Defra

Risk Reduction Strategy and Analysis of the Advantages and Drawbacks for Tetrachloroethylene

Final Report - Stage 4

August 2005

Entec UK Limited

Defra

Risk Reduction Strategy and Analysis of the Advantages and Drawbacks for Tetrachloroethylene

Final Report - Stage 4

August 2005

Entec UK Limited

Report for

Daveshini Padayachee
Chemicals & GM Policy
Defra
3/E5 Ashdown House
123 Victoria Street
London SW1E 6DE

Main Contributors

Oliver Warwick
Keith Lawton
Caspar Corden

Issued by

....
Oliver Warwick

Approved by

....
Mark Watson

Entec UK Limited

17 Angel Gate
City Road
London
EC1V 2SH
England
Tel: +44 (0) 207 843 1400
Fax: +44 (0) 207 843 1410

15206-01

h:\projects\em-260\15000 projects\15206 pp defra perc risk reduction\c - client\reports\stage 4\tetra rrs stage 4 report amended 250805.doc

Certificate No. EMS 69090 Certificate No. FS 13881

In accordance with an environmentally responsible approach, this document is printed on recycled paper produced from 100% post-consumer waste, or on ECF (elemental chlorine free) paper

Executive Summary

Introduction

A European Union risk assessment has identified a need to limit the risks to the environment associated with the manufacture and processing of tetrachloroethylene as an intermediate. As 'rapporteur' to the European Commission for the substance, the UK is required to develop a risk reduction strategy to effectively limit the risks.

Entec UK Limited has been commissioned under contract to the Department for Environment, Food and Rural Affairs (Defra) to undertake work to develop a risk reduction strategy. This document is concerned with the development of a risk reduction strategy to address risks for the environment. This document presents the final results in development of the risk reduction strategy following the approach set out in relevant guidance (European Commission, 1998).

The project was conducted in three stages:

Stage 1 of the project involved data gathering and evaluation of all known uses of tetrachloroethylene and establishment of the range of potential risk reduction options and current control measures in place. A report on Stage 1 was submitted to Defra in April 2005.

Stage 2 of the work involved undertaking a systematic qualitative and semi-quantitative assessment of the advantages and drawbacks of a number of options for addressing the risks. A report on Stage 2 was submitted to Defra in July 2005. The draft conclusions in the Stage 2 report were given consideration by the Steering Group and other relevant stakeholders at the Steering Group meeting on 12th July 2005.

This report presents the final risk reduction strategy for tetrachloroethylene (Stage 4 of the work), and includes various amendments raised in the last steering group meeting.

It should be noted that Stage 3, involving collating further information on the risk reduction options under consideration and more detailed quantification, was not considered to be required. Further to this Stage 5 a regulatory impact assessment is not required as the risk reduction measures proposed do not involve marketing and use restrictions.

Current Risk Reduction Measures

Current legislation that will affect the risks associated with tetrachloroethylene is the Integrated Pollution Prevention and Control regime, through which limits on emissions of tetrachloroethylene from large plants (production of tetrachloroethylene and its use as an intermediate) are being introduced. These measures will continue to have an effect in reducing the risks associated with the substance. Although no risks from tetrachloroethylene use in surface cleaning and dry cleaning of textiles was identified in the environmental risk assessment, an overview of these uses and the effect of the implementation of the Solvent Emissions Directive have been made.

Assessment of Possible Further Risk Reduction Measures

It was agreed by the steering group for this risk reduction strategy that the following four risk reduction options should be considered in detail:

- '**Do nothing**' option, relying on current legislation and its continuing implementation over the next few years.
- Introduction of **emission limits or quality standards** through legislation and/or official guidance for implementation of that legislation (Integrated Pollution Prevention and Control).
- **Marketing and Use restrictions**, placing restriction on use in consumer products.
- **Voluntary emissions controls** as an alternative to a legislative approach.

The relative advantages and drawbacks of these measures have been considered, based on a range of criteria set out in the Technical Guidance Document on Development of Risk Reduction Strategies

For **production and use as an intermediate of tetrachloroethylene**, information has been provided by two EU producers on current emissions (including the site for which a risk to the environment was identified in the European Risk Assessment). By comparison to the results of the risk assessment, it is considered likely that there have been significant reductions in emissions at the production site. Therefore, it may be the case that emissions have already been limited sufficiently to remove the concern. However, emissions data would, of course, need to be properly verified.

Production sites are already regulated under the IPPC regime and, irrespective of whether existing legislation is considered to be sufficient, it would also be appropriate to ensure that the relevant regulators of affected processes are fully aware of the conclusions of the environmental risk assessment in order to determine whether there is any potential to further reduce emissions, as well as to ensure that emissions are well controlled.

