be 7,816 l/kg, and the factor for accumulation from food will be assumed to be in the range 1 to 2 on a lipid basis as a realistic worst case (this range reflects the uptake seen (for whatever reason) in some laboratory and field studies; the actual appropriate basis for determining such factors in laboratory studies is unclear at present).

No data are available for the accumulation of short-chain chlorinated paraffins in earthworms and so a bioaccumulation factor of 11.4 kg earthworm/kg soil has been estimated using EUSES (using log Kow = 6). This estimated bioaccumulation factor is similar to those measured for uptake of short-chain chlorinated paraffins from sediment by *Lumbriculus variegatus* (bioaccumulation factor 1.9-9.1 kg/kg). In addition, recent studies have shown that medium-chain chlorinated paraffins are accumulated by earthworms from soil (RAR, 2002) and a bioaccumulation factor of 5.6 kg/kg was determined for that substance based on experimental data. Thus, the bioaccumulation factor of 11.4 kg/kg estimated for short-chain chlorinated paraffins appears to be reasonable.

3.1.1.6 Environmental distribution

3.1.1.6.1 Summary of original risk assessment report

The organic carbon-water partition coefficient (Koc) was estimated to be 91,200 l/kg (based on a log Kow of 6) and was measured at 199,500 l/kg for a commercial C_{10-13}, 55% wt. Cl product.

3.1.1.6.2 Updated information

The Koc value for a $C_{12}H_{20}Cl_6$ chlorinated paraffin has been determined using a batch method with freshwater sediments and filtered lake water (Drouillard, 1996, as quoted in Tomy, 1998). The log Koc value determined was in the range 4.81-4.94 (Koc = 64,565-87,096 l/kg).

Fisk et al. (1998b) determined log Koc values of 4.1 (Koc = 12,589 l/kg) for $C_{12}H_{20.1}Cl_{5.9}$ (55.9% wt. Cl) and 4.7 (Koc = 50,119 l/kg) for $C_{12}H_{16.2}Cl_{9.8}$ (68.5% wt. Cl) after 14 days in an aerobic sediment system containing oligochaetes (*Lumbriculus variegatus*).

Further Koc values have been determined by Thompson and Nobel (2007) during a biodegradation study using both freshwater and marine sediment (details of the conditions used are given in Section 3.1.1.4.2). The substances used in the test were a ^{14}C-$C_{10}H_{14.9}Cl_{7.1}$ substance and a ^{14}C-$C_{13}H_{18.8}Cl_{9.2}$ substance. Based on the mean concentrations of the substance (as determined by total ^{14}C analysis) present in the water phase and the sediment phase during the test log Koc values of 3.0-3.9 (Koc 1,000-8,000 l/kg) and 3.3-4.3 (Koc 2,000-20,000 l/kg) were determined for the $C_{10}H_{14.9}Cl_{7.1}$ and $C_{13}H_{18.8}Cl_{9.2}$ substance respectively. It should be noted that degradation of the test substance was evident in this test, and so the Koc values may have been affected by the presence of degradation products (only total ^{14}C was determined in the study). Therefore these values are not considered to be reliable.

The new data are similar to those already considered in the original assessment. A Koc value of 199,500 l/kg based on a commercial product will be used in the updated assessment.

3.1.2 Aquatic compartment

3.1.2.1 Calculation of PECs

The PECs in this updated risk assessment have been calculated using EUSES. The degradation rate constants (assumed to be not biodegradable, atmospheric half-life = 7.2 days) and the behaviour during waste water treatment (93% to sludge and 7% to waste water) are identical to those used in the original risk assessment. The Koc value used in this updated assessment is 199,500 l/kg compared with the value of 91,200 used in the original risk assessment. This higher value was determined for a 55% wt. Cl short chain chlorinated paraffin and the determination was carried out to inform the original risk assessment. Details of this Koc value, and a discussion of its effect on the original risk assessment conclusions, were given in Appendix C of the original risk assessment report.

As noted in Section 2.2.2, a significant reduction in the amounts of short-chain chlorinated paraffins used in the EU has occurred since 2001 (the base-line year for the above emission estimates). The effect of this reduction in use on the resulting emissions and PEC/PNEC ratios is considered in Appendix C of this assessment.

The revised PECs calculated for surface water and sediment are summarised in **Table 3.8**.

Table 3.8 Summary of revised PECs for surface water and sediment

Scenario		$C_{local, water}$	$PEC_{local, water}$[a]	$PEC_{local, sediment}$[a, b]
Production sites		<0.028 and <0.097 μg/l	<0.040-<0.055 and <0.11-<0.12 μg/l	<0.17-<0.24 and <0.50-<0.54 mg/kg wet wt.
Rubber (worst case estimate)	Compounding site (formulation)	0.10-0.17 μg/l	0.11-0.20 μg/l	0.50-0.89 mg/kg wet wt.
	Conversion site (processing)	0.034-0.29 μg/l	0.046-0.31 μg/l	0.20-1.36 mg/kg wet wt.
	Combined compounding/ conversion site	0.14-0.46 μg/l	0.15-0.48 μg/l	0.64-2.09 mg/kg wet wt.
Rubber (alternate estimate)		0.011 μg/l	0.023-0.039 μg/l	0.10-0.17 mg/kg wet wt.
Textiles	Compounding site (formulation)	1.5 μg/l	1.5 μg/l	6.5-6.6 mg/kg wet wt.
	Backcoating site (processing)	2.0-2.7 μg/l	2.0-2.7 μg/l	8.8-11.8 mg/kg wet wt.
Sealants/adhesives formulation and use		Negligible	Negligible	Negligible
Paints and coatings	Formulation site	Negligible	Negligible	Negligible
	Industrial application of paints (processing)	0.059-0.20 μg/l	0.071-0.23 μg/l	0.31-1.00 mg/kg wet wt.
Regional sources			$PEC_{regional, water}$ =0.012-0.027 μg/l	$PEC_{regional, sediment}$ = 0.090-0.21 mg/kg wet wt.
Continental sources			$PEC_{continental, water}$ = 0.001-0.003 μg/l	$PEC_{continental, sediment}$ = 0.011-0.025 mg/kg wet wt.

a) These calculations were carried out using EUSES 1.0 (modified to take account of the methods in the revised Technical Guidance Document). EUSES 2.0.1 has become available since these calculations were made. Similar local PECs are obtained using this version of the program but the resulting regional PECs are 0.016-0.037 μg/l for surface water and 0.14-0.32 mg/kg wet weight for sediment. This does not have a significant effect on the conclusions of the assessment.

b) The calculations assume that the substance is not readily biodegradable (and so use the default degradation half-life for aerobic sediment of 1×10^6 days). As discussed in Section 3.1.1.4.2, the results of a recent biodegradation simulation test with freshwater sediment is available. The results of this test gave a mean mineralisation half-life of around 1,630 days for a 65% wt. Cl short-chain chlorinated paraffin for aerobic sediment. Using this degradation half-life for sediment, the local PECs obtained using EUSES 2.0.1 are again similar to those given in the Table, but the regional PEC for sediment is 0.13-0.31. This does not have a significant effect on the conclusions of the assessment.

The predicted concentrations of short-chain chlorinated paraffins in the effluents from waste water treatment plants are in the range 1.5×10^{-4} to 0.035 mg/l for the various scenarios considered in this assessment.

3.1.2.2 Levels of short-chain chlorinated paraffins in water and sediment

3.1.2.2.1 Levels in water

Summary of original risk assessment report

The measured concentrations of short-chain chlorinated paraffins in surface water were 0.05-0.3 μg/l in areas remote from industry and 0.1-2 μg/l in areas close to industry.

Updated information

Levels of C_{10-17} chlorinated paraffins in the effluent from a chlorinated paraffin production plant in Canada have been reported to be around 12.7 μg/l, but they were not detected in sediments downstream of the plant (Metcalfe-Smith et al., 1995; as reported in Tomy, 1998).

Further levels of short-chain chlorinated paraffins in final effluent from municipal waste water treatment plants in Canada have been reported by Muir et al. (2001). The waste water treatment plants were all located at the western end of Lake Ontario and the samples were collected in 1996. The results are shown in **Table 3.9**. The levels were found to be higher in samples from industrial areas (e.g. Hamilton and St. Catherines) than in non-industrial areas (e.g. Niagara-on-the-Lake). The concentration present in Lake Ontario surface water (samples taken in 1999 at 1 m depth from the west basin) was 1.75 ng/l (the equivalent concentration in 2000 was 0.77 ng/l; personal communication).

Table 3.9 Concentrations of short-chain chlorinated paraffins in municipal waste water treatment plant effluent (Muir et al., 2001)

Location	Concentration (μg/l)
Hamilton	0.448
Burlington	0.068
Niagara Falls	0.082
St. Catherines treatment plant 1	0.110
St. Catherines treatment plant 2	0.080
Niagara-on-the-Lake	0.060

Tomy (1997; as reported in Tomy, 1998) found C_{10-13} chlorinated paraffins to be present in Red River, downstream of Winnipeg in Canada, at levels of around 0.02-0.05 μg/l.

An in-depth study of the levels of short- and medium-chain chlorinated paraffins in industrial areas of the United Kingdom has been carried out (CEFAS, 1999; Nicholls, 2001). The main purpose of the study was to determine the concentrations of chlorinated paraffins in surface water, sediment, biota and soil associated with their industrial use. The sampling sites were chosen with regards to their proximity to known sources/users of short- or medium-chain chlorinated paraffins such as polymer product manufacturing sites, rubber product manufacturing sites, metal working sites, lubricant blending sites, sealant and adhesive manufacturing sites, chlorinated paraffin manufacturing sites, paint manufacturing sites, PVC product manufacturing sites, leather finishing chemicals formulation sites and leather finishing sites.

Samples were collected during early summer 1998 and were filtered (<0.45 μm) before analysis and so the reported values represent the dissolved concentration in water. It is possible that the filtering (glass microfibre pre-filter in series with a 0.45 μm PTFE filter) may have also removed some of the dissolved chlorinated paraffin from solution (by adsorption). However, recovery experiments were carried out using pure water spiked with a medium-chain chlorinated paraffin, which was filtered in the same way as the environmental samples. The recoveries were in the range 47-83% (mean value 68±12%) for the method overall (personal communication), indicating that the method used was acceptable. The levels found in sediment, biota and soil are reported later in the appropriate sections of this report.

In this study, no short- or medium-chain chlorinated paraffins were detected (detection limit around 0.1 μg/l) in any of the surface water samples taken except in some samples from a site near to engineering (metal working) activity. These were identified as being short-chain length chlorinated paraffins and the concentration found was 0.2-1.7 μg/l.

Comparison of predicted and measured levels

The levels measured in surface water close to industrial activity in the United Kingdom were, with the exception of a few samples taken near to metal working activity, <0.1 μg/l. This is lower than the concentration predicted for many of the uses of short-chain chlorinated paraffins and may indicate that the methods used to estimate the concentrations may have overestimated the actual release. The predicted regional concentration (0.012-0.027 μg/l) is consistent with the available data.

Recent information from Canada has indicated that short-chain chlorinated paraffins are present in effluent from municipal waste water treatment plants (0.06-0.45 μg/l) and also effluent from a chlorinated paraffin production plant (12 μg/l).

3.1.2.2.2 Levels in sediments

Summary of original risk assessment report

There were few data available for short-chain chlorinated paraffins alone. The sediment levels measured for the combined short- and medium-chain chlorinated paraffins were reasonably consistent with the sediment levels predicted at the time for short-chain chlorinated paraffins in the regional and continental scenarios. The levels of short-chain chlorinated paraffins in sediments from Germany were generally in the range 10-80 μg/kg dry weight and short-chain chlorinated paraffins were found at 3-47.5 μg/kg in mud samples from Rotterdam Harbour, Hamburg Harbour and the mud flats at Kaiser Wilhelm Koog and Den Helder.

Updated information

Tomy et al. (1997a) reported that short-chain chlorinated paraffins were present at a concentration of around 245 μg/kg dry weight in sediments from the mouth of the Detroit River at Lake Erie and Middle Sister Island in western Lake Erie. The samples were collected in August 1995.

Muir et al. (2001) determined the levels of short-chain chlorinated paraffins in surface sediment samples from harbour areas in western Lake Ontario. The samples were collected in

1996. The levels found were 24-27 μg/kg dry weight at Toronto inner harbour, 5.9 μg/kg dry weight at Humber River mouth (Toronto), 7.3 μg/kg dry weight at Port Credit Harbour, 27-41 μg/kg dry weight at Hamilton west harbour, 290 μg/kg dry weight at Hamilton Windemere Basin and 81 μg/kg dry weight at northest Hamilton. The highest levels were present at the most industrialised site sampled (Windemere Basin).

CSTEE (2002a) indicates that Marvin et al. (2002) reported that short-chain chlorinated paraffins were generally relatively evenly distributed in sediments from Lake Ontario and estimated that the average concentration was around 36 μg/kg dry weight. Muir et al. (2002) give the mean value for Lake Ontario in 1998 as 49 μg/kg dry weight for total short chain chlorinated paraffins (the mean values were 11.8 μg/kg dry weight for C_{10}-chlorinated paraffins, 17.2 μg/kg dry weight for C_{11}-chlorinated paraffins, 16.7 μg/kg dry weight for C_{12}-chlorinated paraffins and 3.2 μg/kg dry weight for C_{13}-chlorinated paraffins).

Tomy et al. (1997b and 1999) reported the following levels of short-chain chlorinated paraffins in surface sediments from the Canadian mid-latitude and Arctic regions: 176 μg/kg dry weight and 8 μg/kg dry weight in samples from Lake Winnipeg (south and north respectively), 257 μg/kg dry weight in samples from Fox Lake (Yukon), 18 μg/kg dry weight in samples from Lake Nipigon (northwest Ontario), 1.6 μg/kg dry weight in samples from Lake Ya Ya and 4.5 μg/kg dry weight in samples from Hazen Lake (Arctic). The chlorine content of the chlorinated paraffins found was in the range 60-70% wt. The concentrations of chlorinated paraffins in deeper layers were lower than found in the surface layers (the surface layer samples generally corresponded to around 1980-1992). Based on these data, the yearly surface flux of chlorinated paraffins to the lakes was estimated as 147 μg/m^2 and 3.99 μg/m^2 for Lake Winnipeg (south and north respectively), 34.1 μg/m^2 for Fox Lake, 2.66 μg/m^2 for Lake Nipigon, 0.45 μg/m^2 for Lake Ya Ya and 0.89 μg/m^2 for Hazen Lake. Local industrial sources (use in cutting oils and paints and plastics) were thought to contribute significantly to the flux to Fox Lake and the southern basin of Lake Winnipeg, but the flux to the other lakes was thought to be mainly as a result of atmospheric transport. Analysis of the sediment cores obtained in Fox Lake indicated that the relative contribution of the C_{10}, C_{11}, C_{12} and C_{13} congeners to the total chlorinated paraffin present appeared to change with depth, indicating that microbial transformation may be occurring in the aerobic surface layers with the congeners persisting in the lower anaerobic layers. However, only very slight differences in relative contribution with depth was seen in the sediment cores from the southern basin of Lake Winnipeg.

An in-depth study of the levels of short- and medium-chain chlorinated paraffins in industrial areas of the United Kingdom has been carried out (CEFAS, 1999; Nicholls, 2001). The main purpose of the study was to determine the concentrations of chlorinated paraffins in surface water, sediment, biota and soil associated with their industrial use. The sampling sites were chosen with regards to their proximity to known sources/users of medium-chain chlorinated paraffins. Samples were collected during early summer 1998. The levels found in sediment are shown in **Table 3.10**. The levels found in surface water, biota and soil are reported in the appropriate sections of this report.

The levels measured in the CEFAS (1999) study are reported on a dry weight basis. In order to make these levels comparable with the PEC estimates, they need to be expressed on a wet weight basis. No details of the water contents were given in the paper and so the default water content from the Technical Guidance Document (80% by volume, 62% by weight) has been used. Thus dry weight values can be converted to approximate wet weight values by dividing

by 2.6. The estimated wet weight values are shown in **Table 3.10** alongside the measured dry weight values.

Table 3.10 Levels of chlorinated paraffins in sediment in the United Kingdom, related to sources (CEFAS, 1999)

Industry	Comment	Sampling site	Measured concentration of total chlorinated paraffin		Assumed concentration of short-chain chlorinated paraffin (mg/kg wet wt.)
			mg/kg dry wt.	Estimated mg/kg wet wt.	
Polymers/ tarpaulins	Identified as medium- or long-chain	1.8 km upstream from STP	<0.2	<0.08	<0.08
		400 m upstream from STP	0.7	0.27	<0.08
		100 m downstream from STP	0.5	0.19	<0.08
		300 m downstream from STP	0.6	0.23	<0.08
		1.8 km downstream from STP	0.8	0.31	<0.08
Synthetic rubber manufacture	Identified as medium-chain, ~50% wt. Cl	1 km upstream of STP	<0.2	<0.08	<0.08
		STP outfall on canal	0.5	0.19	<0.08
		100 m downstream from STP on canal	0.3	0.12	<0.08
		300 m downstream from STP on canal	2.8	1.1	<0.08
		300 m downstream from STP on river	2.0	0.77	<0.08
		700 m downstream from STP on river	1.3	0.5	<0.08
		1.8 km downstream	2.7	1.0	<0.08
Lubricant blending/ metal working	Identified as medium-chain ~50% wt. Cl. Actual levels may be higher as destructive interference was seen in the analyses.	Upstream of STP	6.0	2.3	<0.08
		100m downstream of STP	3.8	1.5	<0.08
		300 m downstream of STP	60.2	23.2	<0.08
		Downstream of STP	65.1	25.0	<0.08
Rubber product manufacturer	Identified as medium-chain, ~40-50% wt. Cl	Upstream of STP	<0.2	<0.08	<0.08
		100 m downstream of STP	<0.2	<0.08	<0.08
		300 m downstream	43.9	16.9	<0.08
		Downstream of STP	<0.2	<0.08	<0.08
		Downstream of STP	16.2	6.2	<0.08
Manufacturer of building sealants/ lubricant blending	No chlorinated paraffins detected	Upstream of STP	<0.2	<0.08	<0.08
		100 m downstream of STP	<0.2	<0.08	<0.08
		300 m downstream of STP	<0.2	<0.08	<0.08
		Downstream of STP	<0.2	<0.08	<0.08

Table 3.10 continued overleaf.

Table 3.10 continued Levels of chlorinated paraffins in sediment in the United Kingdom, related to sources (CEFAS, 1999)

Industry	Comment	Sampling site	Measured concentration of total chlorinated paraffin		Assumed concentration of short-chain chlorinated paraffin (mg/kg wet wt.)
			mg/kg dry wt.	Estimated mg/kg wet wt.	
Control site - no known uses.	Identified as medium chain, ~45% wt. Cl	Upstream of STP	<0.2	<0.08	<0.08
		100 m downstream of STP	32.2	12.4	<0.08
		300 m downstream of STP	60.4	23.2	<0.08
		1.2 km downstream of STP	45.0	17.3	<0.08
Manufacturer of chlorinated paraffins	Identified as a mixture of short- and medium-chain	2 km from STP discharge point	39.4	15.2	up to 15.2
		Lock	53.3-63.0	20.5-24.2	up to 20.5-24.2
		400 m from lock	3.8	1.5	up to 1.5
		1.8 km from lock	2.0	0.77	up to 0.77
		2 km from lock	1.6	0.62	up to 0.62
		Bank, opposite lock	1.5	0.58	up to 0.58
		Upstream of lock	6.3	2.4	up to 2.4
Paint manufacturer	Identified as medium-chain	Upstream of discharge	<0.2	<0.08	<0.08
		500 m downstream of discharge	<0.2	<0.08	<0.08
		600 m downstream of discharge	0.3	0.12	<0.08
		800 m downstream of discharge	6.1	2.3	<0.08
		1 km downstream of discharge	6.4	2.5	<0.08
		Downstream of discharge	0.4	0.15	<0.08
Lubricant manufacturer (and other industries)	Identified mainly as short- chain, medium- chain also present	Canal, 1 km west of discharge	0.6	0.23	up to 0.23
		Canal, 500 m west of discharge	n.q.	-	-
		Canal, 4 km east of discharge	0.5	0.19	up to 0.19
		Brook, 300 m upstream of STP	1.6	0.62	up to 0.62
		Brook, 100 m downstream of STP	0.5	0.19	up to 0.19
		Brook, 300 m downstream of STP	1.0	0.38	up to 0.38
PVC cable manufacturer	Identified as medium-chain, ~52% wt. Cl	Upstream of STP	<0.3	<0.12	<0.12
		100 m downstream of STP	5.7	2.2	<0.12
		300 m downstream of STP	12.8	4.9	<0.12
		Downstream of STP	19.0	7.3	<0.12

Table 3.10 continued overleaf.

Table 3.10 continued Levels of chlorinated paraffins in sediment in the United Kingdom, related to sources (CEFAS, 1999)

Industry	Comment	Sampling site	Measured concentration of total chlorinated paraffin		Assumed concentration of short-chain chlorinated paraffin (mg/kg wet wt.)
			mg/kg dry wt.	Estimated mg/kg wet wt.	
Metal working/ leather finishing	Mixture of short- and medium-chain, ~<60% wt. Cl. Actual levels may be higher as destructive interference was seen in the analyses.	Upstream of STP	0.8	0.31	up to 0.31
		100 m downstream of STP	1.8	0.69	up to 0.69
		300 m downstream of STP	1.8	0.69	up to 0.69
		Downstream of STP	4.9	1.9	up to 1.9
		Downstream of STP	2.5	0.96	up to 0.96
PVC production/ paint manufacture	Identified as a mixture of short- and medium-chain	Upstream of STP	0.7	0.27	up to 0.27
		At STP outfall	n.q.	-	-
		100 m downstream of STP	21.1	8.12	up to 8.12
		800 m downstream of STP	<0.2	<0.08	<0.08
		2.5 km downstream of STP	5.3	2.0	up to 2.0
Leather finishing chemicals formulation site	Identified mainly as medium-chain	2.3 km upstream of STP	1.1	0.42	<0.08
		100 m upstream of STP	13.5	5.2	<0.08
		600 m downstream of STP	1.1	0.42	<0.08
		1.7 km downstream of STP	0.8	0.31	<0.08
		2.0 km downstream of STP	1.9	0.73	<0.08
		Downstream of STP	1.0	0.38	<0.08
		3.0 km downstream of STP	<0.4	<0.15	<0.08
Producer of PVC compound	Identified as mainly medium-chain	Upstream of STP	1.3	0.5	<0.08
		100 m downstream of STP	18.0	6.9	<0.08
		300 m downstream of STP	25.6	9.8	<0.08
		500 m downstream of STP	58.4	22.5	<0.08
Background site	No chlorinated paraffins identified	4 sites	<0.2	<0.08	<0.08

n.q. Not quantifiable.

a) Concentrations on a wet weight basis are estimated from the data reported using the default water contents for sediment given in the Technical Guidance Document.

b) Concentration of short-chain chlorinated paraffin assumed to be present in the sample based on the main types of chlorinated paraffins reported to be present in the sample. It should be noted that the unambiguous identification of short-chain chlorinated paraffins in samples where other chlorinated paraffins (e.g. medium-chain) are also present is very difficult and so the values given should be considered as indicative rather than absolute concentrations.

As can be seen from the data in **Table 3.10** short-chain chlorinated paraffins were found to dominate in only a few of the samples. For most samples medium-chain chlorinated paraffins were identified as the dominant chlorinated paraffin present, but it is also possible that some short-chain chlorinated paraffins could also have been present in these samples. In particular, it should be noted that short-chain chlorinated paraffins were identified to be present in

sediment close to a chlorinated paraffin production site (up to 24.2 mg/kg wet weight (mixture of short- and medium-chain chlorinated paraffins)) and a PVC and/or paint manufacturing site (up to 8.1 mg/kg wet weight (mixture of short- and medium-chain chlorinated paraffins)).

Stern et al. (2003; as reported in UNECE, 2003) have investigated the levels of short-chain chlorinated paraffins in a lake sediment core taken from a lake on Devon Island, Nunavut, Canada. The levels of short-chain chlorinated paraffins in layers dating back to 1931 were low (<0.2 µg/kg dry weight), but were found to increase steadily in layers from 1943 onwards, reaching 0.8 µg/kg dry weight in the layer corresponding to 1956. The concentration was then found to decrease to <0.2 µg/kg dry weight between 1970 and 1980, but then showed an increasing trend up to 0.9 µg/kg dry weight in 1997 (the last year measured). These samples were taken from a very remote lake in the Arctic (75°34'N; 89°19'W) and provide evidence for transport to and deposition in the Arctic (UNECE, 2003). An unpublished draft report by Environment Canada (2003) reports the same trends (but slightly higher levels).

A sediment core taken in 1988 from the western basin of Lake Ontario (43°26'01''N, 79°24'00''W; the sample was taken approximately 40 km from the nearest sewage treatment plant) showed a maximum concentration of short-chain chlorinated paraffin of around 800 µg/kg dry weight (Environment Canada, 2003). The maximum concentration was found in the sediment layer corresponding to the 1970s but had fallen to around 390 µg/kg dry weight in the layer corresponding to 1996. Short-chain chlorinated paraffins could be determined in the layers dating back to 1913 (as short-chain chlorinated paraffins were not manufactured in Canada until the 1940s, the occurrence in the older layers was thought to be as a result of diffusion of residues through the sediment core or an artefact of sampling).

SFT (2002b) carried out a screening study for the concentrations of short-chain chlorinated paraffins in sediments associated with the effluents from waste dumps in Norway. In all, samples from five locations were analysed and short-chain chlorinated paraffins were found to be present in all five samples at a concentration of 0.33-19.4 mg/kg wet weight.

Comparison of predicted and measured levels

The new data indicate that short-chain chlorinated paraffins are widely found in the sediment compartment, including samples taken from remote Arctic regions. The highest levels are generally associated with industrial activities. A recent survey of industrial sources in the United Kingdom found elevated levels close to a chlorinated paraffin production site (up to 24.2 mg/kg wet wt. as a mixture of short- and medium-chain chlorinated paraffins) and a PVC or paint manufacturing site (up to 8.1 mg/kg wet wt. as a mixture of short- and medium-chain chlorinated paraffins). The actual concentration of short-chain chlorinated paraffin present in these samples is uncertain, but the findings indicate that release to the environment can occur from these sources. The possible presence of short-chain chlorinated paraffins in sediment close to a PVC or paint manufacturing site is of note as short-chain chlorinated paraffins are not used in PVC and, according to a recent Emission Scenario Document (Environment Agency, 2003a), the emissions to waste water (and hence sediment) of chlorinated paraffins from paint formulation sites would be expected to be negligible.

3.1.3 Terrestrial compartment

3.1.3.1 Predicted concentrations

The revised PECs calculated for soil are summarised in **Table 3.11**.

Table 3.11 Summary of revised PECs for surface soil

Scenario		Agricultural soil averaged over 30 days[a]	Agricultural soil averaged over 180 days[a]	Grassland averaged over 180 days[a]
Production sites		Negligible[b]	Negligible[b]	Negligible[b]
Rubber (worst case estimate)	Compounding site (formulation)	0.62-1.03 mg/kg wet wt.	0.62-1.03 mg/kg wet wt.	0.25-0.41 mg/kg wet wt.
	Conversion site (processing)	0.21-1.73 mg/kg wet wt.	0.21-1.73 mg/kg wet wt.	0.082-0.69 mg/kg wet wt.
	Combined compounding/ conversion site	0.82-2.76 mg/kg wet wt.	0.82-2.76 mg/kg wet wt.	0.33-1.10 mg/kg wet wt.
Rubber (alternate estimate)		0.071 mg/kg wet wt.	0.071 mg/kg wet wt.	0.030 mg/kg wet wt.
Textiles	Compounding site (formulation)	8.97 mg/kg wet wt.	8.97 mg/kg wet wt.	3.57 mg/kg wet wt.
	Backcoating site (processing)	12.2-17.2 mg/kg wet wt.	12.2-17.2 mg/kg wet wt.	4.86-6.84 mg/kg wet wt.
Sealants/adhesives formulation and use		Negligible	Negligible	Negligible
Paints and coatings	Formulation site	Negligible	Negligible	Negligible
	Industrial application of paints (processing)	0.36-1.23 mg/kg wet wt.	0.36-1.22 mg/kg wet wt.	0.14-0.49 mg/kg wet wt.
Regional sources		Agricultural soil – 0.54-1.41 mg/kg wet wt. Natural soil – 0.0011-0.0025 mg/kg wet wt. Industrial soil – 1.53-3.04 mg/kg wet wt.		
Continental sources		Agricultural soil – 0.055-0.14 mg/kg wet wt. Natural soil – 0.0005-0.0011 mg/kg wet wt. Industrial soil – 0.16-0.31 mg/kg wet wt.		

a) These calculations were carried out using EUSES 1.0 (modified to take account of the methods in the revised Technical Guidance Document). EUSES 2.0.1 has become available since these calculations were made. Using this version of the program but the resulting regional PECs are 0.13-0.35 mg/kg wet wt. for agricultural soil, 0.0014 0.0033 µg/kg wet wt. for natural soil and 0.79-1.56 mg/kg for industrial soil. In addition the local PECs estimated are slightly higher than shown in the Table (for example the 30 day average concentration in agricultural soil for the rubber: conversion site scenario is 0.22-1.82. For most scenarios, these differences have no effect on the outcome of the assessment. However there are some implications for the local rubber: conversion site and the regional industrial soil scenarios (see Section 3.3.2).

b) Sludge from the treatment plant is not applied to soil.

3.1.3.2 Measured data

Summary of original risk assessment report

No data were available on the levels of short-chain chlorinated paraffin in soil. Short-chain chlorinated paraffins were found to be present at a concentration of 47-65 mg/kg dry weight in sewage sludge from a waste water treatment plant in Germany.

Updated information

A monitoring survey of concentrations of short- and medium-chain chlorinated paraffins in sewage sludge, soil and earthworms associated with some uses of chlorinated paraffins in the United Kingdom has been carried out (CEFAS, 1999; Nicholls, 2001) and the results are summarised in **Table 3.12**. The samples used in the study were collected in the early summer of 1998.

Table 3.12 Levels of short- and medium-chain chlorinated paraffins in sewage sludge, agricultural land and earthworms from the United Kingdom (CEFAS, 1999)

Location	Comment	Sample type	Concentration[a]
South West	Sewage treatment plant associated with polymers/tarpaulin industry. Soil received repeated application of fertiliser made from sludge.	Digested sewage sludge	2.9 mg/kg dry weight
		Dried digested sewage sludge (fertiliser)	27.7 mg/kg dry weight
		Soil receiving fertiliser	<0.1 mg/kg dry weight
		Earthworms	<0.1 mg/kg fresh weight
South East	Sewage treatment plant associated with synthetic rubber and other varied industries. Digested sewage frequently applied to soil.	Digested sewage sludge	12.1 mg dry weight
		Soil receiving sewage sludge	<0.1 mg/kg dry weight
		Earthworms	0.7 mg/kg fresh weight
Wales	Sewage treatment plants associated with formulation and use of metal working fluids. Digested sewage applied to soil January 1998. Tentatively identified as short-chain[a].	Digested sewage sludge	11.8 mg/kg dry weight
		Soil receiving sewage sludge	<0.1 mg/kg dry weight
		Earthworms	<0.1 mg/kg fresh weight
West Midlands	Sewage treatment plant associated with formulation and use of metal working fluids. Digested sewage frequently applied to soil. Known to have been applied January 1998.	Digested sewage sludge	17.1 mg/kg dry weight
		Soil receiving sewage sludge	<0.1 mg/kg dry weight
		Earthworms	0.3 mg/kg fresh weight
East Midlands	Sewage treatment plant associated with rubber production. Several applications of sludge made during February 1998.	Digested sewage sludge	3.4 mg/kg dry weight
		Soil receiving sewage sludge	<0.1 mg/kg dry weight
		Earthworms	<0.1 mg/kg fresh weight
East Anglia	Industry source unknown. Digested sewage frequently applied to soil.	Digested sewage sludge	1.8 mg/kg dry weight
		Soil receiving sewage sludge	<0.1 mg/kg dry weight
		Earthworms	0.5 mg/kg fresh weight
North West	Sewage treatment plant associated with formulation and use of metal working fluids, and other industries. Digested sewage frequently applied to soil. Several applications made during 1997/1998	Digested sewage sludge	6.7 mg/kg dry weight
		Soil receiving sewage sludge	<0.1 mg/kg dry weight
		Earthworms	<0.1 mg/kg fresh weight
North East	Sewage treatment plant associated with PVC/other industries. Digested sewage frequently applied to soil.	Digested sewage sludge	93.1 mg/kg dry weight
		Soil receiving sewage sludge	<0.1 mg/kg dry weight
		Earthworms	1.7 mg/kg fresh weight

a) The actual identity of the residues present (i.e. medium-chain or short-chain chlorinated paraffin) was difficult to assign owing to the high concentration of co-extracted lipid-soluble material

The levels found in digested sewage sludge prior to application onto soil were in the range 2.9-93 mg/kg dry weight and the levels found in soil where the sludge was applied were generally not detected (<0.1 mg/kg dry weight which is equivalent to <0.088 mg/kg on a wet weight basis). In general it was not possible to identify exactly what type (short- or medium-chain) was present in the samples.

The levels of short-chain chlorinated paraffins in further sewage sludge samples from the United Kingdom have recently been determined (Stevens et al., 2003). Samples of digested sludge from 14 waste water treatment plants from domestic and/or urban and/or industrial areas were analysed. The total concentration of short-chain chlorinated paraffins found ranged between 6.9 and 200 mg/kg dry weight (mean level found was 42 mg/kg dry weight). The report concluded that theses findings were indicative of there being numerous ongoing diffuse sources of the substance.

Junk and Meisch (1993) reported that short-chain chlorinated paraffins (~56% wt. Cl) were present at a concentration of 582 mg/kg in paving stones collected outside a metal working plant in Germany.

Comparison of predicted and measured levels

The measured levels of short-chain chlorinated paraffins in agricultural soil receiving sewage sludge containing chlorinated paraffins are generally <0.088 mg/kg wet weight. This is lower than the predicted regional concentration of 0.54-1.41 mg/kg wet wt. This may reflect the fact that the approach used in this assessment may overestimate the actual emissions of short-chain chlorinated paraffins to the environment or may underestimate actual degradation rates in soil. In order to take into account these possibilities, the assessment will also consider a regional agricultural soil concentration of 0.088 mg/kg wet weight alongside the predicted concentrations.

The available measured data for digested sewage sludge indicate that short-chain chlorinated paraffins are widely found in sludge at concentrations of 10-200 mg/kg dry weight. This indicates that application of sewage sludge to soil will be a major route for exposure of the soil compartment to short-chain chlorinated paraffins, and is considered further in the risk characterisation.

3.1.4 Atmosphere

3.1.4.1 Calculation of PECs

The revised PECs calculated for air are summarised in **Table 3.13**.

Table 3.13 Summary of revised PECs for air

Scenario		Local concentration in air during an emission episode	Local annual average concentration in air	PEC_{local} during emission episode[c]
Production sites		0	0	5.3×10^{-7}-1.3×10^{-6} mg/m³
Rubber (worst case estimate)	Compounding site (formulation)	3.5×10^{-6}-5.8×10^{-6} mg/m³	1.9×10^{-6} mg/m³	4.0×10^{-6}-7.1×10^{-6} mg/m³
	Conversion site (processing)	3.5×10^{-6}-3.0×10^{-5} mg/m³	1.9×10^{-6}-9.5×10^{-6} mg/m³	4.0×10^{-6}-3.1×10^{-5} mg/m³
	Combined compounding/ conversion site	7.0×10^{-6}-3.5×10^{-5} mg/m³	3.8×10^{-6}-1.1×10^{-5} mg/m³	7.5×10^{-6}-3.6×10^{-5} mg/m³
Rubber (alternate estimate)		0	0	5.3×10^{-7}-1.3×10^{-6} mg/m³
Textiles	Compounding site (formulation)	0	0	5.3×10^{-7}-1.3×10^{-6} mg/m³
	Backcoating site (processing)	0	0	5.3×10^{-7}-1.3×10^{-6} mg/m³
Sealants/adhesives formulation and use		Negligible	Negligible	5.3×10^{-7}-1.3×10^{-6} mg/m³
Paints and coatings	Formulation site	Negligible	Negligible	5.3×10^{-7}-1.3×10^{-6} mg/m³
	Industrial application of paints (processing)	0	0	5.3×10^{-7}-1.3×10^{-6} mg/m³
Regional sources		5.3×10^{-7}-1.3×10^{-6} mg/m³		
Continental sources		2.3×10^{-7}-5.4×10^{-7} mg/m³		

a) Sludge from the treatment plant is not applied to soil.
b) 1×10^{-6} mg/m³ = 1 ng/m³ = 1,000 pg/m³.
c) These calculations were carried out using EUSES 1.0 (modified to take account of the methods in the revised Technical Guidance Document). EUSES 2.0.1 has become available since these calculations were made. Similar ' local PECs are obtained using this version of the program but the resulting regional PEC is 4.7×10^{-7}-1.1×10^{-6} mg/m³.

3.1.4.2 Measured levels

3.1.4.2.1 Summary of original risk assessment report

No measured data were available.

3.1.4.2.2 Updated information

The levels of SCCPs in air have been determined in samples from a semi-rural site in the United Kingdom (sampled between May 1997 and January 1998), a semi-rural site in southern Ontario, Canada (sampled during summer 1990), and a remote area in the Canadian Arctic (sampled between September and December 1992) (Peters et al., 1998). The analytical method used could determine chlorinated paraffins with chain lengths between C_{10} and C_{13} with between 5 and 9 chlorine atoms per molecule. The mean total (vapour + particulate phase) levels found were 99±101 pg/m^3 at the semi-rural site in the United Kingdom,

543±318 pg/m^3 at the semi-rural site in southern Ontario and 20±32 pg/m^3 at the remote site. Peters et al. (2000) determined the level of short-chain chlorinated paraffin in air at a semi-rural site in United Kingdom, over a 12-month period (samples taken at 2-weekly intervals). The arithmetic and geometric means found were 320±320 pg/m^3 and 160 pg/m^3 respectively. Around 95% of the short-chain chlorinated paraffins found were associated with the gaseous phase.

Tomy (1997; as reported in Tomy, 1998) found that short-chain chlorinated paraffins (60-70% wt. Cl) were present in air from Egbert, Canada at a concentration of 65-924 pg/m^3 (mean 543 pg/m^3). The samples were 24-hour composite samples collected daily over a 4-month period during the summer of 1990.

Muir et al. (2001) reported short-chain chlorinated paraffins to be present at a concentration of 249 pg/m^3 in air overlying the west basin of Lake Ontario. The sample was collected in June 1999.

The levels of short-chain chlorinated paraffins in air from the Arctic have been reported by Bidleman et al. (2001). The air samples were collected from January 1994 to January 1995. The concentrations of short-chain chlorinated paraffins in samples from Alert were found to be highest in the late summer months. The levels found ranged from 1.07 to 7.25 pg/m^3 and were dominated by the contributions from chlorodecanes (C_{10} fractions).

The levels of short-chain chlorinated paraffins in Arctic air have been investigated by Borgen et al. (2000). In this study samples (total volume 1,700-2,850 m^3) were collected during March to May 1999 at Mt. Zeppelin, Svalbard. The concentration of short-chain chlorinated paraffins (with 5-10 chlorine atoms/molecule) determined was 9.0 pg/m^3 on 26th March, 23 pg/m^3 on April 9th, 28 pg/m^3 on April 16th, 16 pg/m^3 on April 30th and 57 pg/m^3 on May 7th. The levels refer to the concentration in the vapour phase plus the particulate phase. The paper indicates that the levels found were of a similar order of magnitude to those in the field blank samples, but that the samples did contain higher amounts of the more volatile short-chain chlorinated paraffins than the blanks, indicating that transport of short-chain chlorinated paraffins by air may be occurring. The paper also indicated that the presence of contaminants such as phthalates may have caused some interference in the analysis, leading to an underestimate of the actual concentration of short-chain chlorinated paraffins.

A further study by Borgen et al. (2002) investigated the levels of short-chain chlorinated paraffins in ambient air from Bear Island in the Arctic. The samples (total volume sampled was 3,252-8,160 m^3) were collected during May to November 2000. The concentrations of short-chain chlorinated paraffins (with 5-10 chlorine atoms/molecule) found were 7.3 ng/m^3 on May 8th-15th, 10.6 ng/m^3 on June 1st-8th, 8.8 ng/m^3 on June 8th-15th, 7.1 ng/m^3 on June 15th-22nd, 1.8 ng/m^3 on June 22nd-29th, 4.3 ng/m^3 on August 10th-27th and 1.8 ng/m^3 on November 13th-21st. The levels again refer to the concentration in the vapour plus particulate phase.

Greenpeace (2003) have carried out a survey of the levels of short-chain chlorinated paraffins in dust samples collected from around 70 households in the United Kingdom. The samples were collected between the 30th October and 8th November 2002 from ten regional areas, and pooled samples (from 7 households in each region) were analysed for the presence of short-chain chlorinated paraffin. The substance was found to be present in eight out of ten pooled samples at a concentration of 1.9 to 13 mg/kg (ppm), with a mean value of 4.3 mg/kg (the analytical method used was considered to be only semi-quantitative for short-chain chlorinated paraffins due to the highly complex nature of the products and so the reported

concentrations are only approximate; the detection limit of the method was around 0.12 mg/kg). In addition, a single dust sample from a household in Denmark and a single dust sample from a household in Finland were found to contain short-chain chlorinated paraffin at a concentration of 5.1 and 9.6 mg/kg respectively, which is similar to the range found in the United Kingdom. The results showed that short-chain chlorinated paraffins are widespread contaminants of the indoor environment.

SFT (2002b and 2004) determined the concentrations of short-chain chlorinated paraffins in three samples of moss from Norway. The samples were taken from Valvik (67.38^{o}N, 14.64^{o}E), Molde (62.73^{o}N, 07.00^{o}E) and Narbuvoll (62.38^{o}N, 11.47^{o}E). The samples were collected in forest areas not closer than 300 m to the nearest road or building/house. The distance of each sampling site from the nearest village/town was at least 10 km. The concentration found was in the range 3-100 μg/kg wet weight. The report suggested that the presence in moss was indicative of transport of short-chain chlorinated paraffins via the atmosphere.

3.1.4.2.3 Comparison of predicted and measured levels

The available monitoring data indicate that short-chain chlorinated paraffins are widely found at low levels in the atmosphere, including remote Arctic environments. They are also present in household dust.

The low levels found - generally in the range 1 pg/m^3-10 ng/m^3 (1×10^{-9}-1×10^{-5} mg/m^3) - are consistent with the low concentrations predicted in the regional and continental scenarios.

3.1.5 Non-compartment specific exposure relevant to the food chain

3.1.5.1 Predicted concentrations

The revised PECs calculated for fish, mussels and earthworms for the assessment of secondary poisoning are summarised in **Table 3.14**.

The Technical Guidance Document indicates that as well as the bioconcentration factor, the biomagnification factor (BMF) for fish should be considered in the determination of the PEC for secondary poisoning using the following equation.

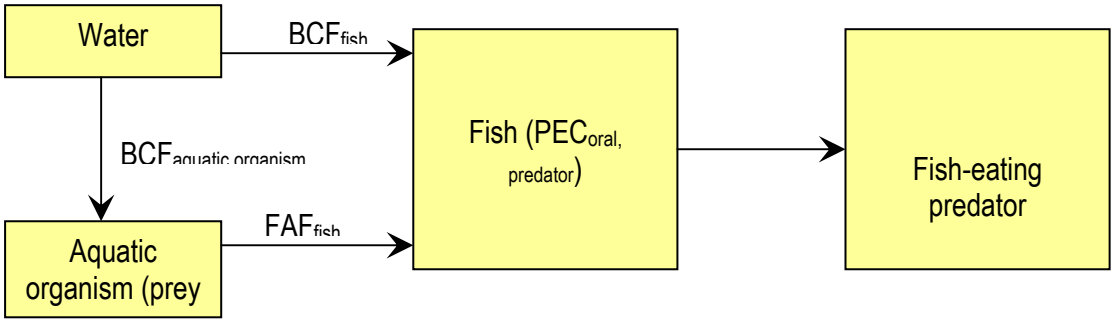
$$PEC_{oral} = PEC_{water} \times BCF \times BMF$$

According to the Technical Guidance Document, a BMF of 10 would be appropriate for short-chain chlorinated paraffins (log Kow = 6, fish BCF = 7,816 l/kg). The available information for short-chain chlorinated paraffins indicates that uptake from food does occur, and can in some cases be significant, but that the use of a BMF of 10 may be overly conservative. Therefore, as discussed in Section 3.1.0.5, an accumulation factor of 1 to 2 would be more appropriate as a worst case (see Section 3.1.0.5) to take account of uptake via food. This range has been used in the calculation of the PECs for fish given in **Table 3.14**.

The concentrations in mussels have been estimated in a similar way as fish using a BCF value for short-chain chlorinated paraffins of 40,900 l/kg for whole mussels and a factor of 1-2 to take account of uptake via food . (Since mussels are filter feeders, it is possible that some of the uptake seen in the study could have been a result of ingestion of substance adsorbed to

particles and so the value might not be a true BCF. It should be noted that there are no standard test methods (e.g. OECD guidelines) for carrying out reliable mussel BCF studies).

It should be noted, however, that the above equation given in the Technical Guidance Document may not be appropriate when considering actual BMF data from laboratory feeding studies. The intention in the Technical Guidance Document is to model the concentration in fish resulting from simultaneous exposure via both water and food, and this is represented by the scheme below. The term food accumulation factor (FAF) is used in this scheme to distinguish it from the BMF given in the equation from the Technical Guidance Document.



$$PEC_{oral,\,predator} = (PEC_{water} \times BCF_{aquatic\ organism} \times FAF_{fish}) + (PEC_{water} \times BCF_{fish}) \text{ - equation 1.}$$

Assuming that the "aquatic organism" in the food chain is also a fish, then this equation simplifies to the following.

$$PEC_{oral,\,predator} = PEC_{water} \times BCF_{fish} \times (1 + FAF_{fish}) \text{ - equation 2.}$$

Using a FAF (BMF) of 1-2 as before, the resulting PECs in predatory fish using equation 2 are shown in **Table 3.14** (marked as alternate method). This still assumes that 50% of the exposure comes from local sources and 50% comes from regional sources (the Technical Guidance default).

An interesting consequence of equation 2 is that it does not require a FAF (or BMF) to be above 1 for food uptake to be important to the overall body burden in predatory fish. For example, FAF values between 0.1 and 1 result in predicted concentrations ranging from 1.1 to 2 times those predicted from the BCF alone. This should not be confused with increasing concentrations found in sequential trophic levels (i.e. biomagnification), because the simplistic calculations used here neglect the fact that the prey fish/organism will also have a contribution from food. More complicated food web approaches that consider several trophic levels are needed to fully assess these aspects (CSTEE, 2003).

CSTEE (2003) carried out some preliminary modelling for short-chain chlorinated paraffins using a food chain consisting of algae and three levels of consumer. The model used was based on the system dynamic model published by Carbonell et al. (2000), and assumed a BCF for fish of 7,000 and 1,000 l/kg, a BCF for algae of 200 and 1,000 (the algal BCFs were not specific to short-chain chlorinated paraffins but were taken from work carried out with other substances (e.g. Sijm et al. (1998) and Hendriks et al. (2001)), and depuration half-lives

of 10 and 20 days. The model was run several times using various combinations of the data and several results indicated that the body burdens resulting from the accumulation from food were up to one order of magnitude higher (or in some cases more) than those resulting from bioconcentration alone. Therefore the CSTEE concluded that it was relevant to consider food uptake when considering the bioaccumulation potential for short-chain chlorinated paraffins.

The earthworm concentrations are based on a bioaccumulation factor of 11.4 kg earthworm/kg soil estimated using EUSES (using log Kow = 6). No data on accumulation of short-chain chlorinated paraffins in earthworms are available, but the estimated bioaccumulation factor is similar to those measured for uptake of short-chain chlorinated paraffins from sediment by *Lumbriculus variegatus* (bioaccumulation factor 1.9-9.9 kg/kg). In addition, recent studies have shown that medium-chain chlorinated paraffins are accumulated by earthworms from soil (RAR, 2002) and a bioaccumulation factor of 5.6 kg/kg was determined for that substance based on experimental data. Thus, the bioaccumulation factor of 11.4 kg/kg estimated for short-chain chlorinated paraffins appears to be reasonable.

The revised PECs calculated for the human food chain are summarised in **Table 3.15**.

Table 3.14 Summary of revised PECs for secondary poisoning

Scenario		Concentration in fish (TGD Method)		Concentration in fish (Alternate Method)		Concentration in mussels (TGD Method)		Concentration in earthworms
		BMF = 1	BMF = 2	FAF = 1	FAF = 2	BMF = 1	BMF = 2	(TGD Method)
Production sites		0.18-0.52 mg/kg	0.36-1.04 mg/kg	0.36-1.04 mg/kg	0.54-1.56 mg/kg	0.94-2.72 mg/kg	1.88-5.44 mg/kg	Negligible[a]
Rubber (worst case estimate)	Compounding site (formulation)	0.31-0.43 mg/kg	0.62-0.86 mg/kg	0.62-0.86 mg/kg	0.93-1.29 mg/kg	1.62-2.25 mg/kg	3.24-4.50 mg/kg	6.58-13.9 mg/kg[b] 4.02-6.35 mg/kg[c]
	Conversion site (processing)	0.16-0.57 mg/kg	0.32-1.14 mg/kg	0.32-1.14 mg/kg	0.48-1.71 mg/kg	0.84-2.98 mg/kg	1.68-5.96 mg/kg	4.22-17.8 mg/kg[b] 1.66-10.3 mg/kg[c]
	Combined compounding/ conversion site	0.38-0.79 mg/kg	0.76-1.58 mg/kg	0.76-1.58 mg/kg	1.14-2.37 mg/kg	1.99-4.13 mg/kg	3.98-8.26 mg/kg	7.69-23.7 mg/kg[b] 5.14-16.2 mg/kg[c]
Rubber (alternate estimate)		0.11-0.23 mg/kg	0.22-0.46 mg/kg	0.22-0.46 mg/kg	0.33-0.69 mg/kg	0.58-1.20 mg/kg	1.16-2.40 mg/kg	3.45-8.41 mg/kg[b] 0.90 mg/kg[c]
Textiles	Compounding site (formulation)	4.85-4.97 mg/kg	9.70-9.94 mg/kg	9.70-9.94 mg/kg	14.6-14.9 mg/kg	25.4-26.0 mg/kg	50.8-52.0 mg/kg	54.0-58.9 mg/kg[b] 51.4 mg/kg[c]
	Backcoating site (processing)	1.52-2.75 mg/kg	3.04-5.50 mg/kg	3.04-5.50 mg/kg	4.56-8.25 mg/kg	7.95-14.4 mg/kg	15.9-28.8 mg/kg	72.5-106 mg/kg[b] 70.0-98.2 mg/kg[c]
Sealants/adhesives formulation and use		Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Paints and coatings	Formulation site	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
	Industrial application of paints (processing)	0.28-0.59 mg/kg	0.56-1.18 mg/kg	0.56-1.18 mg/kg	0.84-1.77 mg/kg	1.47-3.09 mg/kg	2.94-6.18 mg/kg	5.1-15.0 mg/kg[b] 2.54-7.46 mg/kg[c]

a) Sludge from the treatment plant is not applied to soil.
b) Calculations based on predicted regional concentration of 0.54-1.41 mg/kg wet wt. for agricultural soil.
c) Calculations based on measured regional concentration of 0.088 mg/kg wet wt. for agricultural soil.

Table 3.15 Summary of revised PECs for human food chain

Scenario		Concentration in food							Total daily human intake (mg/kg bw/day)
		Fish (mg/kg)[b]	Root crops (mg/kg)	Leaf crops (mg/kg)	Drinking water (mg/l)	Meat (mg/kg)	Milk (mg/kg)	Air (mg/m^3)	
Production sites		0.27-0.83	Negligible[a]	Negligible[a]	Negligible[a]	Negligible[a]	Negligible[a]	5.3×10^{-7}-1.3×10^{-6}	0.0004-0.0014
Rubber (worst case estimate)	Compounding site (formulation)	0.53-0.642	1.26-2.09	0.002-0.003	0.0002-0.0003	0.0068-0.010	0.002-0.003	2.4×10^{-6}-3.2×10^{-6}	0.0079-0.013
	Conversion site (processing)	0.24-0.94	0.42-3.52	0.002-0.010	0.00005-0.0005	0.0047-0.025	0.0015-0.008	2.4×10^{-6}-3.3×10^{-6}	0.0028-0.021
	Combined compounding/ conversion site	0.67-1.36	1.66-5.61	0.0039-0.011	0.0002-0.0008	0.011-0.033	0.003-0.011	4.3×10^{-6}-1.2×10^{-5}	0.010-0.034
Rubber (alternate estimate)		0.12-0.24	0.14-0.14	0.0005-0.0011	0.00002	0.0012-0.0023	0.0004-0.0007	5.3×10^{-7}-1.3×10^{-6}	0.00099-0.0012
Textiles	Compounding site (formulation)	9.61-9.73	18.2	0.0007-0.0013	0.0026	0.046-0.047	0.015	5.3×10^{-7}-1.3×10^{-6}	0.12
	Backcoating site (processing)	2.95-5.29	24.9-35.0	0.0007-0.0015	0.0035-0.0049	0.063-0.089	0.020-0.028	5.3×10^{-7}-1.3×10^{-6}	0.14-0.20
Sealants/adhesives formulation and use		Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	5.3×10^{-7}-1.3×10^{-6}	Negligible
Paints and coatings	Formulation site	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	5.3×10^{-7}-1.3×10^{-6}	Negligible
	Industrial application of paints (processing)	0.47-0.92	0.73-2.49	0.0005-0.0011	0.0001-0.0003	0.0026-0.008	0.0008-0.0026	5.3×10^{-7}-1.3×10^{-6}	0.0048-0.015
Regional sources		0.092-0.21	1.09-2.87	0.0005-0.0011	0.0002-0.0004	0.0073-0.019	0.0023-0.0060	5.3×10^{-7}-1.3×10^{-6}	0.0062-0.016

a) Sludge from the treatment plant is not applied to soil.
b) BMF not included in calculation.

3.1.5.2 Measured levels

3.1.5.2.1 Levels in aquatic biota

Summary of original risk assessment report

Short-chain chlorinated paraffins were found to be present in fish (up to 1,600 μg/kg lipid (unspecified chain length)), marine mammals (up to ~500 μg/kg fresh wt.) and mussels (up to 12,000 μg/kg (mixture of short- and medium-chain chlorinated paraffins)).

Updated information

Tomy et al. (1997a) reported that short-chain chlorinated paraffins (60-70% wt. Cl) were present at a concentration of around 1,010 μg/kg wet weight (also reported as 1,148 μg/kg dry weight in Tomy, 1998) in yellow perch and 241 μg/kg wet weight (also reported as 305 μg/kg dry weight in Tomy, 1998) in catfish from the mouth of the Detroit River at Lake Erie and 651 μg/kg wet weight (also reported as 1,205 μg/kg dry weight in Tomy, 1998) in zebra mussels from Middle Sister Island in western Lake Erie. The samples were collected in August 1995 and were taken from an industrialised area.

Metcalfe-Smith et al. (1995; as reported in Tomy, 1998) reported that the level of short-chain chlorinated paraffins (60-70% wt. Cl) in white suckers from the St. Lawrence River, downstream of a chlorinated paraffin manufacturing plant, was <3,500 μg/kg dry weight.

Tomy (1997; as reported in Tomy, 1998) found short-chain chlorinated paraffins (60-70% wt. Cl) to be present in blubber from marine mammals from Canada and Greenland. The levels found were 370-1,363 μg/kg dry weight in Beluga from the St. Lawrence River, 106-253 μg/kg dry weight in Beluga from northwest Greenland, 178-302 μg/kg dry weight in Beluga from Hendrickson Island, 362-490 μg/kg dry weight in walrus from northwest Greenland and 374-767 μg/kg dry weight in ringed seal from southwest Ellesmere Island.

The levels of short-chain chlorinated paraffins in carp from Hamilton Harbour (western Lake Ontario), lake trout from Port Credit (northwestern Lake Ontario) and Niagara-on-the-Lake (southwestern Lake Ontario) and beluga whale from the St. Lawrence River estuary and southeast Baffin Island in the Canadian Arctic have been determined by Muir et al. (2001). The fish were collected in 1996 and the beluga samples were collected in 1988-1991 and 1995. The levels found are shown in **Table 3.16**.

Table 3.16 Levels of short-chain chlorinated paraffins in biota from Canada (Muir et al., 2001)

Species	Sample	Mean concentration of short-chain chlorinated paraffin (mg/kg wet wt.)
Beluga whale (*Delphinapterus leucas*)	9 Female blubber samples from St. Lawrence Estuary, 1988-1991.	0.94±0.48
	3 Male blubber samples from St. Lawrence Estuary, 1988-1991.	0.85±0.56
	3 Female blubber samples from South East Baffin Island, 1995.	0.116±52
	3 Male blubber samples from South East Baffin Island, 1995.	0.168±0.035
Carp (*Cyprinus carpio*)	3 Samples from Hamilton Harbour, 1996.	2.63±2.56
Lake trout[a] (*Salvelinus namaycush*)	5 Samples from Niagara-on-the-Lake, 1996.	0.059±0.051
	5 Samples from Port Credit, 1996.	0.073±0.047

a) Elsewhere in the paper these are indicated as being rainbow trout.

Data on the levels of short-chain chlorinated paraffin in beluga whale, rainbow trout and carp from Canada have also been reported by Bennie et al. (2000). For the whale, 37 blubber samples and 6 liver samples from 25 individuals were analysed for C_{10-13} chlorinated paraffins. The samples were taken from dead animals from the St. Lawrence River between 1987 and 1991. The fish samples were all taken from Lake Ontario in 1996 and three carp and ten trout were analysed (whole body homogenates). Some of these samples appear to have been the same as those analysed by Muir et al. (2001) discussed above. The area sampled was near to a chlorinated paraffin production site. The levels are shown in **Table 3.17**. The authors indicated that the method used (involving low resolution mass spectrometry) may be more subject to analytical interferences from other organohalogen compounds than some of the methods used in other analyses, and that the levels found in beluga whale in this study are one or two orders of magnitude higher than the levels found by Muir et al. (2001) when analysing the same sample extracts. Therefore the results of this study should be treated with caution.

Table 3.17 Levels of short-chain chlorinated paraffins in biota from Canada (Bennie et al., 2000)

Species	Sample	Lipid content	Concentration of short-chain chlorinated paraffin (mg/kg wet wt.)
Beluga whale (*Delphinapterus leucas*)	Blubber samples from 15 females taken from mid depth of the subcutaneous fat	81-91% range 86.2% mean	4.60-60.7 range 25.9 mean
	Blubber samples from 10 males taken from mid depth of the subcutaneous fat	68-96% range 83.5% mean	27.6-85.6 range 46.1 mean
	Liver samples from 3 females	11-32% range	0.54-38.5 range
	Liver samples from 3 males	20-52% range	4.61-8.52 range
Carp (*Cyprinus carpio*)	Whole body homogenates from 3 individuals	12-19% range 16% mean	0.12-1.25 range 0.50 mean
Trout (*Oncorhynchus mykiss*)	Whole body homogenates from 10 individuals	18-30% range 24% mean	0.45-5.33 range 1.47 mean

An in-depth study of the levels of short- and medium-chain chlorinated paraffins in industrial areas of the United Kingdom has been carried out (CEFAS, 1999; Nicholls, 2001). The

sampling sites were chosen with regards to their proximity to known sources/users of chlorinated paraffins. Samples were collected during early summer 1998. The levels found in biota are shown in **Table 3.18**. The actual identity of the chlorinated paraffin (short- or medium-chain) was difficult to assign reliably in this study.

Table 3.18 Levels of short- and medium-chain chlorinated paraffins in fish and benthos in the United Kingdom, related to sources (CEFAS, 1999)

Industry	Comment/tentative identification[a]	Sample	Concentration of chlorinated paraffin (mg/kg fresh weight)
Polymers/ tarpaulins		Fish: roach muscle	<0.2
Synthetic rubber manufacture		Fish: perch muscle	<0.2
Metal working		Fish: flounder muscle	<0.1
Lubricant blending/ metal working	Possibly medium-chain - levels could not be accurately quantified owing to interferences.	Benthos: 90% Hindinae + Lymnaeidae	0.3
		Fish: roach muscle	0.6
		Fish: eel muscle	0.7
		Fish: pike liver	2.8
Sealant and adhesive manufacture	Possibly short-chain.	Benthos: 25% Spaeridae, 13% Hindinae, 9% Gammanidae, 25% Asellidae, 17% Planerbidae, 9% Valvatidae, 2% Sialidae	0.3
		Fish: roach liver	<0.1
Rubber product manufacturer	Possibly medium-chain.	Benthos: 2% Viviparidae, 16% Lymnaeidae, 5% Gammanidae, 16% Asellidae, 3% Zygoptera, 5% Corixidae, 16% Chironomidae, 8% Caddis, 3% Beetle, 16% Hindinae, 8% Hydrobiidae.	0.1
		Fish: roach muscle	<0.1
		Fish: eel liver	<0.2
Manufacturer of building sealants/ lubricant blending		Fish: roach muscle	<0.1
Manufacturer of chlorinated paraffins	Possibly mixture of short- and medium-chain	Benthos: 90% Chironomidae, 8% Gamanidae, 2% Lymnaeidae	0.1
		Fish: eel liver	0.2
Control site - no known uses.	Possibly medium-chain	Benthos: 18% Chironomidae, 71% Lymnaeidae, 7% Asellidae, 4% Sphaendae	0.5
		Fish: carp muscle	0.5

Table 3.18 continued overleaf

Table 3.18 continued Levels of short- and medium-chain chlorinated paraffins in fish and benthos in the United Kingdom, related to sources (CEFAS, 1999)

Industry	Comment/tentative identification[a]	Sample	Concentration of chlorinated paraffin (mg/kg fresh weight)
Lubricant manufacturer(and other industries)	Possibly short-chain.	Benthos: 95% Gammanidae, 5% Chironomidae	0.1
PVC cable manufacturer	Possibly medium-chain.	Benthos: 90% Spaeridae, 5% Lymnaeidae, 5% Hirudinae	0.8
Metal working/ leather finishing	Possibly mixture of short- and medium-chain.	Benthos: 50% Asellidae, 40% Chironomidae, 5% Tipulidae, 4% Hirudinae, 1% Lymnaeidae	0.5
Metal working sites	Possibly short-chain.	Benthos: 60% Oligochaetes, 20% Chironomidae, 16% Lymnaeidae, 4% Sphaeridae.	<0.05
		Fish: whole, Stone Loach	5.2
PVC production/ paint manufacture	Possibly mixture of short- and medium chain.	Benthos: 95% Asellidae, 5% Oligochaetes	0.7
Leather finishing chemicals formulation site		Benthos: 65% Sphaeridae, 265 Lymnaeidae, 3% Planorbidae, 2% Corixidae, 2% Sialidae, 2% Hinidinae, 2% Valvatidae	<0.05
		Fish: roach muscle	<0.05
		Fish: eel liver	<0.05
Background site		Fish: eel muscle	<0.05

a) The actual identity of the residues present were difficult to assign owing to the high concentration of co-extracted lipid-soluble material. Tentative identity based on the chlorinated paraffins found in sediment in the area.

Borgen et al. (2001) determined the levels of short-chain chlorinated paraffins (with 5-10 chlorine atoms/molecule) in freshwater fish from various locations in Norway. The results are summarised in **Table 3.19**.

Table 3.19 Levels of short-chain chlorinated paraffins in fish from Norway

Sample	Location	Concentration (μg/kg lipid)
Trout muscle	Takvatn	172
	Fjellfrøsvatnet	545
	Grunnvatnet	1,692
	Store Raudvannet	108
	Selbusjøen	436
	Breimsvatn	923
	Bogevatnet	1,414
	Kalsjøen	178
	Kalandsvatn	254
	Vegår	263
	Mårvann	256
	Grindheimsvatn	733
	Lygne	408
Arctic char muscle	Ellasjøen[a]	592
	Velmunden	500
Burbot liver	Grensefoss	741
	Selbusjøen	226
	Røgden	787
	Røgden	1,152
	Øgderen	695
	Femsjøen	3,700

a) This location is at Bear Island at a latitude of 74°N and is considered to be a remote Arctic site.

SFT (2002b) have recently determined the concentrations of short-chain chlorinated paraffins present in blue mussel and cod livers from Norway. Short-chain chlorinated paraffins were found to be present in all samples analysed and the concentrations found were 18-130 μg/kg wet weight in two samples of blue mussel from Oslofjord, 14 μg/kg wet weight in a sample of mussel from Risøy and 23-750 μg/kg wet weight in four samples of cod liver from Oslofjord. Cod liver samples from inner Olsofjord were found to have the highest concentrations and indicated that a local emission source may be present.

Comparison of predicted and measured levels

The new data available indicate that short-chain chlorinated paraffins are present in a wide range of aquatic organisms, including fish and marine mammals, at locations both close to industrial sources and from more remote locations. The levels found are generally up to a few mg/kg. These measured levels are of a similar order to those predicted for fish from the various uses of short-chain chlorinated paraffins (it is generally not possible to make a direct comparison as few of the measured levels of chlorinated paraffins in biota are directly related to a specific industrial source of release).

3.1.5.2.2 Levels in other biota

Summary of original risk assessment report

Short-chain chlorinated paraffins had been found to be present in various terrestrial mammals, bird livers and muscle, and various foodstuffs. In addition, short-chain chlorinated paraffins were found to be present in human breast milk samples from Germany (ca. 3 μg/kg lipid) and from Canada (Hudson Strait; 10.6-16.5 μg/kg lipid (mean 12.8 μg/kg lipid)).

Updated information

Tomy (1997; as reported in Tomy, 1998) found that short-chain chlorinated paraffins (around 60-70% wt. Cl) were present at a concentration of 11-17 μg/kg lipid (mean concentration 13 μg/kg lipid) in human breast milk from Inuit women living on the Hudson Strait in northern Québec, Canada. These are probably the same data as already included in the original risk assessment report.

A recent study has found short-chain chlorinated paraffins to be present in human breast milk samples from the United Kingdom (Thomas and Jones, 2002). In all, 22 breast milk samples were analysed (8 from Lancaster and 14 from London, randomly chosen from a limited number of samples collected for a different study). Short-chain chlorinated paraffins were found at concentrations of 4.6-110 μg/kg lipid in five out of eight samples from Lancaster and at concentrations of 4.5-43 μg/kg lipid in seven out of 14 samples from London. No short-chain chlorinated paraffins were found in the remaining samples (the detection limit of the method used varied with sample size but was in the range 1.6-15 μg/kg lipid). Although not calculated in the original paper, it is possible to estimate that the mean level found in breast milk was around 20±30 μg/kg lipid (based on the positive findings alone) or 12±23 μg/kg lipid (assuming that not detected = half the detection limit).

In addition to human breast milk, Thomas and Jones (2002) also determined the levels of short-chain chlorinated paraffins in a sample of cow's milk from Lancaster and single butter samples from various regions of Europe (Denmark, Wales, Normandy, Bavaria, Ireland, and southern and northern Italy). Short-chain chlorinated paraffins were not detected in the cow's milk sample (detection limit <1.2 μg/kg lipid) but were found in the butter samples from Denmark at 1.2 μg/kg and Ireland at 2.7 μg/kg. The detection limit for the butter samples ranged between 0.72 and 1.1 μg/kg.

Thomas et al. (2003) carried out a follow-up study on the levels of short-chain chlorinated paraffins in breast milk samples from the United Kingdom using a more sensitive analytical procedure. In this study relatively large samples of human milk-fat were collected from the London (twenty samples) and Lancaster (five samples) areas of the United Kingdom between late 2001 and June 2002 (it should be noted that some of the samples from London were from the same mother; five samples were provided from one mother over a three-day period, two samples were provided from another mother over a two-day period, a further two samples were provided by another mother over a five-day period, and a further two samples were provided by another mother over an unknown period). The analysis was carried out using high resolution gas chromatograph (HRGC) coupled with electrochemical negative ionisation (ECNI)-high resolution mass spectrometry (HRMS) detection. The analytical standards used were a commercial short-chain and medium-chain chlorinated paraffin (C_{10-13}, 60% wt. Cl and C_{14-17}, 52% wt. Cl). In addition to total short-chain chlorinated paraffins, twelve samples (four from Lancaster and eight from London) were also analysed in more detail to determine

the various types of chlorinated paraffin (in terms of chlorine number and carbon chain length distributions) present in the samples.

Short-chain chlorinated paraffins were detected in all samples from Lancaster and in sixteen out of the twenty samples from London. The median and the 95th percentile levels found were 180 and 680 μg/kg lipid and the range of concentrations found was between 49 and 820 μg/kg lipid. No significant difference was found between the concentrations in the samples from Lancaster and those from London. The more detailed analysis of the types of chlorinated paraffins present indicated that, in general, the pattern of chain-lengths found for short-chain chlorinated paraffins were very similar to that in the commercial product used as analytical standard.

Chlorinated paraffins have been found to be present in the biodegradable fraction of household waste from Sweden in 1995 (Nilsson et al., 2001). The concentration found in one sample was around 4.2-5.5 mg/kg dry matter (some of the other samples appeared to contain no chlorinated paraffin) but the actual type of chlorinated paraffin found is not clear from the paper (it may have been a medium-chain chlorinated paraffin).

Comparison of predicted and measured levels

Short-chain chlorinated paraffins have been found to be present in a range of food samples, including human breast milk. As the measured levels are not generally related to specific sources of release it is not possible to compare the levels found with those predicted.

The levels of short-chain chlorinated paraffins in breast milk in the recent (2002) survey in the United Kingdom (mean level around 12-20 μg/kg lipid) appear to be similar to those found in an earlier study in northern Quebec, Canada (mean level around 13 μg/kg lipid), but slightly higher than those found in Germany (ca. 3 μg/kg lipid). The levels found in a follow up (2003) survey in the United Kingdom (49-820 μg/kg lipid; median 180 μg/kg lipid) appear to be higher than found in the other surveys. However, the relatively small number of samples analysed, and the inherent difficulties in analysing samples for low levels of short-chain chlorinated paraffins (which can be considered to be a complex mixture of many individual components of differing carbon chain length and chlorine contents), means that it is difficult to draw any firm conclusions over the patterns seen in the breast milk data.

3.1.6 Exposure assessment for the marine environment

The methodology outlined in the marine risk assessment guidance essentially assumes that the adsorption/desorption, degradation and accumulation behaviour in the marine environment can, in the absence of specific information for the marine environment, be adequately described by the properties of the substance relevant for the freshwater environment. The relevant properties for short-chain chlorinated paraffins are summarised in **Table 3.20**.

Table 3.20 Adsorption and accumulation properties for short-chain chlorinated paraffins used in the marine risk assessment

Property	Value
Log Kow	6.0
Water solubility	0.47 mg/l
Organic carbon – water partition coefficient (Koc)	199,500 l/kg
Solid-water partition coefficient in suspended matter (Kp_{susp})	19,950 l/kg
Suspended matter - water partition coefficient ($K_{susp\text{-}water}$)	4,988 m^3/m^3
Fish bioconcentration factor (BCF_{fish})	7,816 l/kg
Mussel bioconcentration factor (BCF_{mussel})	40,900 l/kg
Biomagnification factor (BMF_1)[a]/food accumulation factor in fish	2
Biomagnification factor in predators (BMF_2)[a]/food accumulation factor in predatory fish	2

a) The marine risk assessment guidance suggests a value of 10 using the BCF_{fish} as the trigger value. Actual biomagnification factors for short-chain chlorinated paraffins appear to be <1-2 based on feeding studies in fish.

The starting point for the local marine assessment is the concentration of short-chain chlorinated paraffins in effluent from the site of discharge. This effluent from industrial sites is, as a default, assumed to enter into the marine environment without further waste water treatment.

As all the emissions are estimated on a mass/day basis, knowledge of the total aqueous effluent volume discharge from generic sites is needed to estimate the resulting concentration. These data are not available. In this situation the Technical Guidance indicates that it can be assumed that the amount emitted per day is effectively diluted into a volume of 200,000 m^3, with adsorption onto suspended matter also being taken into account.

The emissions used as the starting point for the marine risk assessment are shown in **Table 3.21** (these are the same as derived in Section 3.1.0). **Table 3.21** also shows the resulting concentrations in seawater, marine sediment and marine biota. These have been estimated using the methods outlined in the Technical Guidance Document and the properties shown in **Table 3.20** for the adsorption and accumulation behaviour of short-chain chlorinated paraffins.

For secondary poisoning, the concentrations in predators and top predators have been estimated using the following equations given in the Technical Guidance Document.

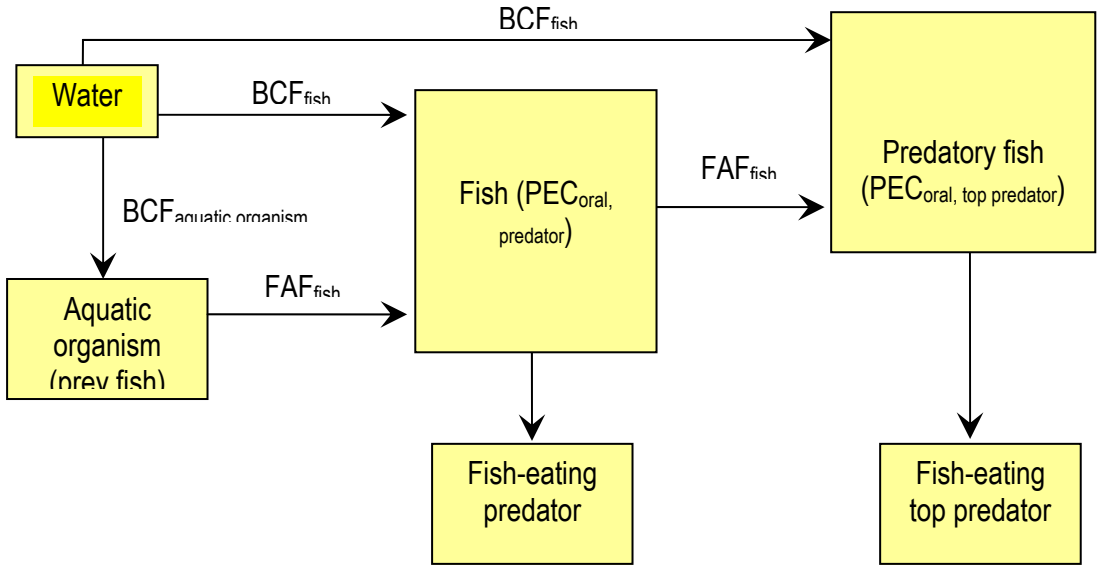
$$PEC_{oral,\ predator} = 0.5\times(PEC_{local,\ seawater,\ ann} + PEC_{regional,\ seawater,\ ann}) \times BCF_{fish}\times BMF_1$$

$$PEC_{oral,\ top\ predator} = (0.1\times PEC_{local,seawater,\ ann} + 0.9\times PEC_{regional,\ seawater\ ann}) \times BCF_{fish}\times BMF_1\times BMF_2$$

As information on bioconcentration of short-chain chlorinated paraffins in mussels is also available, a similar example calculation could be carried out replacing BCF_{fish} with BCF_{mussel}. This would lead to the values for $PEC_{oral,\ predator}$ and $PEC_{oral,\ top\ predator}$ (and subsequent PEC/PNEC ratios) around 5.2 times higher than estimated using the BCF_{fish}.

Similar to the situation for secondary poisoning discussed in Section 3.1.4.1, the above equations given in the Technical Guidance Document may not be appropriate when considering actual BMF data from feeding studies. The intention in the Technical Guidance

Document is to model the concentration in fish resulting from simultaneous exposure via both water and food in a simplified food chain. An example scheme that can utilise that available food uptake data for short-chain chlorinated paraffins is presented below. The term food accumulation factor (FAF) is used in this scheme to distinguish it from the BMF given in the equation from the Technical Guidance Document. It should be noted that this scheme differs from the Technical Guidance, where the top predator could be a predatory mammal or bird that feeds on other marine mammals or birds (a different equation would need to be constructed for such food chains). However, the scheme presented does allow the available food uptake data for short-chain chlorinated paraffins by fish to be utilised in an extended food chain.



Assuming that the "aquatic organism" in the food chain is also a fish, then the appropriate equations for this scheme are as follows.

$$PEC_{oral,\,predator} = PEC_{water} \times BCF_{fish} \times (1 + FAF_{fish}) \text{ - equation 3.}$$

$$PEC_{oral,top\ predator} = (1 + FAF_{fish})^2 \times BCF_{fish} \times PEC_{water} \text{ - equation 4.}$$

Using a FAF (BMF) of 1-2 as before, the resulting PECs for predators and top predators using equations 2 and 3 respectively are shown in **Table 3.21** (marked as alternate method). This still assumes that 50% of the exposure comes from local sources and 50% comes from regional sources for predators, and that 10% of the exposure comes from local sources and 90% comes from regional sources for top predators (the Technical Guidance defaults).

The calculations in **Table 3.21** have assumed that the $PEC_{regional,\ seawater}$ is approximately 1.7×10^{-3}-4.0×10^{-3} µg/l. These values have been estimated using EUSES 2.0 and the regional emissions given in **Table 3.1.** The equivalent predicted regional concentration in marine sediment is 0.015-0.034 mg/kg wet weight.

Table 3.21 Estimated PECs for short-chain chlorinated paraffins for the local marine risk assessment

Scenario	Comment	Daily emission to water (kg/day)	No. of days of release	$C_{local, seawater}$ (µg/l)[a]	$C_{local, seawater, ann}$ (µg/l)	$PEC_{local, seawater}$ (µg/l)[b]	$PEC_{local, seawater, ann}$ (µg/l)[b]	$PEC_{local, sed}$ (mg/kg wet wt.)	$PEC_{oral\ predator}$ (mg/kg)[b]		$PEC_{oral, top\ predator}$ (mg/kg)[b,]	
									TGD method[d]	Alternate method	TGD method[d]	Alternate method
Production sites		<0.089	300	<0.0032[c]	<0.0026	<0.0049-<0.0072	<0.0043-<0.0066	<0.021-<0.031	<0.047-<0.083	<0.070-<0.12	<0.062-<0.13	<0.14-<0.30
Rubber (worst case estimate)	Compounding site (formulation)	0.038-0.063	118-200	0.14-0.24	0.077-0.079	0.14-0.24	0.079-0.083	0.61-1.04	0.63-0.68	0.95-1.02	0.30-0.38	0.68-0.86
	Conversion site (processing)	0.0125-0.106	118-200	0.048-0.41	0.026-0.13	0.050-0.41	0.028-0.13	0.22-1.78	0.23-1.05	0.30-1.58	0.14-0.52	0.31-1.17
	Combined compounding/ conversion site	0.050-0.169	118-200	0.19-0.65	0.10-0.21	0.19-0.65	0.10-0.21	0.82-2.82	0.79-1.67	1.19-2.51	0.36-0.76	0.81-1.71
Rubber (alternate estimate)		0.0042	118	0.016	0.0052	0.018-0.020	0.0069-0.0092	0.078-0.087	0.067-0.10	0.10-0.15	0.070-0.14	0.16-0.32
Textiles	Compounding site (formulation)	0.55	300	2.12	1.74	2.12	1.74	9.19	13.6	20.4	5.48-5.56	12.3-12.5
	Backcoating site (processing)	0.75-1	66-88	2.88-3.85	0.52-0.92	2.88-3.85	0.52-0.92	12.5-16.7	4.08-7.22	6.12-10.8	1.68-2.98	3.78-6.71
Paints and coatings	Formulation site	Negligible		Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
	Industrial application of paints (processing)	0.022-0.075	173-300	0.085-0.29	0.070-0.14	0.087-0.29	0.072-0.14	0.38-1.25	0.58-1.13	0.87-1.70	0.28-0.44	0.63-1.0

a) Assumes the daily emission is diluted into 200,000 m^3 of water and the concentration of suspended matter in the seawater is 15 mg/l.
b) Calculations assume $PEC_{regional, seawater}$ is 1.7×10^{-3}-4.0×10^{-3} µg/l and uses a BMF or food accumulation factor of 2 as appropriate.
c) Calculation based on actual effluent data for a site that discharges into the sea.
d) Calculation based on BCF_{fish}. If the BCF_{mussel} were used the resulting PECs would all be higher by a factor of 5.2.

3.2 EFFECTS ASSESSMENT: HAZARD IDENTIFICATION AND DOSE (CONCENTRATION) – RESPONSE (EFFECT) ASSESSMENT

3.2.1 Aquatic compartment (incl. sediment)

3.2.1.1 Fish

3.2.1.1.1 Summary of original risk assessment report

Short-chain chlorinated paraffins are of low acute toxicity to fish with 48- and 96-hour LC_{50}s in excess of the water solubility of the substance. Chronic toxicity values include a 60-day LC_{50} of 0.34 mg/l for rainbow trout and no observed effect concentrations of <0.040 and 0.28 mg/l for rainbow trout and sheepshead minnow respectively.

3.2.1.1.2 Updated information

A toxicity test using embryos of Japanese medaka (*Oryzias latipes*) is also available (Fisk et al., 1999). This study used a series of four short-chain chlorinated paraffins with single carbon chain lengths and known chlorine contents. The first two compounds were synthesised by the chlorination of either 1,5,9-decatriene or 1,10-undecadiene, and so the positions of the chlorine atoms along the molecule were generally known. The composition of these two products was

average formula $C_{10}H_{15.5}Cl_{6.5}$ 63.0% wt. Cl consisting of
55% 1,2,5,6,9,10-hexachlorodecane (61.0% wt. Cl)
41% x,1,2,5,6,9,10-heptachlorodecane (64.8% wt. Cl)
4% x,y,1,2,5,6,9,10-octachlorodecane (69.1% wt. Cl) and

average formula $C_{11}H_{18.4}Cl_{5.6}$ 56.9% wt. Cl consisting of
40% x,1,2,10,11-pentachloroundecane (53.8% wt. Cl)
49% x,y,1,2,10,11-hexachloroundecane (58.7% wt. Cl)
10% x,y,z,1,2,10,11-heptachloroundecane (62.5% wt. Cl),

where x, y, and z are unidentified positions on the carbon chain.

The other compounds were synthesised by the free radical chlorination of either 1-^{14}C-decane or 1-^{14}C-dodecane, and resulted in more complex mixtures. The composition of these products was

average formula ^{14}C-$C_{10}H_{15.3}Cl_{6.7}$ 63.7% wt. Cl consisting of
0.1% $C_{10}H_{18}Cl_4$ (50.7% wt. Cl)
4.1% $C_{10}H_{17}Cl_5$ (56.2% wt. Cl)
37% $C_{10}H_{16}Cl_6$ (61.0% wt. Cl)
45% $C_{10}H_{15}Cl_7$ (64.8% wt. Cl)

12% $C_{14}H_{14}Cl_8$ (68.1% wt. Cl)
1.5% $C_{10}H_{13}Cl_9$ (70.7% wt. Cl) and

average formula ^{14}C-$C_{12}H_{19.5}Cl_{6.5}$ 58.5% wt. Cl consisting of
14% $C_{12}H_{19}Cl_5$ (51.9% wt. Cl)
31% $C_{12}H_{18}Cl_6$ (56.8% wt. Cl)
50% $C_{12}H_{17}Cl_7$ (60.6% wt. Cl)
5% $C_{12}H_{16}Cl_8$ (64.8% wt. Cl).

In the experiment, fertilised eggs from the fish were individually exposed to each test substance in 1.8 ml vials with teflon-lined caps. The chlorinated paraffins were added to the vials by firstly dissolving the substances in a mixture of dichloromethane and hexane and then adding the required amount of solution to the vial and allowing the solvent to evaporate for 24 hours. Then 1 ml of the medaka rearing solution was added to the vial and the mixture was sonicated for 30 minutes before one fertilised egg was added to each vial. The vials were then sealed and incubated at 25°C for the test period (20 days). The concentrations of chlorinated paraffin tested were based on their estimated water solubility, along with concentrations of 1/100, 1/10, 10× and 100× the estimated water solubility (extra dilutions were also used in some experiments). Separate experiments were used to determine the extent of the adsorption of the ^{14}C-labelled chlorinated paraffin onto the glass vials and these data were used to determine the amount of chlorinated paraffin that was needed in order to achieve the desired test concentration in the test medium. Sets of ten vials were used for each test concentration, and one control group of ten vials was established for every five treatments.

The analytical methodology used was only sufficiently sensitive enough to determine the concentrations of the ^{14}C-labelled compound. Therefore, the actual concentration of the two unlabelled substances in the test media was estimated from the measurements with the ^{14}C-labelled substances, along with knowledge of the amounts added to the vials. Similarly, the concentration of the chlorinated paraffin present in the eggs and larvae could only be determined with the ^{14}C-labelled substance. The measured concentrations of the ^{14}C-labelled chlorinated paraffin in the test media were found to be close to the desired concentration in the low concentration vials, but were lower than expected in the high test concentration vials, possibly owing to increased adsorption onto the glass vial. The measured and estimated concentrations for the ^{14}C-labelled chlorinated paraffins are shown in **Table 3.22**, along with a brief description of the effects seen.

Exposure to the C_{10} 63.0% wt. Cl substance and the ^{14}C-C_{10} 63.7% wt. Cl labelled substance at concentrations of 9.6 mg/l and 7.7 mg/l respectively caused 100% mortality in the eggs within either 10-12 days (C_{10} 63.0% wt. Cl substance) or 2 days (^{14}C-C_{10} 63.7% wt. Cl labelled substance). No significant deaths or recognisable lesions occurred in the eggs from any other treatment, but larvae exposed to the higher concentrations of all four short-chain chlorinated paraffins were lethargic (with little or no movement) and in many cases these larvae also had large yolk sacs.

The hatching success in the exposed and control vials was low and variable, and in almost all cases unhatched eggs were still alive on the last observation day (day 20). Further observation on day 40 indicated that the majority of eggs had hatched by this time. The average hatching time in this study was >15 days, which was longer than normal for this species (11-13 days). It was thought that the variable hatching rate was unlikely to be related to the chlorinated paraffin exposure.

Based on the results of this study, the following NOECs and LOECs were derived from the data by the authors.

$C_{10}H_{15.5}Cl_{6.5}$	NOEC = 62 µg/l	LOEC = 460 µg/l
^{14}C-$C_{10}H_{15.3}Cl_{6.5}$	NOEC = 50 µg/l	LOEC = 370 µg/l
$C_{11}H_{18.4}Cl_{5.6}$	NOEC = 57 µg/l	LOEC = 420 µg/l
^{14}C-$C_{12}H_{19.5}Cl_{6.5}$	NOEC = 9.6 µg/l	LOEC = 55 µg/l

The authors indicated that these data were fully consistent with narcosis as the mechanism of toxicity caused by short-chain chlorinated paraffins in this study.

Table 3.22 Exposure concentrations and uptake in Medaka eggs and larvae of ^{14}C-C_{14}, 55% wt. Cl chlorinated paraffin

Test substance	Measured or estimated water concentration (µg/l)	Effects seen compared with control
$C_{10}H_{15.5}Cl_{6.5}$, 63.0% wt. Cl	5.9[e]	No significant deaths or lesions.
	62[e]	No significant deaths or lesions.
	460[e]	No significant deaths or lesions. Larvae were lethargic.
	2,700[e]	No significant deaths or lesions. Larvae were lethargic.
	9,600[e]	All eggs died within 10-12 days. The eggs appeared to develop normally and then died suddenly.
^{14}C-$C_{10}H_{15.3}Cl_{6.7}$, 63.7% wt. Cl	4.7[m]	No significant deaths or lesions.
	50[m]	No significant deaths or lesions.
	370[m]	No significant deaths or lesions. Larvae were lethargic.
	2,200[m]	No significant deaths or lesions. Larvae were lethargic.
	5,100[m]	No significant deaths or lesions. Larvae were lethargic.
	7,700[m]	All eggs died within 2 days. Larvae were lethargic.
$C_{11}H_{18.4}Cl_{5.6}$, 56.9% wt. Cl	5.4[e]	No significant deaths or lesions.
	57[e]	No significant deaths or lesions.
	420[e]	No significant deaths or lesions. Larvae were lethargic.
	2,500[e]	No significant deaths or lesions. Larvae were lethargic.
	8,900[e]	No significant deaths or lesions. Larvae were lethargic.
^{14}C-$C_{12}H_{19.5}Cl_{6.5}$ 58.5% wt. Cl	0.70[m]	No significant deaths or lesions.
	9.6[m]	No significant deaths or lesions.
	55[m]	No significant deaths or lesions. Larvae were lethargic.
	270[m]	No significant deaths or lesions.

m) Measured concentration based on ^{14}C-measurements.
e) Estimated concentration (see text).

This study is similar in some ways to the OECD 210 fish early life-stage test, but falls short of the current guidelines in some areas as follows.

- This study was carried out for approximately 3 days post-hatch, but the OECD guideline recommends a test duration of 30 days post-hatch for *Oryzias latipes*.

- The test was carried out as a static test in sealed vials - no indication was given as to whether the dissolved oxygen level was maintained at a suitable level throughout the test period.
- The rate of hatching was slow in controls and so it is difficult to determine if any effects were seen on this endpoint.
- The number of eggs/test concentration was only 10 compared with at least 60 recommended in the OECD guidelines.

The effects of the same four short-chain chlorinated paraffins as above on behaviour and liver and thyroid histology in juvenile rainbow (*Oncorhynchus mykiss*) trout have been studied through dietary exposure (Cooley et al., 2001). The food used in the test was commercial fish food that was spiked with a known concentration of each chlorinated paraffin. The fish food consisted of 41% protein, 14% lipid and 3% fibre. In the test, juvenile rainbow trout (initial weight ~2 g) were exposed to one of three concentrations of each chlorinated paraffin for either 21 or 85 days. The daily feeding rate was equivalent to 1.5% of the mean weight of the fish. Each treatment group consisted of 10 fish housed in either 10, 20 or 40 l glass aquaria supplied with dechlorinated tap water (using a flow-through system) at 11^{o}C. Three control groups were also run. After 21 days exposure the trout from the two highest exposure groups for each chlorinated paraffin (and two control groups) were subject to histological examination (five fish per treatment) and analysis of the chlorinated paraffin concentration (five fish per treatment). Three fish were also sacrificed from each low exposure group and the remaining control group (but were not analysed) and the remaining fish in the low exposure groups were exposed for a further 64 days. On day 85 the remaining fish were subject to histological examination (three fish per treatment) and analysis of the chlorinated paraffin concentration (three fish per treatment). The concentrations used in the test, and the effects seen, are summarised in **Table 3.23**.

No effects were seen in the test on the mean weights of fish or on liver somatic indices when compared to controls, and no treatment-related mortalities were seen in the test. The fish exposed to the lowest concentration of each short-chain chlorinated paraffin were considered to show normal behaviour when compared to the control fish, however abnormal behaviour was seen in the fish exposed to the middle concentration of each short-chain chlorinated paraffin. This abnormal behaviour included delayed or absent startle response, reduced aggressive behaviour when feeding, failure to feed on certain days, loss of equilibrium and development of dark skin colouration. Similar abnormal behaviour was also noted at the highest exposure concentration for each short-chain chlorinated paraffin, but here the onset of these effects occurred earlier than for the middle exposure groups, and in many cases the fish stopped feeding.

Qualitative histological examination of the livers and thyroid after 21-days' exposure was carried out only for the middle exposure groups for each chlorinated paraffin tested. These examinations indicated that a number of alterations had occurred on exposure to all four short-chain chlorinated paraffins, but that the occurrence, extent, and types/stages of alterations differed between the various treatment groups. All treatments showed fish with livers displaying hepatocytes with fewer vacuoles. The most severe and advanced alterations occurred in fish from the experiments with the labelled C_{10} 63.7% wt. Cl substance and to a slightly lesser extent the $C_{11}H_{18.4}Cl$ 56.9% wt. Cl substance. The alterations seen included sites of inflammation composed largely of lymphocytes, hepatocyte necrosis and fibrosis. No lesions or abnormalities were seen in the thyroids of fish exposed to the middle concentration

of any of the short-chain chlorinated paraffins tested. Qualitative histological examinations were not carried out for the high exposure groups owing to the erratic feeding seen.

Table 3.23 Effects of dietary exposure to short-chain chlorinated paraffins on juvenile rainbow trout (Cooley et al., 2001)

Chlorinated paraffin	Exposure period (days)	Concentration in food (mg/kg)	Summary of effects seen
$C_{10}H_{15.5}Cl_{6.5}$ 63% wt. Cl	85	0.87	Normal behaviour. No effects on liver or thyroid.
	21	12	Abnormal behaviour from day 16 onwards. Qualitative effects seen on liver and statistically significant (p=0.05) effects seen on hepatocyte volume index and nucleus:cytoplasm area ratio. No qualitative effects seen on thyroid but the thyroid epithelium cell heights were increased compared with the control population.
	21	62	Abnormal behaviour from day 2 onwards.
^{14}C-$C_{10}H_{15.3}Cl_{6.7}$ 63.7% wt. Cl	85	0.84	Normal behaviour. A marginal (significant at the p=0.1 level) effect on hepatocyte nuclear diameters and hepatocyte volume index. No effects on thyroid.
	21	13	Abnormal behaviour from day 4 onwards. Qualitative effects seen on liver and marginal effects (significant at p=0.1 level) were seen on hepatocyte volume index. No effects on thyroid.
	21	74	Abnormal behaviour from day 3 onwards.
$C_{11}H_{18.4}Cl_{5.6}$ 56.9% wt. Cl	85	1.8	Normal behaviour. No effects on liver or thyroid.
	21	2.6	Abnormal behaviour from day 5 onwards. Qualitative effects seen on liver. No effects on thyroid.
	21	14	Abnormal behaviour from day 2 onwards.
^{14}C-$C_{12}H_{19.5}Cl_{6.5}$ 58.5% wt. Cl	85	1.9	Generally normal behaviour. Two trout developed dark spots on back in day 11. No effects on liver or thyroid.
	21	14	Abnormal behaviour from day 3 onwards. Qualitative effects seen on liver and a statistically significant (p=0.05) effect seen in hepatocyte volume index. No effects on thyroid.
	21	58	Abnormal behaviour from day 4 onwards.

a) BAFs have been estimated in this report from the data (BAF = concentration in fish/concentration in food).
b) The concentration was determined by parent compound analysis.
c) The concentration was determined by ^{14}C analysis.

In addition to the qualitative histological examinations, quantitative histomorphological measurements were also carried out on livers and thyroid of the exposed fish in the middle exposure group after 21 days, and also the low exposure group after 85 days. The parameters investigated included hepatocyte nuclear diameter, hepatocyte volume index, nucleus:cytoplasm area ratio and thyroid epithelium cell height. After 21 days exposure to the middle concentration, no significant differences (p=0.05) were seen in the hepatocyte nuclear diameters in fish exposed to each of the four short-chain chlorinated paraffins when compared with the control fish. The mean hepatocyte volume index was found to be significantly (p=0.05) reduced when compared with controls in fish exposed to the middle concentration of the C_{10} 63.0% wt. Cl and the ^{14}C-C_{12} 58.5% wt. Cl treatments (the hepatocyte volume index values of trout exposed to the middle ^{14}C-C_{10} 63.7% wt. Cl were marginally different from controls (significant at the p=0.1 level)). A significant difference (p=0.05) between exposed fish and control fish was also found for the nucleus:cytoplasm area ratio and thyroid epithelium cell heights for fish exposed to the middle concentration of

the C_{10} 63.0% wt. Cl treatment (no significant differences in these endpoints were seen for the middle concentrations of the other short-chain chlorinated paraffins tested).

For the low dose treatments at 85 days, no significant differences were seen in any of the above parameters for the exposed fish compared with control fish at the p=0.05 level. Marginally significantly different responses (p=0.1 level) were seen for hepatocyte nuclear diameters and hepatocyte volume index between the group exposed to the low dose of the ^{14}C-C_{10} 63.7% wt. Cl substance and the control population.

It is not clear from these studies if the effects seen were a result of a direct toxic effect of the short-chain chlorinated paraffin or occurred as result of the reduced feeding seen in many of the exposed fish (although this in itself could be considered an effect of the short-chain chlorinated paraffin). Thus, although it is clear that adverse effects were seen, it is not certain that they are directly related to the toxicity of short-chain chlorinated paraffins.

3.2.1.2 Aquatic invertebrates

3.2.1.2.1 Summary of original risk assessment report

24-Hour EC_{50}s for short-chain chlorinated paraffins with daphnids ranged from 0.3 to 11.1 mg/l, with acute NOECs ranging from 0.06 to 2 mg/l. In 21-day tests with daphnids, EC_{50}s ranged from 0.101 to 0.228 mg/l and NOECs ranged from 0.005-0.05 mg/l.

3.2.1.2.2 Updated information

The acute toxicity of a short-chain chlorinated paraffin to *Daphnia magna* has been studied by both Frank (1993) and Frank and Steinhäuser (1994). The chlorinated paraffin used in these studies was a commercial C_{10-13} product with a 56% by weight chlorine content. In the test, stock solutions of the chlorinated paraffin were made up in water to give nominal concentrations of either 100 mg/l or 10 g/l (the 10 g/l experiment was carried out twice). The 100 mg/l solution was sonicated for one hour and then left to stand in the dark for 48 hours before use. The 10 g/l solutions also stood for 48 hours in the dark before use, but this time without sonication. After this period, the solutions were filtered firstly with glass filters and then with membrane filters to remove undissolved test substance (microscopic and spectroscopic investigations of the filtered solutions gave no indication of the presence of droplets) to give the respective water soluble fractions. The concentrations of medium-chain chlorinated paraffin in the water soluble fractions were then determined by AOX (adsorbable organic halogen) analysis (detection limit of 10 µg/l Cl was equivalent to around 20 µg/l of the chlorinated paraffin). This analysis showed that the concentration of chlorinated paraffin present in the water soluble fraction was around 2.4-2.5 mg/l (Frank, 1993) and a mean of 2.6 mg/l (Frank and Steinhäuser, 1994) for the 10 g/l nominal solutions and a mean of 168 µg/l for the 100 mg/l stock solution (Frank and Steinhäuser, 1994).

The acute (48-hour) toxicity tests were carried out using dilutions of the prepared water soluble fractions. The method used was DIN 38 412, Teil 11, which is equivalent to OECD 202. In the test using the water soluble fraction from the 100 mg/l nominal solution an EC_{50} of 0.138 mg/l and an EC_0 of 0.028 mg/l was determined. In the two experiments using the water soluble fraction from the 10 g/l stock solution, EC_0 values of 0.86 and 0.89 mg/l (Frank, 1993; slightly different values of 0.81 and 0.96 mg/l are given in the Frank and

Steinhäuser (1994) paper) and 2.05 mg/l (Frank and Steinhäuser, 1994) were reported and the EC_{10} was reported to be 2.4-2.5 mg/l (Frank, 1993; a slightly different value of 1.3-1.5 mg/l was given in the Frank and Steinhäuser (1994) paper). Frank and Steinhäuser (1994) noted that the effects seen in the acute tests showed poor reproducibility, probably because effects were seen only around the water solubility limit of the substance. However, the authors thought that the possibility of undissolved droplets affecting the results could be ruled out, as floating *Daphnia* were only sporadically observed in the test. Nevertheless, the results of these studies should be treated with caution.

Further short-term toxicity tests with *Daphnia magna* have been carried out by Koh and Thiemann (2001). Two commercial short-chain chlorinated paraffins, a C_{10-13}, 56% wt. Cl product and a C_{10-13}, 62% wt. Cl product, were tested. The method used was based on DIN 38 412, Teil II. Acetone was used as a cosolvent in the test (0.1 ml/l in the test solutions) and a stock solution of either 200 µg/l for the C_{10-13}, 56% wt. Cl substance or 100 µg/l for the $C_{10-13,}$ 62% wt. Cl substance was prepared for use in the test. Few other test details are reported. The 48-hour EC_{50} values determined were 0.140 mg/l for the C_{10-13}, 56% wt. Cl product and 0.075 mg/l for the C_{10-13}, 62% wt. Cl.

A 96-hour EC_{50} of <300 µg/l has been reported for a C_{10-13}, 70% wt. Cl short-chain chlorinated paraffin with the brackish water harpacticoid *Nitrocra spinipes* (Tarkpea et al., 1981; as quoted in WHO, 1996). No other details of the test were reported by WHO (1996), but the test method was probably the same as reported by Tarkpea et al. (1986), where a static method was employed using water of salinity 7‰ at a temperature of 20-22°C without aeration, probably using acetone as cosolvent.

3.2.1.3 Algae

3.2.1.3.1 Summary of original risk assessment report

96-hour EC_{50}s ranged from 0.043 to 3.7 mg/l, with the marine alga *Skeletonema costatum* appearing to be more sensitive to short-chain chlorinated paraffins than the fresh water alga *Selenastrum capricornutum*[10]. A NOEC of 0.012 mg/l was reported in the study with *S. costatum*. The toxic effects seen with the marine alga were transient, with no effects being seen at any concentration after seven days exposure.

3.2.1.3.2 Updated information

Toxicity tests with the freshwater alga *Scenedesmus subspicatus* have been carried out by Koh and Thiemann (2001). Two commercial short-chain chlorinated paraffins, a C_{10-13}, 56% wt. Cl product and a C_{10-13}, 62% wt. Cl product, were tested. The method used was based on DIN 38 412, part 9. Acetone was used as a co-solvent in the test (0.1 ml/l in the test solutions) and a stock solution of either 200 µg/l for the C_{10-13}, 56% wt. Cl substance or 100 µg/l for the $C_{10-13,}$ 62% wt. Cl substance was prepared for use in the test. Few other test details are reported. The undiluted solution of both chlorinated paraffins was found to have no effect on growth (biomass) or growth rate of the alga over 72 hours. Thus the NOEC is

[10] *Selenastrum capricornutum* is now *Pseudokirchneriella subcapitata*

≥0.2 mg/l for the C_{10-13}, 56% wt. Cl substance and ≥0.1 mg/l for the C_{10-13}, 62% wt. Cl substance.

3.2.1.4 Micro-organisms

3.2.1.4.1 Summary of original risk assessment report

Short-chain chlorinated paraffins appear to be of low toxicity to micro-organisms. Significant effects (>10% inhibition of gas production) were found to occur in anaerobic micro-organisms from domestic waste water treatment plants only at chlorinated paraffin concentrations of 600-5,000 mg/l.

3.2.1.4.2 Updated information

The toxicity of short-chain chlorinated paraffins to bioluminescent bacteria *Vibrio fischeri* has been investigated by Koh and Thiemann (2001). Two commercial short-chain chlorinated paraffins, a C_{10-13}, 56% wt. Cl product and a C_{10-13}, 62% wt. Cl product, were tested. The method used was based on DIN 38 412 part 34, and both a short-term (30 minute) and long-term (24 hour) test were carried out for each substance. Acetone was used as a cosolvent in the test (0.1 ml/l in the test solutions) and a stock solution of either 200 μg/l for the C_{10-13}, 56% wt. Cl substance or 100 μg/l for the $C_{10-13,}$ 62% wt. Cl substance was prepared for use in the test. Few other test details are reported. The results were expressed in terms of the dilution of the stock solution required to cause <20% inhibition of light emission at 585 nm from the bacteria. In the short-term (30 minute test) <20% inhibition was seen at a dilution of 1 (i.e. NOEC/EC_{20} ≥ 0.2 mg/l for the C_{10-13}, 56% wt. Cl substance and ≥0.1 mg/l for the C_{10-13}, 62% wt. Cl substance). In the long-term (24 hour test) a dilution of 2 caused <20% inhibition (i.e. NOEC/EC_{20} = 0.1 mg/l for the C_{10-13}, 56% wt. Cl substance and = 0.05 mg/l for the C_{10-13}, 62% wt. Cl substance).

3.2.1.5 Predicted no effect concentrations (PNEC) for the aquatic compartment

The PNEC for surface water for short-chain chlorinated paraffins was 0.5 μg/l from the original report (using an assessment factor of 10 on long-term invertebrate toxicity data). The new aquatic toxicity data for short-chain chlorinated paraffins confirm the data available previously and so the PNEC for surface water for this update will also be taken to be 0.5 μg/l.

The $PNEC_{microorganisms}$ was determined to be 6 mg/l in the original report. No new toxicity data relevant to this endpoint are available (the Technical Guidance Document indicates that tests with *Vibrio fisheri* should not be used to derive a $PNEC_{microorganisms}$ for protection of waste water treatment processes as it is a marine organism) and so the $PNEC_{microorganisms}$ will be taken to be 6 mg/l in this update.

3.2.1.6 Predicted no effect concentration (PNEC) for sediment-dwelling organisms

In the original risk assessment the $PNEC_{sediment}$ was estimated to be 0.88 mg/kg wet weight using the equilibrium partitioning approach. This value was estimated using a Koc value of 91,200 l/kg (giving a $K_{susp\text{-}water}$ of 2,281 m^3/m^3). This updated assessment is based on a slightly higher Koc value of 199,500 (giving a $K_{susp\text{-}water}$ of 4,988 m^3/m^3). Using this Koc, the equilibrium partitioning approach gives a $PNEC_{sediment}$ of 2.17 mg/kg wet weight.

The Technical Guidance Document indicates that the ingestion of sediment-bound substance by sediment-dwelling organisms may not be sufficiently explained by this relationship for substances with a log Kow greater than 5, and suggests that the PEC/PNEC ratio is increased by a factor of 10 in order to account for this possibility.

In this respect it is also necessary to consider the data available on the structurally similar medium-chain chlorinated paraffins. Three long-term toxicity tests for both sediment and soil organisms have recently been completed for this substance and these data are discussed in detail in the risk assessment report for that substance (RAR, 2003). For medium-chain chlorinated paraffins the PNEC obtained using the equilibrium partitioning approach for both the sediment and the terrestrial compartment agreed with the PNEC derived from the toxicity data directly (within a factor of 2.6 for sediment; the two soil PNECs were essentially the same). At least some of the difference between the two values for sediment could be explained by the fact that the NOECs underlying both PNEC determinations depends to some extent on the actual concentrations and concentration intervals used in the various tests. Taking this into account suggests that there is good agreement between the PNECs obtained by the two methods. This then indicates that the observed toxicity for medium-chain chlorinated paraffins in sediment is consistent with exposure being mainly via the pore water and that it is not necessary to apply a factor of 10 to the equilibrium partitioning method to account for possible direct ingestion for this substance.

The updated risk characterisation will use a $PNEC_{sediment}$ of 2.17 mg/kg wet wt. for the risk characterisation but, based on the data available for medium-chain chlorinated paraffins, the risk characterisation ratios will not be increased by a factor of 10 to take into account possible direct ingestion of sediment-bound substance as this appears to be overly conservative for chlorinated paraffins[11].

3.2.2 Terrestrial compartment

No new data are available on the toxicity of short-chain chlorinated paraffins to terrestrial organisms. In the original risk assessment report the $PNEC_{soil}$ was estimated as 0.80 mg/kg wet weight using the equilibrium partitioning approach. This value was estimated using a Koc value of 91,200 l/kg (giving a $K_{soil\text{-}water}$ of 2,736 m^3/m^3). This updated assessment is

[11] Some EU member states, notably Germany, and the CSTEE, have argued that the factor of 10 should be applied here as the sediment tests carried out with medium-chain chlorinated paraffins had not fully taken into account the possibility of increased exposure from the ingestion of contaminated food (although it was recognised that the test had been carried out using the best available method at the time, it was thought that this could have led to an underestimation of the actual toxicity of medium-chain chlorinated paraffins). Other member states, e.g. the Netherlands, thought that the factor of 10 should be applied to take into account the fact that the approach required a read-across from medium-chain chlorinated paraffins to short-chain chlorinated paraffins and that this may not be valid. Overall it was agreed that the $PNEC_{sediment}$ of 2.17 mg/kg wet wt. should be used in the risk characterisation but that this uncertainty should be reflected in the conclusions.

based on a slightly higher Koc value of 199,500 (giving a $K_{soil\text{-}water}$ of 5,985 m^3/m^3). Using this Koc, the equilibrium partitioning approach gives a $PNEC_{sediment}$ of 1.76 mg/kg wet weight.

The Technical Guidance Document indicates that the ingestion of sediment-bound substance by sediment-dwelling organisms may not be sufficiently explained by this relationship for substances with a log Kow greater than 5, and suggests that the PEC/PNEC ratio is increased by a factor of 10 in order to account for this possibility.

Similar to the case discussed above for sediment, it appears that, based on the data available for medium-chain chlorinated paraffins, the use of a factor of 10 to take into account possible direct ingestion is overly conservative for chlorinated paraffins. Thus the updated risk characterisation will use a $PNEC_{soil}$ of 1.76 mg/kg wet wt. without the factor of 10[12].

3.2.3 Atmosphere

It is not possible to derive a PNEC for this endpoint. Direct emissions of short-chain chlorinated paraffins to the air from local sources are predicted to be relatively low, but volatilisation to air from products over extended time periods is expected to occur. The predicted concentrations are, however, all very low and reflect the small but measurable volatility of this group of substances. Therefore, neither biotic nor abiotic effects are likely because of low concentrations predicted and measured.

Short-chain chlorinated paraffins have been raised as a concern with regard to long-range atmospheric transport under persistent organic pollutant (POP) conventions (see Section 2.3 and Section 3.3.5).

3.2.4 Non-compartment specific effects relevant to the food chain (secondary poisoning)

3.2.4.1 Avian toxicity

3.2.4.1.1 Summary of original risk assessment report

A NOAEL of 166 mg/kg food was determined for mallard ducks in an avian reproduction test.

3.2.4.1.2 Updated information

The toxicity of a $C_{10\text{-}13}$, 49% wt. Cl and a $C_{10\text{-}13}$, 70% wt. Cl chlorinated paraffin to chicken embryos has been studied. In the study, the chlorinated paraffin was injected into fertilized hens' eggs after 4 days of incubation in an emulsion of peanut oil, lecithin and water at a dose of 100 or 200 mg/kg egg. No effects were seen on the incubation time, hatching rate,

[12] Some EU member states have argued that the factor of 10 should be applied for the same reasons as outlined for sediments (see Section 3.2.1.6). Overall it was agreed that the $PNEC_{soil}$ of 1.76 mg/kg wet wt. should be used in the risk characterisation but that this uncertainty should be reflected in the conclusions.

hatching weight, weight gain after hatch (the observations were made up to day 39 after the start of incubation) or liver weights of the chicks when compared with the control group (Brunström, 1983).

In a further injection study, Brunström (1985) investigated the effects of the same C_{10-13}, 49% wt. Cl and a C_{10-13}, 70% wt. Cl chlorinated paraffins on liver weight, microsomal enzyme activities and cytochrome P-450 concentration in chick embryos after 20 days of incubation. In this experiment the chlorinated paraffin concentration used was 300 mg/kg egg. No effects were seen on the viability of the chick embryos owing to the either treatment. For the C_{10-13}, 49% wt. Cl product a statistically significant increase in liver weight ($p=0.01$), increase in cytochrome P-450 concentration ($p=0.001$), decrease in AHH (aryl hydrocarbon (benzo[a]pyrene) hydroxylase) activity ($p=0.05$) and decrease in ECOD (7-ethoxycoumarin O-deethylase) activity ($p=0.001$) was seen in the treated population when compared to the control population. For the C_{10-13}, 70% wt. Cl product a statistically significant increase in liver weight ($p=0.001$), increase in cytochrome P-450 concentration ($p=0.001$) and increase in APND (aminopyrine N-demethylase) activity ($p=0.001$) was observed in the treated population when compared to the control population.

Studies involving the injection of a substance into eggs are not suitable for use in deriving a PNEC for secondary poisoning, since the route of exposure is inappropriate.

3.2.4.2 Mammalian toxicity

Mammalian toxicity data have not been reviewed as part of this update.

3.2.4.3 Predicted no effect concentration (PNEC) for secondary poisoning

In the original risk assessment report a PNEC for secondary poisoning of 16.6 mg/kg food was derived for short-chain chlorinated paraffins based on a mallard reproduction study carried out according to the OECD 206 guideline. This value was estimated using an assessment factor of 10 on the NOEC (166 mg/kg food) from the study. The Technical Guidance Document now indicates that an assessment factor of 30 is more appropriate for this type of study and so a PNEC of 5.5 mg/kg can be estimated from these data.

The Technical Guidance Document also indicates that if data are available for both avian species and mammals, then a PNEC should be derived from both data sets and the lowest one used in the risk characterisation.

The available mammalian data are summarised in the original risk assessment report. Here chronic effects (effects on kidney, liver and thyroid) on laboratory rodents were seen at concentrations of 100 mg/kg body weight/day and above in rats (14-90 day studies). In addition, 13-week reproductive studies with rats and mice are also available which showed effects at concentrations greater than 500 mg/kg body weight/day. It should be noted that, for medium-chain chlorinated paraffins, effects on rat pups have been observed as a result of exposure of dams to medium-chain chlorinated paraffins during the lactation period. No similar study for short-chain chlorinated paraffins currently exists, but, reading across from medium- to short-chain chlorinated paraffins, it is possible that such effects might also occur for short-chain chlorinated paraffins. However, in terms of the derivation of the PNEC for secondary poisoning, these effects did not result in the lowest NOAEL for medium-chain

chlorinated paraffins (here the effects on liver, thyroid and kidneys were the most sensitive indicators of toxicity) and so were not directly used in deriving the PNEC for that substance.

Using the conversion factors given in the Technical Guidance Document a dose of 100 mg/kg body weight/day is approximately equal to a dose of 1,000-2,000 mg/kg food. The assessment factor that should be applied to the results from 90-day studies is 90. However, taking into account the fact that data are also available for reproduction and other chronic (e.g. carcinogenicity) studies for short-chain chlorinated paraffins, an assessment factor of 30 appears to be more appropriate. Therefore, based on these data, a PNEC of around 33-67 mg/kg food can be estimated. It should be noted however, that these values are derived from concentrations where effects were first seen in some studies rather than true NOEC values.

It should be noted that the available rodent data are consistent with the avian data since the lowest dose found to cause slight effects in the mallard reproduction study was around 1,000 mg/kg food, which is similar to the concentration where effects start to be observed in mammals.

The risk characterisation for secondary poisoning will be carried out using a PNEC of 5.5 mg/kg food.

Effects have been seen in a feeding study with fish at concentrations around this value (no effects or marginal effects were seen at around 0.84-1.9 mg/kg food, with effects on behaviour being seen from 2.6 mg/kg food and effects on liver and thyroid being seen at higher concentrations in some experiments). These data are summarised in Section 3.2.1.1.2. Erratic feeding was also seen in many of the exposures and it is not clear if the effects seen were due to a true toxic action of the short-chain chlorinated paraffin or a consequence of the reduced feeding (although the reduction in feeding could be considered an effect of short-chain chlorinated paraffins). No guidance is currently available on the use of this type of study (both for the estimation of the PEC and the estimation of the PNEC) and so this information is not used for the assessment of secondary poisoning here.

3.2.5 Marine effects assessment

3.2.5.1 Water

The available toxicity data for freshwater and marine organisms are summarised in Section 3.2.1. The Technical Guidance Document recommends that the pooled data for both freshwater and marine organisms are considered in the PNEC derivation.

The overall long-term toxicity data set for short-chain chlorinated paraffins consists of data for two species of freshwater fish (lowest NOEC = 0.0096 mg/l), one marine fish species (NOEC = 0.28 mg/l for *Cyprinodon variegates*), two species of freshwater invertebrates (lowest NOEC = 0.005 mg/l), two species of marine invertebrates (lowest NOEC = 0.007 mg/l for *Mysidopsis bahia*[13] (the other study with marine invertebrates investigated effects on growth in *Mytilus edulis.* No significant effects on growth were seen at 0.0023 mg/l whereas effects on growth were seen at 0.0093 mg/l. As only two concentrations were tested in this study it is not possible to derive a reliable LOEC or NOEC from the data)),

[13] *Mysidopsis bahia* is now *Americamysis bahia*

two freshwater algal species (lowest NOEC = 0.39 mg/l) and one marine algal species (NOEC = 0.012 mg/l *Skeletonema costatum*).

The lowest overall NOEC obtained for short-chain chlorinated paraffins is 0.005 mg/l from a 21-day test with the freshwater species *Daphnia magna.*

In accordance with the Technical Guidance Document an assessment factor of 50 could be applied to the available data as there are NOECs from freshwater/marine species covering three trophic levels (algae, fish and crustaceans) with in addition long-term data from an additional marine taxonomic group (molluscs – although it is not possible to derive an actual NOEC from this study (only two concentrations were tested) the actual NOEC is in the range 0.0023 mg/l to 0.0093 mg/l and so is similar to those obtained from other invertebrate tests. Thus, although the PNEC cannot be based on these data, they do provide support for the use of an assessment factor of 50 on the other available data).

The Technical Guidance Document indicates that toxicity data on a further marine taxonomic group is necessary in order to reduce the factor. Therefore, the PNEC for marine organisms will be taken to be 0.1 μg/l using an assessment factor of 50.

3.2.5.2 Sediment

There are no sediment toxicity data available for short-chain chlorinated paraffins. According to the Technical Guidance Document, the PNEC for marine sediments can provisionally be calculated using the equilibrium partitioning method. Using the PNEC of 0.1 μg/l for marine waters and a $K_{susp\text{-}water}$ of 4,988 m^3/m^3, the $PNEC_{marine\ sediment}$ can provisionally be estimated to be 0.43 mg/kg wet weight. The Technical Guidance Document also indicates that, for substances with a log Kow >5, the resulting PEC/PNEC ratios should be increased by a factor of 10 to take into account the possibility of uptake by ingestion of sediment. However, as explained in Section 3.2.1.6, there is evidence from tests carried out with medium-chain chlorinated paraffins that the extra factor of 10 may be overprotective for chlorinated paraffins and so it is proposed that this factor is not applied here for short-chain chlorinated paraffins[14]. The $PNEC_{marine\ sediment}$ will be taken to be 0.43 mg/kg wet weight.

3.2.5.3 Secondary poisoning

According to the Technical Guidance Document, the derivation of the $PNEC_{oral}$ for secondary poisoning for the marine environment is identical to that used for the terrestrial and freshwater food chain. Therefore the $PNEC_{oral}$ will be taken to be 5.5 mg/kg food, as derived in Section 3.2.4.

3.3 RISK CHARACTERISATION

This section presents the risk characterisation for surface water, sediment, waste water treatment plants, soil, air, secondary poisoning and the marine environment.

[14] Some EU member states have argued that the factor of 10 should still be applied for the same reasons as outlined for freshwater sediments (see Section 3.2.1.6). Overall it was agreed that the PNEC of 0.43 mg/kg wet wt. should be used in the risk characterisation but that this uncertainty should be reflected in the conclusions.

As noted in Section 2.2.2, a significant reduction in the amounts of short-chain chlorinated paraffins used in the EU has occurred since 2001 (the base-line year for the emission estimates and following PEC/PNEC ratios). The effect of this reduction in use on the resulting PEC/PNEC ratios is considered in Appendix C.

3.3.1 Aquatic compartment (including sediment)

3.3.1.1 Water

The PNEC for surface water is 0.5 μg/l and is unlikely to be refined by further testing. The resulting PEC/PNEC ratios are shown in **Table 3.24**.

Table 3.24 Summary of revised PEC/PNEC ratios for surface water

Scenario		$PEC_{local, water}$ (μg/l)	PEC/PNEC
Production sites		<0.040-<0.055 and <0.11-<0.12	<0.080-<0.11 and <0.22-<0.24
Rubber (worst case estimate)	Compounding site (formulation)	0.11-0.20	0.22-0.40
	Conversion site (processing)	0.046-0.31	0.092-0.62
	Combined compounding/ conversion site	0.15-0.48	0.30-0.96
Rubber (alternate estimate)		0.023-0.039	0.046-0.078
Textiles	Compounding site (formulation)	1.5	**3**
	Backcoating site (processing)	2.0-2.7	**4.00-5.40**
Sealants/adhesives formulation and use		Negligible	<1
Paints and coatings	Formulation site	Negligible	<1
	Industrial application of paints (processing)	0.071-0.23	0.14-0.46 mg/kg wet wt.
Regional sources		$PEC_{regional, water}$ = 0.012-0.027	0.024-0.054

The worst case PEC/PNEC ratios indicate that the risk to surface water is low from production, rubber compounding and conversion, formulation and use in sealants, formulation and use in paints and coatings and regional sources.

For textiles the worst case calculations indicate a potential risk to the aquatic compartment from both formulation of backcoatings and application to textiles. It may be possible to refine the PECs for this endpoint by obtaining more specific information related to the actual emissions of short-chain chlorinated paraffins from backcoating formulation and textile backcoating processes. Despite a legal requirement to supply such data for several life cycle stages under European Commission Regulation (EC) No 642/2005 [Official Journal of the European Union L 107 28.4.2005], Industry has indicated that it is unable to comply (Euro Chlor, 2005). This is due to both a diminishing number of users and analytical difficulties in detecting low concentrations of short-chain chlorinated paraffins in effluent and environmental samples. Consequently, the PEC estimates cannot be refined further and so are considered to be the best that are achievable based on present knowledge.

In addition, a small amount of short-chain chlorinated paraffins may be applied to textiles by impregnation. This process may have the potential to release short-chain chlorinated paraffins to surface water at a local site.

Result

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

The local risk to surface water from production, compounding and conversion of rubber, formulation and use of sealants, and formulation and use of paints and coatings appears to be low due to limited release. The risk to surface water at the regional level is also low.

Conclusion (iii) There is a need for limiting the risks; risk reduction measures which are already being applied shall be taken into account.

This applies to the local assessment for the formulation of backcoatings and application of backcoatings to textiles.

3.3.1.2 Sediment

The PNEC for sediment is 2.17 mg/kg wet weight. This value is derived using the equilibrium partitioning approach. According to the Technical Guidance Document the PEC/PNEC ratios obtained using this value should be increased by a factor of 10 to take into account the possibility of direct ingestion of sediment-bound substance. However, there is evidence from experiments with medium-chain chlorinated paraffins that this factor of 10 is overprotective for chlorinated paraffins and so it is not used here for short-chain chlorinated paraffins. The resulting PEC/PNEC ratios based on the PNEC of 2.17 mg/kg wet weight are shown in **Table 3.25**.

The PEC/PNEC ratios are above 1 for the worst case scenarios considered for the formulation of backcoatings and application of backcoatings to textiles. It should however be noted that if the PEC/PNEC ratios are increased by a factor of 10 (as has been suggested by some EU member states - see Section 3.2.1.6), a possible risk would be identified from most of the local sources (but not from regional sources). In addition, elevated levels of short-chain chlorinated paraffins have been measured at several locations in the United Kingdom (see Section 3.1.1.2.2). Although the actual concentration of short-chain chlorinated paraffins in these samples is somewhat uncertain, it is possible that the PNEC may have been exceeded in some cases. The samples were taken from localities where chlorinated paraffins were expected to be used.

As discussed in Section 3.3.1.1, it appears unlikely that further exposure information will become available to enable the PECs for formulation of backcoatings and application of backcoatings to be refined. However, it may be possible to revise the PNEC for sediment by carrying long-term sediment organism toxicity testing.

Table 3.25 Summary of revised PEC/PNEC ratios for sediment

Scenario		$PEC_{local, sediment}$ (mg/kg wet wt.)	PEC/PNEC ratio
Production sites		<0.17-<0.24 and <0.50-<0.54	<0.078-<0.11 and <0.23-<0.25
Rubber (worst case estimate)	Compounding site (formulation)	0.50-0.89	0.23-0.41
	Conversion site (processing)	0.20-1.36	0.092-0.63
	Combined compounding/conversion site	0.64-2.09	0.29-0.96
Rubber (alternate estimate)		0.10-0.17	0.046-0.078
Textiles	Compounding site (formulation)	6.5-6.6	**3.0**
	Backcoating site (processing)	8.84-11.8	**4.1-5.4**
Sealants/adhesives formulation and use		Negligible	<1
Paints and coatings	Formulation site	Negligible	Negligible
	Industrial application of paints (processing)	0.31-1.00	0.14-0.46
Regional sources		$PEC_{regional, sediment}$ = 0.090-0.21	0.041-0.097

Result

Conclusion (i) There is a need for further information and/or testing.

The current PEC/PNEC ratios for formulation of backcoatings and application of backcoatings to textiles are above 1. Refinement of the PECs for these scenarios is considered unlikely (see Section 3.3.1.1), but long-term sediment organism toxicity testing could be performed to remove any remaining uncertainty in the PNEC (a more conservative interpretation of the current data would indicate a possible risk for most of the local scenarios). However, given that a risk has already been identified for surface water from these uses, together with the findings for other end-points (e.g. secondary poisoning and the marine PBT assessment), it is not recommended that this is pursued further at this stage.

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

The local risk to the sediment compartment from production, compounding and conversion of rubber, formulation and use of sealants and formulation and use of paints and coatings appears to be low due to limited release. The risk at the regional level also appears to be low.

3.3.1.3 Waste water treatment processes

A PNEC of 6 mg/l has been estimated for wastewater treatment microorganisms. The concentrations of short-chain chlorinated paraffins predicted in effluents from wastewater treatment microorganisms are in the range 1.5×10^{-4} to 0.035 mg/l for all scenarios considered in this assessment. The PEC/PNEC ratios are therefore all below one for this endpoint.

Result

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

The risk to wastewater treatment processes is low.

3.3.2 Terrestrial compartment

The PNEC for the terrestrial compartment is 1.76 mg/kg wet weight. This value is derived using the equilibrium partitioning approach. According to the Technical Guidance Document the PEC/PNEC ratios obtained using this value should be increased by a factor of 10 to take into account the possibility of direct ingestion of soil-bound substance. However, there is evidence from experiments with medium-chain chlorinated paraffins that this factor of 10 is overprotective for chlorinated paraffins and so it is not used here for short-chain chlorinated paraffins. The resulting PEC/PNEC ratios based on the PNEC of 1.76 mg/kg wet weight are shown in **Table 3.26**.

Table 3.26 Summary of revised PEC/PNEC ratios for soil

Scenario		**PEC_{soil} (agricultural soil) (mg/kg wet wt.)**	**PEC/PNEC ratio**
Production sites		Negligible[a]	<1
Rubber (worst case estimate)	Compounding site (formulation)	0.62-1.03	0.35-0.59
	Conversion site (processing)	0.21-1.73	0.12-0.98[c]
	Combined compounding/ conversion site	0.82-2.76	0.47-**1.57**
Rubber (alternate estimate)		0.071	0.040
Textiles	Compounding site (formulation)	8.97	**5.10**
	Backcoating site (processing)	12.2-17.2	**6.93-9.77**
Sealants/adhesives formulation and use		Negligible	<1
Paints and coatings	Formulation site	Negligible	<1
	Industrial application of paints (processing)	0.36-1.23	0.20-0.70
Regional sources		Agricultural soil – 0.088[b] Natural soil – 0.0011-0.0025 Industrial/urban soil – 1.53-3.04	0.05[b] 0.0006-0.0014 0.87-**1.73**[d]

a) Sludge from the treatment plant is not applied to soil.
b) Regional agricultural soil concentration based on the available measured data. PEC/PNEC ratios <1 are also obtained based on the predicted regional concentrations in agricultural soil.
c) The PEC/PNEC ratios are based on calculations using EUSES 1.0. If EUSES 2.0.1 is used the resulting PEC/PNEC ratio would be 0.13-1.03, indicating a possible risk from this scenario.
d) The PEC/PNEC ratios are based on calculations using EUSES 1.0. If EUSES 2.0.1 is used the resulting PEC/PNEC ratios would be 0.44-0.89, indicating no risk from this scenario.

The major source of short-chain chlorinated paraffins in agricultural soil is predicted to be the application of sewage sludge containing the short-chain chlorinated paraffins. The local risks to the terrestrial compartment from production, formulation and use in sealants, and formulation and application of paints are small. At the regional level, the risk to agricultural

soil appears to be low based on the available measured and predicted data. The concentration in natural soil is also predicted to be below the PNEC (atmospheric deposition is the predominant route of exposure for the natural soil compartment).

The PEC/PNEC ratios are greater than 1 for the worst-case scenarios considered for the combined compounding and conversion of rubber (and also possibly conversion of rubber alone based on the EUSES 2.0.1 calculation) and formulation and application of backcoating for textiles. It should, however, be noted that if the PEC/PNEC ratios are increased by a factor of 10 (as suggested by some EU member states - see Section 3.2.2), a possible risk would be identified from most local sources. It would be possible to refine the PNEC for soil by carrying out further long-term toxicity testing.

Recent data from the United Kingdom have shown that short-chain chlorinated paraffins are widely found at levels in the range 10-200 mg/kg dry weight in digested sewage sludge. Although the sources of chlorinated paraffin emissions related to these samples are unknown (i.e. it is not clear if they are representative of background/regional or local concentrations), they do provide an indication of the likely concentration of short-chain chlorinated paraffins in sewage sludge. Application of this sludge to agricultural land is likely to be a significant route of exposure for the terrestrial environment to short-chain chlorinated paraffins. For example, the approximate soil concentration resulting after 10 years of continuous application of this sludge to soil would be around 0.14-2.8 mg/kg wet weight, which would give approximate PEC/PNEC ratios of 0.080-1.59.

The worst-case regional concentration predicted for industrial/urban soil leads to a PEC/PNEC ratio above 1 based on the EUSES 1.0 calculation (using EUSES 2.0.1 the maximum PEC/PNEC ratio would be 0.89). The major source of short-chain chlorinated paraffin in this type of soil is predicted to come from the "waste remaining in the environment" over the lifetime of products containing short-chain chlorinated paraffins, and also from their disposal. The methods used to estimate these emissions are relatively crude and have a high uncertainty but, nevertheless, they suggest that a potential risk to the environment may arise from the use of products containing short-chain chlorinated paraffins at a regional level. The uncertainties in the calculation mean that it is difficult to draw a definitive conclusion for this endpoint.

A large area of uncertainty in the predicted concentrations in the soil compartment, particularly at the regional level, results from the default biodegradation rate used in the EUSES model. For substances that are not classified as readily or inherently degradable, the default half-life for biodegradation is of the order of 1×10^6 days (2,740 years). This degradation rate may underestimate the actual degradation of short-chain chlorinated paraffins in soil (although the substances are not classified as either readily or inherently biodegradable, there are other experimental data that indicate that they may biodegrade under certain conditions, and a mineralisation half-life of around 1,630 days (4.5 years) has been determined for a 65% wt. Cl short-chain chlorinated paraffin in freshwater sediment). Therefore, it may be possible to refine the PECs for, in particular, the regional compartment by carrying out further testing in order to identify a reliable rate of mineralization for short-chain chlorinated paraffins in soil.

In addition, there is potential to refine the PECs by obtaining more specific information related to the actual emissions of short-chain chlorinated paraffins from these processes. Particular areas could include the following:

- information on actual releases from the compounding and conversion of rubber;

- information on releases from backcoating formulation sites and textile backcoating sites; and
- information on releases from products during their use and disposal.

However, despite a legal requirement to supply such data under European Commission Regulation (EC) No 642/2005 [Official Journal of the European Union L 107 28.4.2005], Industry has indicated that it is unable to comply (Euro Chlor, 2005). This is due to both a diminishing number of users and analytical difficulties in detecting low concentrations of short-chain chlorinated paraffins in effluent and environmental samples. Consequently, the PEC estimates cannot be refined further and so are considered to be the best that are achievable based on present knowledge.

Although there are some uncertainties in the calculated PECs for the terrestrial compartment, it is clear (based on measured levels in sludge) that there is potential for significant exposure of the terrestrial compartment to short-chain chlorinated paraffins from the application of sewage sludge and, possibly, from "waste remaining in the environment".

Result

Conclusion (i) There is a need for further information and/or testing.

The current PEC/PNEC ratios for compounding and conversion in rubber, formulation of backcoatings and application of backcoatings to textiles are above 1. Refinement of the PECs for these scenarios is considered unlikely, but long-term soil organism toxicity testing could be performed to remove any remaining uncertainty in the PNEC (a more conservative interpretation of the current data would indicate a possible risk for most of the local scenarios). In addition, consideration could be given to carrying out further soil biodegradation testing of short-chain chlorinated paraffins. However, given the findings for other end-points (e.g. secondary poisoning and the marine PBT assessment), it is not recommended that this is pursued further at this stage. The actual level of risk to the regional industrial/urban soil compartment from "waste remaining in the environment" is unclear at present.

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

The local risk to the terrestrial compartment from production, formulation and use of sealants and formulation and use of paints appears to be low. The risk at the regional level also appears to be low for agricultural soil.

3.3.3 Atmosphere

It is not possible to derive a PNEC for the atmospheric compartment, due to lack of suitable effects data. Although direct emissions of short-chain chlorinated paraffins to the air from local sources are predicted to be relatively low, volatilisation to air from products over extended time periods is expected to occur. The predicted concentrations are, however, all very low and reflect the small but measurable volatility of this group of substances. Therefore, neither biotic nor abiotic effects are likely because of low concentrations predicted and measured.

Result

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

This conclusion applies to production and all uses. Short-chain chlorinated paraffins have been raised as a concern with regard to long-range atmospheric transport under persistent organic pollutant (POP) conventions (see Section 2.3 and Section 3.3.5).

3.3.4 Secondary poisoning

The PNEC for secondary poisoning is 5.5 mg/kg food. The resulting PEC/PNEC ratios for secondary poisoning are shown in **Table 3.27**.

The risks of secondary poisoning via the fish and earthworm food chains from production, from the formulation and use of short-chain chlorinated paraffins in sealants, and also formulation of paints, appear to be low due to limited release. For the other uses of short-chain chlorinated paraffins, a risk of secondary poisoning is identified, mainly for the earthworm food chain. When the possible uptake and accumulation in mussels is considered, several scenarios lead to PEC/PNEC ratios above 1.

Measurements indicate that the substance is widely distributed in the environment, and it has been detected in sewage sludge, the Arctic, human breast milk and marine predators such as Beluga whales and seals. The trends in levels are unknown, and they may be due (in part at least) to local sources, uses that take place in other regions, or uses that have recently been banned in the EU. It is therefore possible that levels may decrease if the current level of emission does not increase. Although the levels do not necessarily suggest that predators are at risk, the combined potential for persistence and bioaccumulation mean that these findings remain a concern. This is considered further in the marine risk assessment (see Section 3.3.5).

It should be noted that the PEC is calculated assuming half of the dose comes from local sources and half from regional sources (in accordance with the TGD). The fish PECs are generally consistent with measured levels found in the environment. Experimental data (for both short-chain chlorinated paraffins and the analogous medium-chain chlorinated paraffins) also indicate that uptake into worms from soils (or sediments) is a significant process. However, the concentrations in earthworms depend crucially on the predicted concentrations in soil and so are subject to the same uncertainties as for the soil compartment (see Section 3.3.2). The same comments about potential refinement with either further biodegradability testing and/or emissions data therefore apply. Nevertheless, as discussed in Section 3.3.2, the PEC estimates for the rubber and textile industries are considered to be the best that are achievable based on present knowledge. (It is not clear if such considerations would also apply to paint application sites.)

Table 3.27 Summary of revised PEC/PNEC ratios for secondary poisoning

Scenario		PEC[b] (mg/kg)							PEC/PNEC[b]						
		Fish (TGD method)		Fish (alternate method)		Mussel (TGD method)		Earthworms (TGD method)	Fish-based food chain (TGD method)		Fish-based food chain (alternate method)		Mussel-based food chain (TGD method)		Earthworm-based food chain (TGD method)
		BMF = 1	BMF = 2	FAF = 1	FAF = 2	BMF = 1	BMF = 2		BMF = 1	BMF = 2	FAF = 1	FAF = 2	BMF = 1	BMF = 2	
Production sites		0.18-0.52	0.36-1.04	0.36-1.04	0.54-1.56	0.94-2.72	1.88-5.44	Negligible[a]	0.033-0.095	0.065-0.19	0.065-0.19	0.098-0.10	0.17-0.49	0.34-0.99	<1
Rubber (worst case estimate)	Compounding site (formulation)	0.31-0.43	0.62-0.86	0.62-0.86	0.93-1.29	1.62-2.25	3.24-4.50	4.02-6.35	0.056-0.078	0.11-0.16	0.11-0.16	0.17-0.23	0.29-0.41	0.59-0.82	0.73-**1.15**
	Conversion site (processing)	0.16-0.57	0.32-1.14	0.32-1.14	0.48-1.71	0.84-2.98	1.68-5.96	1.66-10.3	0.029-0.10	0.058-0.21	0.058-0.21	0.087-0.31	0.15-0.54	0.31-**1.08**	0.30-**1.87**
	Combined compounding/ conversion site	0.38-0.79	0.76-1.58	0.76-1.58	1.14-2.37	1.99-4.13	3.98-8.26	5.14-16.2	0.069-0.14	0.14-0.29	0.14-0.29	0.21-0.43	0.36-0.75	0.72-**1.50**	0.93-**2.95**
Rubber (alternate estimate)		0.11-0.23	0.22-0.46	0.22-0.46	0.33-0.69	0.58-1.20	1.16-2.40	0.90	0.020-0.042	0.040-0.084	0.040-0.084	0.060-0.13	0.11-0.22	0.21-0.44	0.16
Textiles	Compounding site (formulation)	4.85-4.97	9.70-9.94	9.70-9.94	14.6-14.9	25.4-26.0	50.8-52.0	51.4	0.88-0.90	**1.76-1.81**	**1.76-1.81**	**2.65-2.71**	**4.62-4.72**	**9.24-9.45**	**9.34**
	Backcoating site (processing)	1.52-2.75	3.04-5.50	3.04-5.50	4.56-8.25	7.95-14.4	15.9-28.8	70.0-98.2	0.28-0.50	0.55-1.0	0.55-1.0	0.83-**1.50**	**1.45-2.62**	**2.89-5.24**	**12.7-17.8**
Sealants/adhesives formulation and use		Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	<1	<1	<1	<1	<1	<1	<1
Paints and coatings	Formulation site	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	<1	<1	<1	<1	<1	<1	<1
	Industrial application of paints (processing)	0.28-0.59	0.56-1.18	0.56-1.17	0.84-1.77	1.47-3.09	2.94-6.18	2.54-7.46	0.051-0.11	0.10-0.21	0.10-0.21	0.15-0.32	0.27-0.56	0.53-**1.12**	0.46-**1.36**

a) Sludge from the treatment plant is not applied to soil.
b) Calculations based on measured regional concentration of 0.088 mg/kg wet wt. for agricultural soil. Similar PEC/PNEC ratios are obtained if the calculations based on the predicted regional concentrations are used.

As discussed in Section 3.1.0.5.2 and 3.1.4.1, there are some uncertainties over the assessment of bioaccumulation/biomagnification for short-chain chlorinated paraffins and it should be recognised that there is a general lack of experience in the application of the methods given in the Technical Guidance Document to address these uncertainties. In particular, it should be noted that the Technical Guidance Document only considers relatively simple food chains and higher levels could be predicted using more complex food chain models (see Section 3.1.4.1; although again there would be some uncertainties associated with the modelled results).

In the case of the terrestrial compartment, although there are some uncertainties in the calculated PECs for earthworms (as mentioned above), it is clear that there is potential (based on both measured levels and theoretical calculations) for significant exposure to short-chain chlorinated paraffins at a regional level from the application of sewage sludge and from "waste remaining in the environment".

Result

Conclusion (i) There is a need for further information and/or testing.

Potential secondary poisoning risks via earthworm-based food chains are identified for several uses. Consideration could be given to carrying out further biodegradation testing in soil to refine the PECs. However, given the findings for other end-points (e.g. the marine PBT assessment), and the fact that all but one of these uses (rubber compounding) also lead to aquatic food chain risks, it is not recommended that this is pursued further at this stage.

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

The risk of secondary poisoning from production, formulation and use of sealants, and also formulation of paints, appears to be low due to limited release.

Conclusion (iii) There is a need for limiting the risks; risk reduction measures which are already being applied shall be taken into account.

This applies risks of secondary poisoning via aquatic food chains from conversion and combined conversion/compounding of rubber, formulation and processing of textile backcoatings, and industrial application of paints/coatings.

3.3.5 Marine risk assessment

3.3.5.1 Risk characterisation for the marine environment

The provisional risk characterisation ratios for water, sediment and predators/top-predators are shown in **Table 3.28**. The risk characterisation ratios indicate there is a potential risk from all uses of short-chain chlorinated paraffins (except formulation and use in sealants and formulation of paints), but not production.

3.3.5.2 PBT assessment

The final part of the marine risk assessment procedure requires a screening of the properties of a substance to see if it should be considered as a persistent (P), bioaccumulative (B) and toxic (T) substance.

3.3.5.2.1 Persistence

A substance is considered to be persistent (P) or very persistent (vP) if it has a half-life >40 days in freshwater (P), or >60 days in marine water (vP), or >120 days in freshwater sediment (P) or >180 days in marine or freshwater sediment (vP).

The results of a biodegradation simulation study with both freshwater and marine sediment are available. Two substances were tested, a C_{10}, 65% wt. Cl substance and a C_{13}, 65% wt. Cl substance. Full details of the studies are given in Section 3.1.1.4.2. Under aerobic conditions the mineralisation half-life was determined to be around 1,340 days for the C_{10}, 65% wt. Cl substance in freshwater sediment, 335 days for the C_{10}, 65% wt. Cl substance in marine sediment, 1,790 days for the C_{13}, 65% wt. Cl substance in freshwater sediment and 680 days for the C_{13}, 65% wt. Cl substance in marine sediment. The mean half-live (average of the two substances, this could be assumed to be representative of a $C_{10\text{-}13}$, 65% wt. Cl product) was determined to be around 1,630 days in freshwater and 450 days in marine sediment.

No information is available with which to estimate a reliable mineralisation half-life for soil or surface water or for short-chain chlorinated paraffins with chlorine contents other than 65% by weight. Based on the available data it is therefore concluded that short-chain chlorinated paraffins meet the criteria for a vP substance.

Table 3.28 Provisional risk characterisation ratios for the marine compartment

Scenario	Step	PEC/PNEC ratios							
		Marine water	Marine sediment	Predators[a, b]			Top predators[a, b]		
				Fish		Mussel (TGD method)	Fish		Mussel
				TGD method	Alternate method		TGD method	Alternate method	
Production		<0.049-<0.072	<0.049-<0.072	<0.009-<0.015	<0.013-<0.022	<0.044-<0.078	<0.011-<0.024	<0.025-<0.058	<0.059-<0.12
Rubber (worst case estimate)	Compounding site (formulation)	**1.4-2.4**	**1.4-2.4**	0.11-0.12	0.17-0.19	0.59-0.64	0.055-0.069	0.12-0.16	0.28-0.36
	Conversion site (processing)	0.50-**4.1**	0.51-**4.1**	0.042-0.19	0.055-0.29	0.22-0.99	0.025-0.095	0.056-0.21	0.13-0.49
	Combined compounding/ conversion site	**1.9-6.5**	**1.9-6.6**	0.14-0.30	0.22-0.46	0.75-**1.58**	0.065-0.14	0.15-0.31	0.34-0.72
Rubber (alternate estimate)		0.18-0.20	0.18-0.20	0.012-0.018	0.018-0.027	0.063-0.095	0.013—0.025	0.029-0.058	0.066-0.13
Sealants/adhesives formulation and use		<1	<1	<1	<1	<1	<1	<1	<1
Textiles	Compounding site (formulation)	**21.2**	**21.4**	**2.47**	**3.71**	**12.9**	1.0	**2.2-2.3**	**5.2**
	Backcoating site (processing)	**28.8-38.5**	**29.1-38.8**	0.74-**1.3**	**1.1-2.0**	**3.9-6.8**	0.31-0.54	0.69-**1.2**	**1.6-2.8**
Paints and coatings	Formulation site	<1	<1	<1	<1	<1	<1	<1	<1
	Industrial application of paints (processing)	0.87-**2.9**	0.88-**2.9**	0.11-0.21	0.16-0.31	0.55-**1.1**	0.051-0.080	0.11-0.18	0.26-0.42
Regional sources		0.017-0.040	0.035-0.079						

a) The PEC/PNEC ratios of predators and top predators have both been calculated using the available BCF data for fish and mussels.
b) The ratios are estimated for the calculations assuming a BMF/FAF of 2.

- A reference substance (aniline) was tested using the same system at a concentration of 50 mg C/l. The degradation seen with this substance was 98.8% after 28 days based on total organic carbon measurements and 72% after 28 days based on CO_2 evolution.

In summary, efforts were made to maximise the availability of the test substance to the microorganisms, and the degradation has been followed by an appropriate method. The method seems as valid a way to conduct an inherent degradability test with a poorly soluble substance as could reasonably be expected. Despite the technical uncertainties with the interpretation of the result, a simulation test would still be needed to determine whether sufficiently rapid degradation can take place at concentrations at or below the water solubility of the substance.

3.3.5.2.2 Bioaccumulation

A substance is considered to be bioaccumulative (B) if it has a bioconcentration factor (BCF) >2,000 l/kg or very bioaccumulative (vB) if it has a BCF >5,000 l/kg. The highest measured BCF value for (freshwater) fish with short chain chlorinated paraffins is around 7,816 l/kg (see Section 3.1.0.5). This value was based on ^{14}C measurements (and so may represent accumulation of metabolites as well as short-chain chlorinated paraffins), but a similar value of 7,273 l/kg was determined in the same study based on parent compound analysis. There are several other fish bioconcentration factors (of variable reliability) below this value (but some of which are above the 2,000 l/kg cut-off). Some data are also available for marine fish. A BCF value of 800-1,000 l/kg has been measured for a brackish water species (*Alburnus alburnus*) but here the exposure period was relatively short (14 days) and it is not clear if steady state was reached in this time. In addition, BCF values in the range 5,785-40,900 l/kg have been determined for a marine mollusc (*Mytilis edulis*) (although this might not represent a true BCF due to possible ingestion of the substance adsorbed to particles). Therefore, the available BCF data indicate that short-chain chlorinated paraffins do meet the very bioaccumulative (vB) criterion.

3.3.5.2.3 Toxicity

A substance is considered to be toxic if it has a chronic NOEC <0.01 mg/l. The lowest NOEC for short-chain chlorinated paraffins is 0.005 mg/l for *Daphnia magna.* In addition effects on growth in marine mussels (*Mytilus edulis*) have been seen at a concentration of 0.0093 mg/l. Therefore it can be concluded that short-chain chlorinated paraffins meet the toxicity criterion.

3.3.5.2.4 Other considerations

The Stockholm Convention on Persistent Organic Pollutants (POPs) is a global treaty to protect human health and the environment (see also Section 2.3). The screening criteria for consideration of a chemical as a POP are given in Annex D of the convention text. In line with the discussion in the preceding paragraphs and together with monitored levels in marine predators and the remote Arctic, and suggestions of long-range transport, short-chain chlorinated paraffins would appear to meet these screening criteria. Short-chain chlorinated paraffins are also being considered as a potential new candidate for inclusion under the 1998

Protocol to the UNCECE Convention on Long-range Transboundary Air Pollution on Persistent Organic Pollutants, which is concerned with emissions to air.

3.3.5.2.5 Potential sources and pathways to the marine environment

As well as the local sources of release associated with production and use considered in **Table 3.21**, short-chain chlorinated paraffins can be emitted to air (due to volatilisation) and water (due to leaching) from products over extended periods of time (i.e. over the lifetime of the product). The estimation of all of these releases is described in Section 3.1.0.2.6, and they are subject to uncertainties. Although it is not possible to quantify how much of these releases will enter the marine environment, it is considered that both the local emissions and diffuse emissions provide potential pathways into the marine environment. For example, leaching losses could eventually end up in surface water that enters the marine environment and volatile losses could be transported to marine environments and subsequently rained out to marine waters.

3.3.5.3 Conclusions for the marine environment

The conclusion of the PBT assessment is that the substance is confirmed as meeting the criteria for very persistent (vP), very bioaccumulative (vB) and toxic (T). This implies that short-chain chlorinated paraffins have the potential to pollute marine (as well as other remote) environments. It should be noted that the substance has already been detected in the remote Arctic and in marine biota (including top predators such as seals and whales). The trends in levels are unknown, and they may be due (in part at least) to a local source or uses that take place in other regions, or uses that are now controlled in the EU. It is therefore possible that levels may decrease if the current level of emission does not increase. However, the possibility of long range transport can not be excluded.

The provisional risk characterisation for the local marine environment indicates that there are concerns based on traditional PEC/PNEC ratios for the current uses of the substance (but not production, use in sealants or for formulation of paints). The PECs have the same basis as those for the freshwater risk assessment and so are subject to the same uncertainties and data gaps as those estimates. The PNEC for marine sediments could be revised if sediment organism toxicity tests were performed. In addition, the PNEC for marine water could be revised if toxicity data on a further marine taxonomic group were provided.

Result

Conclusion (i) There is a need for further information and/or testing.

A potential risk for marine water and sediment is identified based on worst case emission estimates for rubber (conversion, compounding and combined sites), formulation and processing of textile backcoatings, and industrial application of paints/coatings. Additional toxicity data would allow the PNEC for both marine water and sediment to be revised, although the only uses for which there is not also a risk for secondary poisoning are rubber formulation and rubber processing. Given concerns over the PBT properties as well, it is not recommended that toxicity testing be pursued.

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

No marine risks are identified for production, rubber (alternative estimate), paint/coating formulation, sealant/adhesive formulation and use, or at the regional level on the basis of PEC/PNEC ratios.

Conclusion (iii) There is a need for limiting the risks; risk reduction measures which are already being applied shall be taken into account.

The substance is confirmed as meeting the criteria for a PBT substance (it is vP, vB and T).

This conclusion also applies to the marine secondary poisoning assessment for combined compounding and conversion of rubber, formulation and processing of textile backcoatings, and industrial application of paints/coatings.

3.3.6 Areas of uncertainty in the environmental risk assessment

As with any "generic" risk assessment there are uncertainties inherent in the approach taken. For short-chain chlorinated paraffins these uncertainties are compounded by the fact that the substance is a complex mixture and is difficult to test in many of the standard assays. This means that derivation of the physico-chemical properties and other data necessary for the environmental modelling is difficult. In this assessment, a set of data that is considered to be representative of the substance has been chosen. However, there are still some areas where reliable information is lacking.

One area where this is particularly apparent is in the actual degradation/removal rate in the environment. This is a vital input into the regional (and to a lesser extent) local concentrations, and has a major impact on the predicted concentrations in soil.

Another area of uncertainty is over the actual emission estimates. For most of the scenarios considered, the best information available to the specific industries has been used in preference to the default values. However, in many cases, this information was not generated for short-chain chlorinated paraffins but has been extrapolated from other substances. This introduces uncertainties into the estimates.

Another area where information is lacking is in the assessment of the "waste remaining in the environment" (essentially polymer particulates containing the substance). Here, there are no agreed methodologies available in the Technical Guidance Document for estimating PECs for this type of release. There are also uncertainties associated with the actual (bio)availability and environmental behaviour of the substance when released in this form.

There is also a possibility of natural organohalogens or other substances interfering with analytical measurement of environmental concentrations. It should be stressed that analysis of chlorinated paraffins itself is very difficult. The individual chlorinated paraffin peaks do not separate cleanly during the chromatographic process and essentially a broad 'hand-shaped' peak is obtained over quite a wide retention time window. Any other compound, whether naturally occurring or not, that goes through the clean up method in a similar way to the chlorinated paraffin (the clean up method used is usually designed to remove some of the more common organohalogen pollutants such as dioxins, furans, PCBs, etc.) and has a similar chromatographic retention time could cause interference. The susceptibility of the analysis to

this type of interference will depend, to some extent, on the specificity of the detection method used.

If chlorinated paraffins are naturally produced that are identical to the anthropogenic ones then they would of course interfere in any analysis. It is possible that some complex natural organohalogen compounds could also interfere with the analysis, although there is no evidence that this occurs in practice. It is impossible to say categorically that naturally occurring chlorinated paraffins do not exist, although if there is any significant source it is most likely to be found in the marine environment. It is highly unlikely that the concentrations measured in, for example, sediment close to sites of production/use are natural rather than anthropogenic.

In any case, the environmental risk assessment conclusions are based on the calculated PECs based on the industrial use and release of chlorinated paraffins. A natural source would only add to the background (regional) levels. The monitoring data in the assessment have been used to support the PECs, but a risk would still be identified even if the monitoring data did not exist. In other words, even if short-chain chlorinated paraffins occur naturally there is still a risk from the use of the anthropogenic substance.

A further area of uncertainty is over the need to apply an extra factor of 10 to the PEC/PNEC ratios for sediment and soil. At present the extra factor is not applied but some EU member states have argued that it should be applied (see Section 3.2.1.6 and 3.2.2) to take account of the uncertainties in the read-across of the data from medium-chain chlorinated paraffins to short-chain chlorinated paraffins, and to take into account uncertainties in the data available for medium-chain chlorinated paraffins.

There are also uncertainties in the assessment of secondary poisoning resulting from the applicability of methods outlined in the Technical Guidance Document to take account of the available data on uptake from food. There is a general lack of experience in the application of the methods given in the Technical Guidance Document to address these uncertainties.

4 HUMAN HEALTH

4.1.1 RISK CHARACTERISATION

4.1.1.1 Humans exposed indirectly via the environment

4.1.1.1.1 Infants exposed via milk

A severe effect (internal haemorrhaging leading to deaths) has been observed in suckling rat pups from dams treated with medium-chain length chlorinated paraffins or MCCPs (for more details see the draft MCCPs human health risk assessment report R331_0405_hh).

Except for two classical teratology studies, no other data are available on the reproductive toxicity of SCCPs. Given the similarity of SCCPs to MCCPs in terms of chemical structure, physico-chemical properties and general toxicological profile, and the fact that human surveys indicate that SCCPs are present in breast milk (see section 3.1.4.2.2), a prudent option might be to assume that the effects via lactation seen with MCCPs would also occur with SCCPs.

However, read-across of this effect from MCCPs to SCCPs was discussed by the EU classification and labelling group at its meeting in September 2004. It was agreed that, in view of remaining uncertainties in the mechanisms of toxicity of these chlorinated paraffins, read-across was not justified. This leaves a potential data gap for SCCPs in relation to this endpoint. However, even if a study were conducted, the end-result would not be, at least in qualitative terms, any worse than taking the precautionary view that the haemorrhaging effects in lactating pups caused by MCCPs would also be produced by SCCPs. Hence, the Rapporteur does not support conclusion (i) for this endpoint, but would rather advocate using the MCCPs data to characterise the risks of internal haemorrhages occurring in an infant population exposed to SCCPs via breast or cow's milk. The only limitation of this approach is that the calculated risks might represent an underestimate of the actual risks if SCCPs were to be shown to be more potent than MCCPs for this effect.

Infants exposed via human breast milk

Of the studies available on levels of SCCPs in breast milk, the most recent one, Thomas et al. (2003) is a very well conducted survey. Hence, the 95th percentile level of 680 μg/kg fat identified from this study will be used in the risk characterisation for comparison with the lowest level of MCCPs in dam breast milk (504 mg/kg milk) causing haemorrhaging effects in the suckling pup. As for MCCPs, the SCCPs intake of an infant and a rat pup is then calculated. Comparing these two estimates of intake, there is a difference of 4 orders of magnitude (MOE = 30,000) between the levels of MCCPs producing haemorrhaging effects in pups and human infant breast milk SCCPs exposure. Even if SCCPs were an order of magnitude more potent than MCCPs, the MOE for SCCPs would be 3,000. Such large Margins of Exposure (MOEs) are deemed to be of no concern, especially if it is considered that the calculation of these MOEs was based on a very conservative approach (the 95th percentile value for SCCPs levels in human breast milk and the lowest concentration of MCCPs in animals causing haemorrhages). In addition, given that the risk reduction programme currently required for the environment should lead to reductions in point source

and diffuse environmental emissions and hence to a marked downward trend in SCCPs exposure, higher risks than those estimated using the MCCPs data are not expected to occur. Further reassurance should also be provided by the monitoring programme of MCCPs and SCCPs levels in breast milk, that industry has volunteered to take forward in order to check future trends. Conclusion (ii) is therefore reached for this scenario.

Infants exposed via cow's milk

Greenpeace (1995) reported levels of total chlorinated paraffins in cow's milk to be 74 μg/kg fat. The actual content of SCCPs can be deduced to be 21% of the total chlorinated paraffins content, i.e. 16 μg/kg fat. Thomas and Jones (2002) also determined the levels of SCCPs in a single sample of cow's milk from Lancaster and single butter samples from various regions of Europe (Denmark, Wales, Normandy, Bavaria, Ireland, and Southern and Northern Italy). SCCPs were not detected in the cow's milk sample (detection limit <1.2 μg/kg fat) but were found in the butter samples from Denmark at 1.2 μg/kg fat and Ireland at 2.7 μg/kg fat. The detection limit for the other butter samples ranged between 0.72 and 1.1 μg/kg fat. Butter is regularly used as a convenient way of obtaining milk-fat samples and therefore the SCCPs levels measured in these butter samples can be considered equivalent to the levels present in cow's milk.

Using the value of 16 μg SCCPs/kg fat as the worst-case estimate, and applying the same assumptions as for infants exposed via breast milk, the infant SCCPs uptake from cow's milk is then calculated. Again, the difference between infant uptake and the lowest MCCPs level producing haemorrhaging effects in pups is 6 orders of magnitude (MOE = 1,300,000). Even if SCCPs were an order of magnitude more potent than MCCPs, the MOE for SCCPs would be 130,000. Such large MOEs are deemed to be of no concern, especially if it is considered that the calculation of these MOEs was based on a very conservative approach (the worst-case estimate for SCCPs levels in cow's milk and the lowest concentration of MCCPs in animals causing haemorrhages). In addition, given that the risk reduction programme currently required for the environment should lead to reductions in point source and diffuse environmental emissions and hence to a marked downward trend in SCCPs exposure, higher risks than those estimated using the MCCPs data are not expected to occur. Conclusion (ii) is therefore reached also for this scenario.

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Appendix A Chloroalkenes (chlorinated olefins)

A.1 Introduction

During the re-evaluation of short-chain chlorinated paraffins, some information has been identified for a related chemical group, the chloroalkenes or chlorinated olefins. The following two CAS numbers appear to be relevant (these are used on the US TSCA Inventory list and the Canadian Domestic Substance List (DSL)).

Alkenes, polymerized, chlorinated	CAS No 68410-99-1 (not on EINECS)
Alkenes, $C_{12\text{-}24}$, chloro	CAS No 68527-02-6 (EINECS no. 271-247-1)

A.2 Production and Use

EuroChlor has confirmed that chlorinated olefins are not manufactured in the EU. The Chlorinated Paraffins Industries Association (CPIA) has similarly confirmed that they are not produced in North America. It should be noted that other manufacturers of chlorinated paraffins are known to exist in Asia. There is no information about whether or not they might produce such compounds. Company specific details have been retrieved from Industry product literature, including Internet websites (where available). Further details are provided in a confidential annex. This can be made available to regulatory authorities on request.

One company formerly supplied several chlorinated alpha-olefin products, as well as a range of chlorinated paraffins. However, the company no longer appears to supply either chlorinated alpha-olefin or chlorinated paraffin products.

The products formerly supplied appeared under the trade name CHLOROWAX with the CAS number 68527-02-6, which referred to "Alkenes, C_{12}-C_{24} Chloro". The CAS number 68927-02-6 also appeared on some of the literature for these products but this was probably an error.

The product description did not distinguish between the chlorinated paraffins and chlorinated alpha-olefins in terms of the possible applications, and no details of the actual uses of the chlorinated alpha-olefins were given.

The Material Safety Data Sheet (MSDS) gave chemical formulas for these substances that indicated they may have been of a single carbon chain length, although this was by no means clear. A range of chlorine contents was given. This probably reflected the variation between batches in the chlorination reaction.

Products that were formerly supplied and had similarities with short-chain chlorinated paraffins are shown in **Table A1**. Example formulae were given in the MSDS. These indicate that the products were actually effectively chlorinated alkanes rather than alkenes (formulae for alkenes would require two less hydrogen atoms/molecule) – however, there were several inconsistencies in the MSDS and so this information should be treated with caution. This company appeared to make no clear distinction between its chlorinated alpha-olefin products and its chlorinated paraffin products (they are all sold under the trade name CHLOROWAX, although the alpha-olefin products have AO at the end of the name). This means that there is the possibility that they could be used interchangeably in some or all applications, although reliable information on the actual uses is not available.

Table A1 Former commercial chlorinated alkenes of relevance to short-chain chlorinated paraffins

Trade Name	Carbon chain length	Example formula	Chlorine content
Chlorowax 500AO	C_{12}	$C_{12}H_{20}Cl_6$	57-60%
Chlorowax 45AO	C_{12}	$C_{12}H_{23}Cl_3$	40-43%
Chlorowax 52AO	C_{12}	$C_{12}H_{21}Cl_5$	51.0-53.5%

A3 Possible environmental effects of chlorinated alkenes

Few details are available on how the chlorinated alkenes were made. It is most likely that they were produced in a similar way as the chlorinated paraffins, which is by free radical chlorination.

As olefins contain carbon-carbon double bonds, it is possible that addition of chlorine to this double bond could occur during the chlorination reaction, as well as substitution of chlorine for hydrogen along the alkyl chain. If chlorine addition to the double bond does occur, then the product of the reaction would essentially be a chlorinated paraffin rather than a chlorinated olefin. The available information is a little unclear as to exactly how these chlorination reactions would proceed and hence what the exact products would be. However, mechanistic organic chemistry books indicate that the hydrogen substitution reactions would generally become more favoured over the chlorine addition reaction to the double bond as the temperature is raised. Thus the actual products may be dependent on the reaction conditions used, and so may be a mixture of chlorinated paraffins and chlorinated olefins.

In this respect, several studies included in the respective risk assessment reports for short-, medium and long-chain chlorinated paraffins have used various alkene feedstocks in order to synthesise chlorinated paraffins of known structure by gas-phase free-radical chlorination. The products from these reactions were chlorinated paraffins derived by chlorine addition across the double bond. The properties (water solubility, vapour pressures, accumulation behaviour and toxicity to fish) of these products were in line with those obtained for chlorinated paraffins produced by the chlorination of an alkane feedstock. Again, the properties of these products were found to depend on the carbon chain length and degree of chlorination. This indicates that chlorinated alkenes, if produced in this manner, would be expected to be effectively indistinguishable from chlorinated alkanes in terms of the environmental behaviour and effects.

A4 Summary

One company used to make chlorinated alkene products but now appears to have ceased production. Both EuroChlor and the CPIA have confirmed that there is no European or North American manufacture of chlorinated alkenes. The situation in Asia is unknown. The products formed from the chlorination of alkenes are expected to have a similar environmental hazard profile as the equivalent chlorinated paraffin. Their uses are unknown, but would be expected to be similar to the equivalent chlorinated paraffin as well.

POSTSCRIPT: At least one North American manufacturer supplies a range of chlorinated/brominated alkenes/alkanes as flame retardants. The actual composition of these products is unclear but at least one of the products appears to contain bromochloroparaffin. These products are used in various plastics applications, including PVC, flexible and rigid polyurethane foam and textiles and so could be considered as possible replacements in these applications for the polybrominated diphenyl ethers and chlorinated paraffins. An assessment of these substances has not been performed. However, they would also be expected to have

persistent, bioaccumulative and toxic properties that will vary depending on the carbon chain length and degree of halogenation.

Appendix B Consideration of short-chain chlorinated paraffin impurities present in commercial medium-chain chlorinated paraffin products

The Scientific Committee on Toxicity, Ecotoxicity and the Environment (CSTEE) has recommended[15] that a detailed assessment should be carried out to address the possible risks from the emissions of short-chain chlorinated paraffins as constituents or impurities of other substances and preparations, including medium-chain chlorinated paraffins, in concentrations in the range between 0.3 and 1% in the following applications:

- in metal working;
- for fat liquoring of leather;
- as plasticizers in paints, coatings or sealants; and
- as flame retardants in rubber, plastics or textiles.

This Appendix estimates the PECs and PEC/PNEC ratios for the short-chain chlorinated paraffins present as impurities in medium-chain chlorinated paraffins. The starting point for the analysis is the emission estimates obtained for medium-chain chlorinated paraffins during the assessment of that substance (February 2003 draft). These data are reproduced in **Table B1**, along with the estimated amounts of short-chain chlorinated paraffins that would be present in the emission assuming they are present as an impurity at either 0.3% or 1% by weight in the medium-chain chlorinated paraffin.

The resulting PECs and PEC/PNEC ratios derived for the short-chain chlorinated paraffin impurities are summarised in **Table B2** (assuming a 0.3% content) and **Table B3** (assuming a 1% content). These estimates use the properties, background regional concentrations and PNECs for short-chain chlorinated paraffins outlined in the main risk assessment report. The PECs for secondary poisoning via the fish food chain have been estimated by both the method outline in the Technical Guidance Document and the alternate method explained in the main risk assessment report (the overall results obtained with the two methods are similar).

For the 0.3% short-chain chlorinated paraffin content, the only scenario where a possible risk was identified for the short-chain chlorinated paraffins was for secondary poisoning through the earthworm food chain for the metal cutting/working scenario involving the intermittent discharge to waste water of spent emulsifiable fluids. However, if the extra uncertainty factor of 10 is applied to the PNECs for soil and sediment, this scenario would also lead to a possible risk to sediment and soil and, in addition, a possible risk to sediment and soil would also be identified for use in leather fat liquors. Further testing would be needed to better define the PNECs for soil and sediment in order to determine whether or not an actual risk existed.

When the 1% short-chain chlorinated paraffin content is considered, a possible risk to surface water, sediment, soil and secondary poisoning by the earthworm food chain is identified for the intermediate discharge scenario for emulsifiable metal cutting/working fluids. In addition, if the extra factor of 10 is applied to the PNEC for sediment and soil, a possible risk would also be identified from the formulation of metal cutting/working fluids (sediment only) and the formulation and use in leather fat liquors (both sediment and soil). Again further testing

[15] http://europa.eu.int/comm/health/ph_risk/committees/sct/sct_opinions_en.htm

would be needed to better define the PNECs for sediment and soil in order to determine whether or not an actual risk exists.

No risks are identified from the short-chain chlorinated paraffin content (0.3%-1%) in medium-chain chlorinated paraffins for use in PVC, rubber/plastics other than PVC, sealants and adhesives, paints and varnishes and carbonless copy paper. It should be noted that for many of these scenarios the predicted concentrations are dominated by the contribution from the regional background concentration from the direct use of short-chain chlorinated paraffins themselves.

Based on this analysis, it can be estimated that no risks would be identified in any scenario if the short-chain chlorinated paraffin content was below 0.21% (or 0.04% if the extra uncertainty factor of 10 is applied to the PNEC for soil; this value could be revised if further testing was carried out to refine the PNEC).

N.B. An environmental risk reduction strategy is currently being developed for medium-chain chlorinated paraffins for a number of its uses, including metal working and leather treatment.

Table B1 Summary of environmental release estimates for short-chain chlorinated paraffins (SCCPs) from use of medium-chain chlorinated paraffins (MCCPs)

MCCPs use	Comment		Estimated local release (kg/day)						
			MCCPs (taken from MCCPs risk assessment report)			Equivalent release of SCCPs			
			Waste water	Air	Number of days of release	0.3% content		1% content	
						Waste water	Air	Waste water	Air
Use in PVC – plastisol coating	Compounding site (formulation)		0.025		300	7.5×10^{-5}		2.5×10^{-4}	
	Conversion site (processing)		0.185	0.185	300	5.55×10^{-4}	5.55×10^{-4}	1.85×10^{-3}	1.85×10^{-3}
	Combined compounding and conversion site		0.21	0.185	300	6.3×10^{-4}	5.55×10^{-4}	2.1×10^{-3}	1.85×10^{-3}
Use in PVC – extrusion/other	Compounding site (formulation)	Open system	0.092	0.055	300	2.8×10^{-4}	1.7×10^{-4}	9.2×10^{-4}	5.5×10^{-4}
		Partially open system	0.50	0.3	300	1.5×10^{-3}	9.0×10^{-4}	5.0×10^{-3}	3.0×10^{-3}
		Closed system	0.0425	0.0255	300	1.28×10^{-4}	7.65×10^{-5}	4.25×10^{-4}	2.55×10^{-4}
	Conversion site (processing)	Open system	0.28	0.28	300	8.4×10^{-4}	8.4×10^{-4}	2.8×10^{-3}	2.8×10^{-3}
		Partially open system	0.3	0.3	300	9.0×10^{-4}	9.0×10^{-4}	3.0×10^{-3}	3.0×10^{-3}
		Closed system	0.255	0.255	300	7.65×10^{-4}	7.65×10^{-4}	2.55×10^{-3}	2.55×10^{-3}
	Combined compounding and conversion site	Open system	0.372	0.335	300	1.12×10^{-3}	1.01×10^{-3}	3.72×10^{-3}	3.35×10^{-3}
		Partially open system	0.8	0.6	300	2.4×10^{-3}	1.8×10^{-3}	8.0×10^{-3}	6.0×10^{-3}
		Closed system	0.298	0.281	300	8.94×10^{-4}	8.43×10^{-4}	2.98×10^{-3}	2.81×10^{-3}
Use in rubber/plastics	Compounding site (formulation)		0.0465	0.0155	300	1.40×10^{-4}	4.65×10^{-5}	4.65×10^{-4}	1.55×10^{-4}
	Conversion site (processing)		0.155	0.155	300	4.65×10^{-4}	4.65×10^{-4}	1.55×10^{-3}	1.55×10^{-3}
	Combined compounding and conversion site		0.202	0.171	300	6.06×10^{-4}	5.13×10^{-4}	2.02×10^{-3}	1.71×10^{-3}
Sealants/adhesives	Formulation/use		negligible	negligible		negligible	negligible	negligible	negligible

Table B1 continued overleaf

Table B1 continued Summary of environmental release estimates for short-chain chlorinated paraffins (SCCPs) from use of medium-chain chlorinated paraffins (MCCPs)

MCCPs use	Comment		Estimated local release (kg/day)						
			MCCPs (taken from MCCPs risk assessment report)			Equivalent release of SCCPs			
			Waste water	Air	Number of days of release	0.3% content		1% content	
						Waste water	Air	Waste water	Air
Paints and varnishes	Formulation		0.15	0.05	300	4.5×10^{-4}	1.4×10^{-4}	1.5×10^{-3}	5.0×10^{-4}
	Industrial application of paints (Processing)		0.059		300	1.8×10^{-4}		5.9×10^{-4}	
	Application by general public (private use)		3×10^{-7}		365	9.0×10^{-10}		3.0×10^{-9}	
Metal cutting/working fluids	Formulation		0.83		300	2.5×10^{-3}		8.3×10^{-3}	
	Use in oil based fluids (processing)	Large site	0.33		300	9.9×10^{-4}		3.3×10^{-3}	
		Small site	0.3		300	9.0×10^{-4}		3.0×10^{-3}	
	Use in emulsifiable fluids (processing)	Use at site	0.025		300	7.5×10^{-5}		2.5×10^{-4}	
		Intermittent discharge	25		6	0.075		0.25	
Leather fat liquors	Formulation		1.1	0.35	300	3.3×10^{-3}	1.1×10^{-3}	0.011	3.5×10^{-3}
	Use – complete processing of raw hides		0.9		300	2.7×10^{-3}		9.0×10^{-3}	
	Use – processing of "wet blue"		3.6		300	0.011		0.036	
Carbonless copy paper	Recycling		6.17		250	0.019		0.0617	

Table B2 Summary of PEC/PNEC ratios for short-chain chlorinated paraffins from use of medium-chain chlorinated paraffins assuming a 0.3% short-chain content

MCCPs use	Comment		Surface water[a]		Sediment[a]		Soil[a]		Secondary poisoning[a]					
			PEC (µg/l)	PEC/ PNEC	PEC (mg/kg wet wt.)	PEC/ PNEC	PEC (mg/kg wet wt.)	PEC/ PNEC	Fish food chain				Earthworm food chain	
									TGD Method		Alternate method			
									PEC (mg/kg)	PEC/PNEC	PEC (mg/kg)	PEC/PNEC	PEC (mg/kg)	PEC/PNEC
Use in PVC – plastisol coating	Compounding site (formulation)		0.028	0.056	0.12	0.055	3.7×10^{-3}	2.1×10^{-3}	0.21-0.42	0.038-0.076	0.42-0.63	0.076-0.11	0.52	0.095
	Conversion site (processing)		0.029	0.058	0.13	0.060	0.012	6.8×10^{-3}	0.21-0.42	0.038-0.076	0.42-0.63	0.076-0.11	0.57	0.10
	Combined compounding and conversion site		0.029	0.058	0.13	0.060	0.013	7.4×10^{-3}	0.22-0.44	0.040-0.080	0.44-0.66	0.080-0.12	0.57	0.10
Use in PVC – extrusion/other	Compounding site (formulation)	Open system	0.028	0.056	0.12	0.055	7.1×10^{-3}	4.0×10^{-3}	0.22-0.44	0.040-0.080	0.44-0.66	0.080-0.12	0.54	0.098
		Partially open system	0.031	0.062	0.14	0.065	0.027	0.015	0.23-0.46	0.042-0.084	0.46-0.69	0.084-0.13	0.65	0.12
		Closed system	0.028	0.056	0.12	0.055	4.6×10^{-3}	2.6×10^{-3}	0.21-0.42	0.038-0.076	0.42-0.63	0.076-0.11	0.53	0.096
	Conversion site (processing)	Open system	0.030	0.060	0.13	0.060	0.016	9.1×10^{-3}	0.22-0.44	0.040-0.080	0.44-0.66	0.080-0.12	0.59	0.11
		Partially open system	0.030	0.060	0.13	0.060	0.017	9.7×10^{-3}	0.22-0.44	0.040-0.080	0.44-0.66	0.080-0.12	0.60	0.11
		Closed system	0.029	0.058	0.13	0.060	0.015	8.5×10^{-3}	0.22-0.44	0.040-0.080	0.44-0.66	0.080-0.12	0.59	0.11
	Combined compounding and conversion site	Open system	0.030	0.060	0.13	0.060	0.021	0.012	0.22-0.44	0.040-0.080	0.44-0.66	0.080-0.12	0.62	0.11
		Partially open system	0.034	0.068	0.15	0.069	0.042	0.024	0.23-0.46	0.042-0.084	0.46-0.69	0.084-0.13	0.74	0.13
		Closed system	0.030	0.060	0.13	0.060	0.017	9.7×10^{-3}	0.22-0.44	0.040-0.080	0.44-0.66	0.080-0.12	0.60	0.11

Table B2 continued overleaf

Table B2 continued Summary of PEC/PNEC ratios for short-chain chlorinated paraffins from use of medium-chain chlorinated paraffins assuming a 0.3% short-chain content

MCCPs use	Comment		Surface water[a]		Sediment[a]		Soil[a]		Secondary poisoning[a]					
			PEC (µg/l)	PEC/ PNEC	PEC (mg/kg wet wt.)	PEC/ PNEC	PEC (mg/kg wet wt.)	PEC/ PNEC	Fish food chain				Earthworm food chain	
									TGD Method		Alternate method			
									PEC (mg/kg)	PEC/PNEC	PEC (mg/kg)	PEC/PNEC	PEC (mg/kg)	PEC/PNEC
Use in rubber/plastics	Compounding site (formulation)		0.028	0.056	0.12	0.055	4.8×10^{-3}	2.7×10^{-3}	0.22-0.44	0.040-0.080	0.44-0.66	0.080-0.12	0.53	0.096
	Conversion site (processing)		0.029	0.058	0.12	0.055	0.010	5.7×10^{-3}	0.22-0.44	0.040-0.080	0.44-0.66	0.080-0.12	0.56	0.10
	Combined compounding and conversion site		0.029	0.058	0.13	0.060	0.012	6.8×10^{-3}	0.22-0.44	0.040-0.080	0.44-0.66	0.080-0.12	0.57	0.10
Sealants/ adhesives	Formulation/use		negligible	<1	negligible	<1	negligible	<1	negligible	<1	negligible	<1	negligible	<1
Paints and varnishes	Formulation		0.029	0.058	0.12	0.055	9.9×10^{-3}	5.6×10^{-3}	0.22-0.44	0.040-0.080	0.44-0.66	0.080-0.12	0.56	0.10
	Industrial application of paints (Processing)		0.028	0.056	0.12	0.055	5.5×10^{-3}	3.1×10^{-3}	0.21-0.42	0.038-0.076	0.42-0.63	0.076-0.11	0.53	0.096
	Application by general public (private use)		0.027	0.054	0.12	0.055	2.5×10^{-3}	1.4×10^{-3}	0.21-0.42	0.038-0.076	0.42-0.63	0.076-0.11	0.51	0.093
Metal cutting/working fluids	Formulation		0.034	0.068	0.15	0.069	0.043	0.024	0.24-0.48	0.044-0.087	0.48-0.72	0.087-0.13	0.75	0.14
	Use in oil based fluids (processing)	Large site	0.030	0.060	0.13	0.060	0.019	0.011	0.22-0.44	0.040-0.080	0.44-0.66	0.080-0.12	0.61	0.11
		Small site	0.029	0.058	0.13	0.060	0.017	9.7×10^{-3}	0.22-0.44	0.040-0.080	0.44-0.66	0.080-0.12	0.60	0.11
	Use in emulsifiable fluids (processing)	Use at site	0.028	0.056	0.12	0.055	3.7×10^{-3}	2.1×10^{-3}	0.21-0.42	0.038-0.076	0.42-0.63	0.076-0.11	0.52	0.095
		Intermittent discharge	0.23	0.46	1.0	0.46	1.23	0.70	0.23-0.46	0.042-0.084	0.46-0.69	0.084-0.13	7.46	**1.4**

Table B2 continued overleaf

Table B2 continued Summary of PEC/PNEC ratios for short-chain chlorinated paraffins from use of medium-chain chlorinated paraffins assuming a 0.3% short-chain content

MCCPs use	Comment	Surface water[a]		Sediment[a]		Soil[a]		Secondary poisoning[a]					
		PEC (µg/l)	PEC/ PNEC	PEC (mg/kg wet wt.)	PEC/ PNEC	PEC (mg/kg wet wt.)	PEC/ PNEC	Fish food chain				Earthworm food chain	
								TGD Method		Alternate method			
								PEC (mg/kg)	PEC/PNEC	PEC (mg/kg)	PEC/PNEC	PEC (mg/kg)	PEC/PNEC
Leather fat liquors	Formulation	0.036	0.072	0.16	0.073	0.056	0.032	0.24-0.48	0.044-0.087	0.48-0.72	0.087-0.13	0.82	0.15
	Use – complete processing of raw hides	0.035	0.070	0.15	0.069	0.047	0.027	0.24-0.48	0.044-0.087	0.48-0.72	0.087-0.13	0.76	0.14
	Use – processing of "wet blue"	0.057	0.11	0.25	0.12	0.18	0.10	0.31-0.61	0.056-0.11	0.61-0.92	0.11-0.17	1.53	0.28
Carbonless copy paper	Recycling	0.029	0.058	0.13	0.060	0.011	6.3×10^{-3}	0.22-0.44	0.040-0.080	0.44-0.66	0.080-0.12	0.57	0.10

a) The following values were used in this comparison:

$PEC_{regional,\ water}$ = 0.027 µg/l
$PEC_{regional,\ sediment}$ = 0.21 mg/kg wet wt.
$PEC_{regional,\ agric.\ soil}$ = 0.088 mg/kg wet wt.
$PEC_{regional,\ natural\ soil}$ = 2.5×10^{-3} mg/kg wet wt.
$PEC_{regional,\ air}$ = 1.3×10^{-6} mg/m^3
$BCF_{earthworm}$ = 11.4 kg/kg

$PNEC_{water}$ = 0.5 µg/l
$PNEC_{sediment}$ = 2.17 mg/kg wet wt.
$PNEC_{soil}$ = 1.76 mg/kg wet wt.
$PNEC_{secondary\ poisoning}$ = 5.5 mg/kg food
BCF_{fish} = 7,816 l/kg
BMF = 1-2

Table B3 Summary of PEC/PNEC ratios for short-chain chlorinated paraffins from use of medium-chain chlorinated paraffins assuming a 1% short-chain content

MCCPs use	Comment		Surface water[a]		Sediment[a]		Soil[a]		Secondary poisoning[a]					
			PEC (µg/l)	PEC/ PNEC	PEC (mg/kg wet wt.)	PEC/ PNEC	PEC (mg/kg wet wt.)	PEC/ PNEC	Fish food chain				Earthworm food chain	
									TGD Method		Alternate Method			
									PEC (mg/kg)	PEC/PNEC	PEC (mg/kg)	PEC/PNEC	PEC (mg/kg)	PEC/PNEC
Use in PVC – plastisol coating	Compounding site (formulation)		0.028	0.056	0.12	0.055	6.6×10^{-3}	3.8×10^{-3}	0.22-0.44	0.040-0.080	0.44-0.66	0.080-0.12	0.54	0.098
	Conversion site (processing)		0.032	0.064	0.14	0.065	0.033	0.019	0.23-0.46	0.042-0.084	0.46-0.69	0.084-0.13	0.69	0.13
	Combined compounding and conversion site		0.033	0.066	0.14	0.065	0.037	0.021	0.23-0.46	0.042-0.084	0.46-0.69	0.084-0.13	0.71	0.13
Use in PVC – extrusion/other	Compounding site (formulation)	Open system	0.030	0.060	0.13	0.060	0.018	0.010	0.22-0.44	0.040-0.080	0.44-0.66	0.080-0.12	0.60	0.11
		Partially open system	0.041	0.082	0.18	0.083	0.084	0.048	0.26-0.52	0.047-0.095	0.52-0.78	0.095-0.14	0.98	0.18
		Closed system	0.028	0.056	0.12	0.055	9.5×10^{-3}	5.4×10^{-4}	0.22-0.44	0.040-0.080	0.44-0.66	0.080-0.12	0.55	0.10
	Conversion site (processing)	Open system	0.035	0.070	0.15	0.069	0.048	0.027	0.24-0.48	0.044-0.087	0.48-0.72	0.087-0.13	0.77	0.14
		Partially open system	0.035	0.070	0.15	0.069	0.051	0.029	0.24-0.48	0.044-0.087	0.48-0.72	0.087-0.13	0.79	0.14
		Closed system	0.034	0.068	0.15	0.069	0.044	0.025	0.24-0.48	0.044-0.087	0.48-0.72	0.087-0.13	0.75	0.14
	Combined compounding and conversion site	Open system	0.037	0.074	0.16	0.074	0.063	0.036	0.25-0.50	0.045-0.091	0.50-0.75	0.091-0.14	0.86	0.16
		Partially open system	0.049	0.098	0.21	0.097	0.13	0.074	0.28-0.56	0.051-0.10	0.56-0.90	0.37-0.16	1.26	0.23
		Closed system	0.035	0.070	0.15	0.069	0.051	0.029	0.24-0.48	0.044-0.087	0.48-0.72	0.087-0.13	0.79	0.14

Table B3 continued overleaf

Table B3 continued Summary of PEC/PNEC ratios for short-chain chlorinated paraffins from use of medium-chain chlorinated paraffins assuming a 1% short-chain content

MCCPs use	Comment		Surface water[a]		Sediment[a]		Soil[a]		Secondary poisoning[a]					
			PEC (µg/l)	PEC/ PNEC	PEC (mg/kg wet wt.)	PEC/ PNEC	PEC (mg/kg wet wt.)	PEC/ PNEC	Fish food chain				Earthworm food chain	
									TGD Method		Alternate Method			
									PEC (mg/kg)	PEC/PNEC	PEC (mg/kg)	PEC/PNEC	PEC (mg/kg)	PEC/PNEC
Use in rubber/plastics	Compounding site (formulation)		0.029	0.058	0.12	0.055	0.010	5.7×10^{-3}	0.22-0.44	0.040-0.080	0.44-0.66	0.080-0.12	0.56	0.10
	Conversion site (processing)		0.032	0.064	0.14	0.065	0.028	0.016	0.23-0.46	0.042-0.084	0.46-0.69	0.084-0.13	0.66	0.12
	Combined compounding and conversion site		0.033	0.066	0.14	0.065	0.036	0.020	0.23-0.46	0.042-0.084	0.46-0.69	0.084-0.13	0.70	0.13
Sealants/ adhesives	Formulation/use		negligible	<1	negligible	<1	negligible	<1	negligible	<1	negligible	<1	negligible	<1
Paints and varnishes	Formulation		0.031	0.062	0.14	0.065	0.027	0.015	0.23-0.46	0.042-0.084	0.46-0.69	0.084-0.13	0.65	0.12
	Industrial application of paints (Processing)		0.029	0.058	0.13	0.060	0.012	6.8×10^{-3}	0.21-0.42	0.038-0.076	0.42-0.63	0.076-0.11	0.57	0.10
	Application by general public (private use)		0.027	0.054	0.12	0.055	2.5×10^{-3}	1.4×10^{-3}	0.21-0.42	0.038-0.076	0.42-0.63	0.076-0.11	0.51	0.093
Metal cutting/working fluids	Formulation		0.050	0.10	0.22	0.10	0.14	0.080	0.29-0.58	0.053-0.11	0.58-0.87	0.11-0.16	1.28	0.23
	Use in oil based fluids (processing)	Large site	0.036	0.072	0.16	0.074	0.056	0.032	0.24-0.48	0.044-0.087	0.48-0.72	0.087-0.13	0.82	0.15
		Small site	0.035	0.070	0.15	0.069	0.051	0.029	0.24-0.48	0.044-0.087	0.48-0.72	0.087-0.13	0.79	0.14
	Use in emulsifiable fluids (processing)	Use at site	0.028	0.056	0.12	0.055	6.6×10^{-3}	3.8×10^{-3}	0.22-0.44	0.040-0.080	0.44-0.66	0.080-0.12	0.54	0.098
		Intermittent discharge	0.70	**1.4**	3.04	**1.4**	4.08	**2.3**	0.26-0.52	0.047-0.095	0.52-0.78	0.095-0.14	23.7	**4.3**

Table B3 continued overleaf

Table B3 continued Summary of PEC/PNEC ratios for short-chain chlorinated paraffins from use of medium-chain chlorinated paraffins assuming a 1% short-chain content

MCCPs use	Comment	Surface water[a]		Sediment[a]		Soil[a]		Secondary poisoning[a]					
		PEC (µg/l)	PEC/ PNEC	PEC (mg/kg wet wt.)	PEC/ PNEC	PEC (mg/kg wet wt.)	PEC/ PNEC	Fish food chain				Earthworm food chain	
								TGD Method		Alternate Method			
								PEC (mg/kg)	PEC/PNEC	PEC (mg/kg)	PEC/PNEC	PEC (mg/kg)	PEC/PNEC
Leather fat liquors	Formulation	0.057	0.11	0.25	0.12	0.18	0.10	0.31-0.62	0.056-0.11	0.62-0.93	0.11-0.17	1.53	0.31
	Use – complete processing of raw hides	0.052	0.10	0.22	0.10	0.15	0.085	0.29-0.58	0.053-0.11	0.58-0.87	0.11-0.16	1.35	0.25
	Use – processing of "wet blue"	0.12	0.24	0.54	0.25	0.59	0.34	0.53-0.56	0.096-0.10	0.56-0.84	0.10-0.15	3.85	0.70
Carbonless copy paper	Recycling	0.032	0.064	0.14	0.065	0.031	0.018	0.23-0.46	0.042-0.084	0.46-0.69	0.084-0.13	0.68	0.12

a) The following values were used in this comparison:

$PEC_{regional,\ water}$ = 0.027 µg/l

$PEC_{regional,\ sediment}$ = 0.21 mg/kg wet wt.

$PEC_{regional,\ agric.\ soil}$ = 0.088 mg/kg wet wt.

$PEC_{regional,\ natural\ soil}$ = 2.5×10^{-3} mg/kg wet wt.

$PEC_{regional,\ air}$ = 1.3×10^{-6} mg/m^3

$BCF_{earthworm}$ = 11.4 kg/kg

$PNEC_{water}$ = 0.5 µg/l

$PNEC_{sediment}$ = 2.17 mg/kg wet wt.

$PNEC_{soil}$ = 1.76 mg/kg wet wt.

$PNEC_{secondary\ poisoning}$ = 5.5 mg/kg food

BCF_{fish} = 7,816 l/kg

BMF = 1-2

Appendix C Consideration of more recent consumption figures

C.1 Introduction

The emission estimates and PEC/PNEC ratios outlined in the main part of the risk assessment are all derived based on figures for the consumption of short-chain chlorinated paraffins in 2001 as the base-line year. New information has since been provided by Industry on consumption in 2003 and 2004 (Euro Chlor, 2004 and 2005). The overall EU consumption of short-chain chlorinated paraffins fell below 1,000 tonnes in 2003 and below 600 tonnes in 2004.

In addition, during the development of the risk reduction strategy for medium-chain chlorinated paraffins (Entec, 2004) updated data became available on the current emission controls used within various industries; some of this is also relevant to the risk assessment for short-chain chlorinated paraffins.

This Appendix considers the effects of these new data on the PECs and PEC/PNEC ratios. Most of the calculation methods used are the same as in the main risk assessment. However, these have been modified (where appropriate) to take into account the new data available. The emission calculations are confidential but a separate confidential annex, containing details of the tonnage and calculation methods used, can be made available to regulatory authorities on request.

The total regional emission estimates for 2001, 2003 and 2004 are summarised below.

Emission compartment	**2001 (from main report)**	**2003**	**2004**
Air	299-1,092 kg/year	139-557 kg/year	63-176 kg/year
Waste water	3,732-9,789 kg/year	1,812-4,853 kg/year	751-1,978 kg/year
Surface water	2,021-4,602 kg/year	898-2,196 kg/year	477-957 kg/year
Urban/industrial soil	3,276-6,492 kg/year	1,340-2,960 kg/year	870-1,390 kg/year

C.2 Updated risk characterisation for the aquatic compartment (incl. sediment)

Note: In the following sections the shaded boxes indicate scenarios where a PEC/PNEC ratio >1 was obtained in the main risk assessment, but which would be now <1 based on the 2003 and 2004 data.

Water

The PNEC for surface water is 0.5 μg/l. The resulting PEC/PNEC ratios are shown in **Table C1**.

Table C1 Summary of revised PEC/PNEC ratios for surface water

Scenario		2003 Figures		2004 Figures	
		$PEC_{local, water}$ (μg/l)	PEC/PNEC	$PEC_{local, water}$ (μg/l)	PEC/PNEC
Production sites		<0.016-<0.027	<0.032-<0.054	<0.013-<0.017	0.026
Rubber (worst case estimate)	Compounding site (formulation)	0.11-0.19	0.22-0.38	0.11-0.18	0.22-0.36
	Conversion site (processing)	0.041-0.30	0.082-0.60	0.037-0.29	0.074-0.58
	Combined compounding/ conversion site	0.14-0.47	0.28-0.94	0.14-0.46	0.28-0.92
Rubber (alternate estimate)	Taken from main risk assessment	0.023-0.039	0.046-0.078		
Textiles	Compounding site (formulation)	0.49-0.50	0.98**-1**	0.093-0.097	0.19
	Backcoating site (processing)	2.0-2.7	**4.0-5.4**	2.0-2.7	**4.0-5.4**
Sealants/adhesives formulation and use		Negligible	<1	Negligible	<1
Paints and coatings	Formulation site	Negligible	<1	Negligible	<1
	Industrial application of paints (processing)	0.037-0.22	0.074-0.44	0.044-0.11	0.088-0.14
Regional sources		7.1×10^{-3}-0.018	0.014-0.036	3.7×10^{-3}-7.6×10^{-3}	7.4×10^{-3}-0.015

The overall conclusions obtained using the 2003 data are the same as those in the main risk assessment report. However, based on consumption in 2004 a risk from textile backcoating compounding sites no longer exists owing to the reduction in tonnage in this application that has now occurred. It should be noted, however, that a risk from textile backcoating sites is still predicted based on this lower consumption figure (here the secenario used is based on estimates of the amounts of backcoating that may be emitted from a site per day, which is independent of the total tonnage). Therefore it is concluded that a risk from the application of textile backcoatings still exists based on the 2004 consumption figures.

Sediment

The PNEC for sediment is 2.17 mg/kg wet weight. This value is derived using the equilibrium partitioning approach. According to the Technical Guidance Document the PEC/PNEC ratios obtained using this value should be increased by a factor of 10 to take into account the possibility of direct ingestion of sediment-bound substance. However, there is evidence from experiments with medium-chain chlorinated paraffins that this factor of 10 is overprotective for chlorinated paraffins and so it is not used here for short-chain chlorinated paraffins. The resulting PEC/PNEC ratios based on the PNEC of 2.17 mg/kg wet weight are shown in **Table C2**.

Table C2 Summary of revised PEC/PNEC ratios for sediment

Scenario		2003 Figures		2004 Figures	
		$PEC_{local,\ sediment}$ (mg/kg wet wt.)	**PEC/PNEC ratio**	**$PEC_{local,\ sediment}$ (mg/kg wet wt.)**	**PEC/PNEC ratio**
Production sites		<0.071-<0.12	<0.033-<0.055	<0.056-<0.073	<0.026-<0.034
Rubber (worst case estimate)	Compounding site (formulation)	0.48-0.81	0.22-0.37	0.46-0.77	0.21-0.35
	Conversion site (processing)	0.18-1.32	0.083-0.61	0.16-1.27	0.074-0.59
	Combined compounding/conversion site	0.62-2.05	0.29-0.94	0.60-2.01	0.28-0.93
Rubber (alternate estimate)	Taken from main risk assessment	0.10-0.17	0.046-0.078		
Textiles	Compounding site (formulation)	2.13-2.18	0.98-**1.0**	0.40-0.42	0.18-0.19
	Backcoating site (processing)	8.79-11.8	**4.1-5.4**	8.78-11.7	**4.0-5.4**
Sealants/adhesives formulation and use		Negligible	<1	Negligible	<1
Paints and coatings	Formulation site	Negligible	<1	Negligible	<1
	Industrial application of paints (processing)	0.16-0.95	0.074-0.44	0.19-0.48	0.088-0.22
Regional sources		0.062-0.15	0.029-0.069	0.032-0.066	0.015-0.030

The overall conclusions based on the 2003 consumption data are essentially the same as those in the main risk assessment report. Similar to the case with the assessment for surface water, the reduction in use of short-chain chlorinated paraffins in textiles in 2004 means that a risk is no longer indicated from textile backcoating formulation sites, but a risk is still predicted from the application of textile backcoatings.

C.3 Updated risk characterisation for the terrestrial compartment

The PNEC for the terrestrial compartment is 1.76 mg/kg wet weight. This value is derived using the equilibrium partitioning approach. According to the Technical Guidance Document the PEC/PNEC ratios obtained using this value should be increased by a factor of 10 to take into account the possibility of direct ingestion of soil-bound substance. However, there is evidence from experiments with medium-chain chlorinated paraffins that this factor of 10 is overprotective for chlorinated paraffins and so it is not used here for short-chain chlorinated paraffins. The resulting PEC/PNEC ratios based on the PNEC of 1.76 mg/kg wet weight are shown in **Table C3**.

Some of the local PECs for soil have increased slightly from those reported in the main assessment. This appears to result from the fact that EUSES 2.0.1 was used to carry out the calculations in this analysis, whereas EUSES 1.0 (modified to take account of the methods in the new Technical Guidance Document) was used for the calculations in the main assessment (EUSES 2 was not available at the time).

Table C3 Summary of revised PEC/PNEC ratios for soil

Scenario		2003 Figures		2004 Figures	
		PEC_{soil} (agricultural soil) (mg/kg wet wt.)	**PEC/PNEC ratio**	**PEC_{soil} (agricultural soil) (mg/kg wet wt.)**	**PEC/PNEC ratio**
Production sites		Negligible[a]	<1	Negligible	<1
Rubber (worst case estimate)	Compounding site (formulation)	0.65-1.08	0.37-0.61	0.65-1.08	0.37-0.61
	Conversion site (processing)	0.22-1.82	0.13-**1.0**	0.22-1.82	0.13-**1.0**
	Combined compounding/ conversion site	0.86-2.91	0.49-**1.7**	0.86-2.91	0.49-**1.7**
Rubber (alternate estimate)	Taken from main risk assessment	0.071	0.040		
Textiles	Compounding site (formulation)	3.1	**1.8**	0.57	0.32
	Backcoating site (processing)	12.9-17.2	**7.3-9.8**	12.9-17.2	**7.3-9.8**
Sealants/adhesives formulation and use		Negligible	<1	Negligible	<1
Paints and coatings	Formulation site	Negligible	<1	Negligible	<1
	Industrial application of paints (processing)	0.19-1.29	0.11-0.73	0.26-0.65	0.15-0.37
Regional sources		Agricultural soil – 0.064-0.088[b]	0.036-0.050[b]	Agricultural soil – 0.027-0.070	0.015-0.040
		Natural soil – 6.2×10^{-4}-1.6×10^{-3}	3.5×10^{-4}-9.1×10^{-4}	Natural soil – 3.2×10^{-4}-6.7×10^{-4}	1.8×10^{-4}-3.8×10^{-4}
		Industrial/urban soil – 0.32-0.71	0.18-0.40	Industrial/urban soil – 0.21-0.33	0.12-0.19

a) Sludge from the treatment plant is not applied to soil.
b) Regional agricultural soil concentration based on the available measured data. PEC/PNEC ratios <1 are also obtained based on the predicted regional concentration (0.17 mg/kg wet wt.) in agricultural soil.

The overall conclusions based on the 2003 consumption data are essentially the same as those in the main risk assessment report, with the exception of industrial urban soil (shaded box). This was indicated as a possible (but highly uncertain risk) in the main risk assessment report, but the lower tonnage used in 2003 now leads to a PEC/PNEC ratios clearly below 1. When the 2004 consumption data are considered, the formulation of textile backcoatings also no longer indicates a risk for the terrestrial compartment.

C.4 Updated risk characterisation for non-compartment specific effects relevant to the food chain (secondary poisoning)

The PNEC for secondary poisoning is 5.5 mg/kg food. The resulting PEC/PNEC ratios for secondary poisoning are shown in **Table C4** (2003 data) and **Table C5** (2004 data).

The main effect of consideration of the 2003 and 2004 data is that the regional background concentration is predicted to decrease from that estimated in the main risk assessment report, with a resulting reduction in the PEC/PNEC ratios for some of the secondary poisoning end-

points. Again the formulation of textile backcoatings is no longer indicating a risk based on the 2004 data, along with the scenario for the industrial application of paints.

C. 5 Updated risk characterisation for the marine environment

The estimated PECs and the provisional risk characterisation ratios for water, sediment and predators/top-predators are shown in **Tables C6** to **C9**.

The overall conclusions of the assessment are similar to those in the main risk assessment. The PEC/PNEC ratios for several end-points have been reduced below 1 using the 2003 or 2004 data (see shaded boxes) but these uses still have PEC/PNEC ratios >1 for some environmental compartments.

Table C4 Summary of revised PEC/PNEC ratios for secondary poisoning (2003 data)

Scenario		PEC[b] (mg/kg)							PEC/PNEC[b]						
		Fish (TGD method)		Fish (alternate method)		Mussel (TGD method)		Earthworms (TGD method)[c]	Fish-based food chain (TGD method)		Fish-based food chain (alternate method)		Mussel-based food chain (TGD method)		Earthworm -based food chain (TGD method)[c]
		BMF = 1	BMF = 2	FAF = 1	FAF = 2	BMF = 1	BMF = 2		BMF = 1	BMF = 2	FAF = 1	FAF = 2	BMF = 1	BMF = 2	
Production sites		<0.086-<0.17	<0.17-<0.34	<0.17-<0.34	<0.26-<0.51	<0.45-<0.89	<0.90-<1.78	Negligible[a]	<0.016-<0.030	<0.031-<0.062	<0.031-<0.062	<0.047-<0.093	<0.082-<0.16	<0.16-<0.32	<1[a]
Rubber (worst case estimate)	Compounding site (formulation)	0.27-0.36	0.54-0.72	0.54-0.72	0.81-1.08	1.41-1.88	2.82-3.76	4.1-6.7	0.049-0.065	0.098-0.13	0.098-0.13	0.15-0.20	0.26-0.34	0.51-0.68	0.73-**1.2**
	Conversion site (processing)	0.13-0.50	0.26-1.0	0.26-1.0	0.39-1.50	0.68-2.62	1.36-5.23	1.6-10.9	0.024-0.091	0.047-0.18	0.047-0.18	0.071-0.27	0.12-0.48	0.24-0.95	0.29-**2.0**
	Combined compounding/ conversion site	0.34-0.71	0.68-1.42	0.68-1.42	1.02-2.13	1.78-3.71	3.56-7.43	5.3-17.1	0.062-0.13	0.12-0.26	0.12-0.26	0.19-0.39	0.32-0.67	0.64-**1.35**	0.96-**3.1**
Rubber (alternate estimate – taken from main risk assessment)		0.11-0.23	0.22-0.46	0.22-0.46	0.33-0.69	0.58-1.20	1.16-2.40	0.77-0.91	0.020-0.042	0.040-0.084	0.040-0.084	0.060-0.13	0.11-0.22	0.21-0.44	0.14-0.16
Textiles	Compounding site (formulation)	1.61-1.70	3.22-3.40	3.22-3.40	4.83-5.1	8.42-8.90	16.8-17.8	18.0-18.2	0.29-0.31	0.58-0.62	0.58-0.62	0.88-0.93	**1.53-1.62**	**3.05-3.24**	**3.3**
	Backcoating site (processing)	1.14-2.07	2.28-4.14	2.28-4.14	3.42-6.21	5.97-10.8	11.9-21.6	73.9-98.5	0.21-0.38	0.41-0.75	0.41-0.75	0.62-**1.13**	**1.08-1.96**	**2.16-3.93**	**13.4-17.9**
Sealants/adhesives formulation and use		Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	<1	<1	<1	<1	<1	<1	<1
Paints and coatings	Formulation site	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	<1	<1	<1	<1	<1	<1	<1
	Industrial application of paints (processing)	0.15-0.33	0.30-0.66	0.30-0.66	0.45-0.99	0.78-1.73	1.56-3.46	1.5-7.9	0.027-0.060	0.055-0.12	0.055-0.12	0.082-0.18	0.14-0.31	0.28-0.63	0.26-**1.4**

a) Sludge from the treatment plant is not applied to soil.
b) Calculations based on measured regional concentration of 0.088 mg/kg wet wt. for agricultural soil. Similar PEC/PNEC ratios are obtained if the calculations based on the predicted regional concentrations are used.
c) The calculations here use an earthworm bioaccumulation factor of 11.4 kg/kg as assumed in the main report.

Table C5 Summary of revised PEC/PNEC ratios for secondary poisoning (2004 data)

Scenario		PEC (mg/kg)							PEC/PNEC						
		Fish (TGD method)		Fish (alternate method)		Mussel (TGD method)		Earthworms (TGD method)[b]	Fish-based food chain (TGD method)		Fish-based food chain (alternate method)		Mussel-based food chain (TGD method)		Earthworm -based food chain (TGD method)[b]
		BMF = 1	BMF = 2	FAF = 1	FAF = 2	BMF = 1	BMF = 2		BMF = 1	BMF = 2	FAF = 1	FAF = 2	BMF = 1	BMF = 2	
Production sites		<0.059-<0.090	<0.12-<0.18	<0.12-<0.18	<0.18-<0.27	<0.31-<0.47	<0.62-<0.94	Negligible[a]	<0.011-<0.016	<0.022-<0.033	<0.022-<0.033	<0.033-<0.049	<0.056-<0.085	<0.11-<0.17	<1[a]
Rubber (worst case estimate)	Compounding site (formulation)	0.24-0.28	0.48-0.56	0.48-0.56	0.72-0.84	1.25-1.46	2.50-2.91	3.9-6.6	0.044-0.051	0.087-0.10	0.087-0.10	0.089-0.15	0.23-0.27	0.45-0.53	0.71-**1.2**
	Conversion site (processing)	0.10-0.42	0.20-0.84	0.20-0.84	0.30-1.26	0.52-2.18	1.04-4.36	1.4-10.8	0.018-0.076	0.036-0.15	0.036-0.15	0.054-0.23	0.095-0.40	0.19-0.79	0.25-**2.0**
	Combined compounding/ conversion site	0.32-0.64	0.64-1.28	0.64-1.28	0.96-1.92	1.66-3.33	3.33-6.66	5.1-17.0	0.058-0.12	0.12-0.23	0.12-0.23	0.17-0.35	0.30-0.61	0.61-**1.21**	0.93-**3.1**
Textiles	Compounding site (formulation)	0.31-0.35	0.62-0.70	0.62—0.70	0.93-1.05	1.61-1.82	3.22-3.64	3.4-3.6	0.056-0.064	0.11-0.13	0.11-0.13	0.17-0.0.19	0.29-0.33	0.59-0.66	0.62-0.65
	Backcoating site (processing)	0.46-0.84	0.92-1.68	0.92-1.68	1.38-2.52	2.39-4.37	4.78-8.74	73.7-98.4	0.084-0.15	0.17-0.31	0.17-0.31	0.25-0.46	0.43-0.79	0.87-**1.59**	**13.4-17.9**
Sealants/adhesives formulation and use		Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	<1	<1	<1	<1	<1	<1	<1
Paints and coatings	Formulation site	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	<1	<1	<1	<1	<1	<1	<1
	Industrial application of paints (processing)	0.072-0.15	0.14-0.30	0.14-0.30	0.21-0.45	0.37-0.78	0.74-1.56	1.6-4.1	0.013-0.027	0.025-0.55	0.025-0.54	0.038-0.082	0.067-0.14	0.13-0.28	0.29-0.75

a) Sludge from the treatment plant is not applied to soil.
b) The calculations here use an earthworm bioaccumulation factor of 11.4 kg/kg as assumed in the main report.

Table C6 Estimated PECs for short-chain chlorinated paraffins for the local marine risk assessment (2003 data)

Scenario	Comment	Daily emission to water (kg/day)	No. of days of release	$C_{local, seawater}$ (µg/l)[a]	$C_{local, seawater, ann}$ (µg/l)	$PEC_{local, seawater}$ (µg/l)[b]	$PEC_{local, seawater, ann}$ (µg/l)[b]	$PEC_{local, sed}$ (mg/kg wet wt.)	$PEC_{oral\ predator}$ (mg/kg)[b]		$PEC_{oral, top\ predator}$ (mg/kg)[b,]	
									TGD method[d]	Alternate method[d]	TGD method[d]	Alternate method[d]
Production sites			300	<0.0032[c]	<0.0026	<0.0040-<0.0051	<0.0034-<0.0045	<0.017-<0.022	<0.032-<0.050	<0.049-<0.075	<0.032-<0.068	<0.073-<0.15
Rubber (worst case estimate)	Compounding site (formulation)	0.038-0.063	118-200	0.14-0.24	0.077-0.078	0.14-0.24	0.078-0.080	0.64-1.06	0.62-0.64	0.92-0.96	0.27-0.30	0.60-0.68
	Conversion site (processing)	0.0125-0.106	118-200	0.048-0.41	0.026-0.13	0.049-0.41	0.027-0.13	0.21-1.78	0.22-1.03	0.33-1.55	0.11-0.46	0.24-1.03
	Combined compounding/ conversion site	0.050-0.169	118-200	0.19-0.65	0.10-0.21	0.19-0.65	0.10-0.21	0.84-2.83	0.79-1.66	1.18-2.48	0.33-0.71	0.75-1.60
Rubber (alternate estimate)		0.0042	118	0.016	0.0052	0.017-0.018	0.0060-0.0071	0.074-0.078	0.053-0.070	0.079-0.11	0.040-0.076	0.091-0.17
Textiles	Compounding site (formulation)	0.18	300	0.69	0.57	0.69	0.57	3.0	4.46-4.47	6.69-6.70	1.80-1.83	4.06-4.13
	Backcoating site (processing)	0.75-1	50-67	2.88-3.85	0.39-0.71	2.88-3.85	0.39-0.71	12.5-16.7	3.05-5.56	4.58-8.35	1.24-2.27	2.79-5.11
Paints and coatings	Formulation site	Negligible		Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
	Industrial application of paints (processing)	0.011-0.075	88-300	0.042-0.29	0.035-0.14	0.043-0.29	0.019-0.14	0.19-1.25	0.15-0.30	0.23-0.46	0.081-0.17	0.18-0.38

a) Assumes the daily emission is diluted into 200,000 m^3 of water and the concentration of suspended matter in the seawater is 15 mg/l.
b) Calculations assume $PEC_{regional, seawater}$ is 7.7×10^{-4}-1.9×10^{-3} µg/l. The regional sediment concentration is 6.6×10^{-3}-0.016 mg/kg wet wt.
c) Calculation based on actual effluent data for a site that discharges into the sea.
d) Calculation based on BCF_{fish} and a BMF of 2 as was used in the main risk assessment. If the BCF_{mussel} were used the resulting PECs would all be higher by a factor of 5.2.

Table C7 Estimated PECs for short-chain chlorinated paraffins for the local marine risk assessment (2004 data)

Scenario	Comment	Daily emission to water (kg/day)	No. of days of release	$C_{local, seawater}$ (µg/l)[a]	$C_{local, seawater, ann}$ (µg/l)	$PEC_{local, seawater}$ (µg/l)[b]	$PEC_{local, seawater, ann}$ (µg/l)[b]	$PEC_{local, sed}$ (mg/kg wet wt.)	$PEC_{oral\ predator}$ (mg/kg)[b]		$PEC_{oral, top\ predator}$ (mg/kg)[b,]	
									TGD method[d]	Alternate method[d]	TGD method[d]	Alternate method[d]
Production sites			300	<0.0032[c]	<0.0026	<0.0036-<0.0040	<0.0030-<0.0034	<0.015-<0.017	<0.027-<0.032	<0.041-<0.048	<0.020-<0.034	<0.045-<0.077
Rubber (worst case estimate)	Compounding site (formulation)	0.038-0.063	118-200	0.15-0.24	0.078-0.080	0.15-0.24	0.079-0.081	0.64-1.06	0.62-0.64	0.92-0.96	0.26-0.28	0.58-0.63
	Conversion site (processing)	0.0125-0.106	118-200	0.048-0.41	0.026-0.13	0.049-0.41	0.027-0.13	0.21-1.77	0.22-1.02	0.33-1.53	0.096-0.42	0.22-0.95
	Combined compounding/ conversion site	0.050-0.169	118-200	0.19-0.65	0.11-0.21	0.19-0.65	0.11-0.21	0.84-2.82	0.86-1.65	1.29-2.48	0.36-0.38	0.81-0.86
Textiles	Compounding site (formulation)	0.033	300	0.13	0.10	0.13	0.11	0.55	0.86-0.87	1.29-1.31	0.36	0.81
	Backcoating site (processing)	0.75-1	20-27	2.89-3.85	0.16-0.29	2.89-3.85	0.16-0.29	12.5-16.7	1.25-2.27	1.88-3.4	0.52-0.92	1.17-2.07
Paints and coatings	Formulation site	Negligible		Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
	Industrial application of paints (processing)	0.015-0.038	80-100	0.058-0.15	0.016-0.032	0.058-0.15	0.016-0.033	0.25-0.64	0.13-0.26	0.20-0.39	0.062-0.13	0.14-0.29

Notes: a) Assumes the daily emission is diluted into 200,000 m^3 of water and the concentration of suspended matter in the seawater is 15 mg/l.

b) Calculations assume $PEC_{regional, seawater}$ is 4.0×10^{-4}-8.2×10^{-4} µg/l. The regional sediment concentration is 3.4×10^{-3}-7.0×10^{-3} mg/kg wet wt.

c) Calculation based on actual effluent data for a site that discharges into the sea.

d) Calculation based on BCF_{fish} and a BMF of 2 as was used in the main risk assessment. If the BCF_{mussel} were used the resulting PECs would all be higher by a factor of 5.2.

Table C8 Provisional risk characterisation ratios for the marine compartment (2003 data)

Scenario	Step	PEC/PNEC ratios (2003 data)							
		Marine water	Marine sediment	Predators[a]			Top predators[a]		
				Fish		Mussel (TGD method)	Fish		Mussel
				TGD method	Alternate method		TGD method	Alternate method	
Production		<0.040-<0.050	<0.039-<0.051	<0.006-<0.009	<0.009-<0.014	<0.031-<0.047	<0.006-<0.012	<0.013-<0.028	<0.031-<0.063
Rubber (worst case estimate)	Compounding site (formulation)	**1.4-2.4**	**1.5-2.5**	0.11-0.12	0.17	0.58-0.63	0.048-0.055	0.11-0.12	0.25-0.29
	Conversion site (processing)	0.49-**4.1**	0.49-**4.1**	0.039-0.19	0.059-0.28	0.20-0.99	0.019-0.084	0.043-0.19	0.10-0.44
	Combined compounding/ conversion site	**1.9-6.5**	**2.0-6.6**	0.14-0.30	0.21-0.45	0.73-**1.6**	0.061-0.13	0.14-0.29	0.32-0.68
Rubber (alternate estimate)		0.17-0.18	0.17-0.18	0.010-0.013	0.014-0.019	0.052-0.068	0.007—0.014	0.017-0.031	0.037-0.073
Sealants/adhesives formulation and use		<1	<1	<1	<1	<1	<1	<1	<1
Textiles	Compounding site (formulation)	**6.9**	**7.0**	0.81	**1.2**	**4.2**	0.33	0.74-0.75	**1.7**
	Backcoating site (processing)	**28.8-38.5**	**29.1-38.8**	0.74-**1.0**	0.83-**1.5**	**3.9-5.2**	0.23-0.41	0.51-0.93	**1.2-2.1**
Paints and coatings	Formulation site	<1	<1	<1	<1	<1	<1	<1	<1
	Industrial application of paints (processing)	0.43-**2.9**	0.44-**2.9**	0.028-0.055	0.042-0.082	0.15-0.28	0.015-0.031	0.033-0.069	0.078-0.16
Regional sources		0.0077-0.019	0.015-0.037						

Note: a) Calculation based on BCF_{fish} and a BMF of 2 as was used in the main risk assessment.

Table C9 Provisional risk characterisation ratios for the marine compartment (2004 data)

Scenario	Step	PEC/PNEC ratios (2004 data)							
		Marine water	Marine sediment	Predators[a]			Top predators[a]		
				Fish		Mussel (TGD method)	Fish		Mussel
				TGD method	Alternate method		TGD method	Alternate method	
Production		<0.036-<0.040	<0.035-<0.040	<0.005-<0.006	<0.007-<0.009	<0.026-<0.031	<0.004-<0.006	<0.008-<0.014	<0.021-<0.031
Rubber (worst case estimate)	Compounding site (formulation)	**1.5-2.4**	**1.5-2.5**	0.11-0.12	0.17	0.57-0.62	0.047-0.051	0.11	0.24-0.27
	Conversion site (processing)	0.49-**4.1**	0.49-**4.1**	0.040-0.19	0.060-0.28	0.21-0.99	0.017-0.076	0.040-0.17	0.088-0.39
	Combined compounding/ conversion site	**1.9-6.5**	**2.0-6.6**	0.16-0.30	0.23-0.45	0.83-**1.6**	0.065-0.069	0.15-0.16	0.34-0.36
Sealants/adhesives formulation and use		<1	<1	<1	<1	<1	<1	<1	<1
Textiles	Compounding site (formulation)	**1.3**	**1.3**	0.16	0.23-0.24	0.83	0.065	0.15	0.34
	Backcoating site (processing)	**28.9-38.5**	**29.1-38.8**	0.23-0.41	0.34-0.62	**1.2-2.1**	0.095-0.17	0.21-0.38	0.49-0.88
Paints and coatings	Formulation site	<1	<1	<1	<1	<1	<1	<1	<1
	Industrial application of paints (processing)	0.58-**1.5**	0.58-**1.5**	0.024-0.047	0.036-0.071	0.12-0.24	0.011-0.024	0.025-0.053	0.057-0.12
Regional sources		0.0040-0.0082	0.008-0.016						

Note: a) Calculation based on BCF_{fish} and a BMF of 2 as was used in the main risk assessment.

C.6 Overall conclusions

The revised calculations using the updated information on the use pattern lead to similar conclusions as given in the main risk assessment report. A significant change in conclusion (no risk now identified) is only found for the:

- regional assessment for industrial soil ("waste remaining in the environment"),
- assessment for textile compounding sites for surface water, freshwater sediment, the terrestrial compartment and secondary poisoning, and
- assessment of industrial application of paints for secondary poisoning based on the 2004 consumption figures.

For the other scenarios that still indicate a risk, the assessment does not appear to be very sensitive to the overall tonnage. In these cases it is the daily amount of short-chain chlorinated paraffin used at a site that appears to drive the scenarios; this value does not necessarily decrease as the overall tonnage decreases. For example, if a company reduces its consumption from 50 to 10 tonnes/year it is possible that there is an equivalent reduction in the number of days of use, resulting in a similar daily consumption.

C.7 Risk management considerations

If the regional background contribution is ignored (this is now of minor importance for most local scenarios), then it is possible to estimate the daily emission from a site that would lead to a PEC/PNEC ratio of 1 for each compartment. The lowest of these values are a daily emission to a waste water treatment plant of 0.055 kg/day (derived from the secondary poisoning endpoint for the terrestrial compartment; this is then protective of the freshwater, freshwater sediment and terrestrial compartment) or a daily emission of 0.026 kg/day directly to marine water if the marine risk assessment is also considered (this value is driven by the PNEC for marine water and sediment). The significance of these values is that if the daily emission from a site is less than these values, then no risk would be identified for any compartment.

Using the default emission factors for water that have been used in the risk assessment it is possible to backcalculate from these emission figures to an equivalent daily usage of short-chain chlorinated paraffins at a site. These calculations are shown below for information in Table C10.

Table C10 Estimate daily usage of short-chain chlorinated paraffins at a site that would not lead to risks being identified.

Scenario	Effective emission factor to waste water	Daily emission value that would lead to a PEC/PNEC <1		Equivalent daily consumption of short-chain chlorinated paraffins that would lead to a PEC/PNEC <1	
		Waste water treatment plant	Marine water	Freshwater and terrestrial risk assessment	Marine risk assessment
Rubber – compounding site	0.015%	<0.055 kg/day	<0.026 kg/day	<367 kg/day	<173 kg/day
Rubber – conversion site	0.005-0.025%	<0.055 kg/day	<0.026 kg/day	<220-<1,100 kg/day	<104-<520 kg/day
Rubber – combined compounding/conversion site	0.02%-0.04%	<0.055 kg/day	<0.026 kg/day	<138-<275 kg/day	<65-<130 kg/day
Textiles – compounding (formulation) site	0.5%	<0.055 kg/day	<0.026 kg/day	<11 kg/day	<5.2 kg/day
Textiles – backcoating site	a	<0.055 kg/day	<0.026 kg/day	Any amount	Any amount
Paints – formulation site	Negligible	<0.055 kg/day	<0.026 kg/day	Not relevant	Not relevant
Paints – industrial application site	0.1%	<0.055 kg/day	<0.026 kg/day	<55 kg/day	<26 kg/day

Note: a) This scenario is based on 1 kg of formulation (containing 0.15-0.2 kg of short-chain chlorinated paraffin being lost between each batch. The daily emission depends on the number of batches and the actual disposal practices at the site.

European Commission

EUR 23396 EN **European Union Risk Assessment Report**
alkanes, C_{10-13}, chloro, **Volume 81**

Editors: S. Pakalin, K. Aschberger, O. Cosgrove, A. Paya-Perez, S. Vegro.

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The report contains the comprehensive risk assessment of the substance alkanes, C10-13,chloro. It has been prepared by the United Kingdom in the frame of Council Regulation (EEC) No. 793/93 on the evaluation and control of the risks of existing substances, following the principles for the assessment of risks to man and the environment, laid down in Commission Regulation (EC) No. 1488/94.

The evaluation considers the emissions and the resulting exposure to the environment and the human population in all life cycle steps. Following the exposure assessment, the environmental risk characterisation for each protection target in the aquatic, terrestrial and soil compartment has been determined. For human health the scenarios for occupational exposure, consumer exposure and human exposed indirectly via the environment have been examinated and the possible risks have been identified.

The risk assessment concludes that there is a risk to aquatic organisms arising from the local emissions of chloro (C10-13) alkanes from the formulation of backcoatings and application of backcoatings to textiles. This conclusion also applies to secondary poisoning via the freswater food chain from the emission from conversion and combined conversion and compounding of rubber, formulation and processing of textile backcoatings, and from the industrial use of paints and coatings; and to secondary poisoning in the marine food chain from combined compounding and conversion of rubber, formulation and processsing of textile backcoatings, and industrial applications of paints and coatings. In addition the evaluation concludes that the substance meets the PBT criteria.

Potential risks are also identified for the sediment and terrestrial environment from certain uses. Further information on long term soil and sediment toxicity could improve the terrestrial and sediment assessment. However it is not recommended to pursue this information at this stage given the risks identified for surface water and the marine environment.

A risk for human health could not be determined.

The conclusion of this report will lead to risk reduction measures to be decided by the risk management committee of the Commission.

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