Conclusions and Recommendations

For sites producing tetrachloroethylene and using the substance as an intermediate in the production of other chemicals, it is concluded that the most appropriate action would be to ensure that regulators under the IPPC regime, take into account the conclusions of the environmental risk assessment in developing emission limits for sites. This should include consideration of whether techniques could be adopted under economically and technically viable conditions, taking into consideration the costs and advantages on a site-specific basis.

It is recommended that the conclusions of this report are taken into account by the UK Government and the European Commission in determining the most appropriate strategy to address the environmental risks associated with tetrachloroethylene in the European Union.

Contents

1. Background

1.1 Overview

Tetrachloroethylene is a colourless non-flammable liquid at normal temperature and pressure with an ether-like odour. It is produced in large quantities (> 100,000 tonnes per annum) within the European Union and it is on the first list of priority substances under the Existing Substances Regulation (EEC No. 793/93). Under this Regulation, the UK is responsible for undertaking an EU-wide assessment of the risks of tetrachloroethylene for human health and the environment and where appropriate, for recommending an EU-wide risk reduction strategy.

The draft environmental risk assessment for tetrachloroethylene was published in 2001 (ECB, 2001) this has been updated and a draft final environmental risk assessment has been produced recently (Environment Agency, 2005A), which is due to be published by the ECB in the near future. The aspects related to risks for the environment were developed by the Environment Agency for England and Wales and those related to human health are being developed separately by the UK Health and Safety Executive (the risk assessment report for human health has not been published and is not currently publicly available, but is due to be published in September 2005). The environmental part of the risk assessment identified a need for limiting the risks associated with use of tetrachloroethylene in relation to the risk of harm to plants from air emissions from production sites and processing of tetrachloroethylene as an intermediate. The Health and Safety Executive will be developing a risk reduction strategy to address the risks to human health in due course.

This document is concerned with the development of a risk reduction strategy to address risks for the environment. The work is being undertaken by Entec UK Limited under contract to the Department for Environment, Food and Rural Affairs (Defra). This document presents the results of **Stage 4** (Final Report) in development of the risk reduction strategy following the approach set out in relevant guidance (European Commission, 1998).

Stage 1 of the project involved data gathering and evaluation of all known uses of tetrachloroethylene, and establishment of the range of potential risk reduction options and current control measures in place. A draft of the Stage 1 report was circulated to the steering group (by Defra) on 14th of April 2005. Comments were collated and agreed and changes made to the final Stage 1 report, which was circulated on 5th May 2005.

Stage 2 of the work involved undertaking a systematic qualitative assessment of the advantages and drawbacks of a number of options for addressing the risks. A report on Stage 2 was submitted to Defra in July 2005 and agreed at a steering group meeting on 12th July 2005.

The steering group meeting confirmed that Stage 3 work, involving collating further information on the risk reduction options under consideration more detailed quantification and consulting with companies and organisations that had not previously been contacted, would not be required. This was because the risk identified was only for one use and at one site and therefore adequate analysis was provided by the Stage 2 report.

Following the amendment and agreement of the Stage 2 report, the Stage 4 report representing the finalised analysis of the advantages and drawbacks is produced here. Stage 5, a regulatory impact assessment, is not required as marketing and use restrictions are not proposed.

1.1.1 Structure of this report

The remainder of this section of the report provides a background to the uses of tetrachloroethylene.

- Section 2 summarises the results of the environmental risk assessment.
- Section 3 provides a discussion of some of the risk reduction measures currently in place.
- Section 4 includes identification of the range of possible further measures
- Section 5 provides assessment of possible further measures;
- Section 6 provides conclusions and recommendations for the most appropriate risk reduction strategy.

1.2 Use of tetrachloroethylene

1.2.1 Production and sales of tetrachloroethylene

Tetrachloroethylene is produced by oxychlorination, chlorination and/or dechlorination reactions of hydrocarbon or chlorinated hydrocarbons. Trichloroethylene and tetrachloroethylene are both produced by the oxychlorination of 1,2-dichloroethane. The relative amounts produced of either substance can be varied by altering the reaction conditions.

There are five companies producing tetrachloroethylene in the EU, these are based in the Czech Republic, France, Germany, Spain and UK (Environment Agency 2005A). A number of suppliers (i.e. vendors, including distributors) are listed in the IUCLID datasheet for the substance (ECB, 2000); the number of companies by country is set out in Table 1.1.

Table 1.1 Known numbers of companies supplying tetrachloroethylene by country (Information from IUCLID dated 2000)

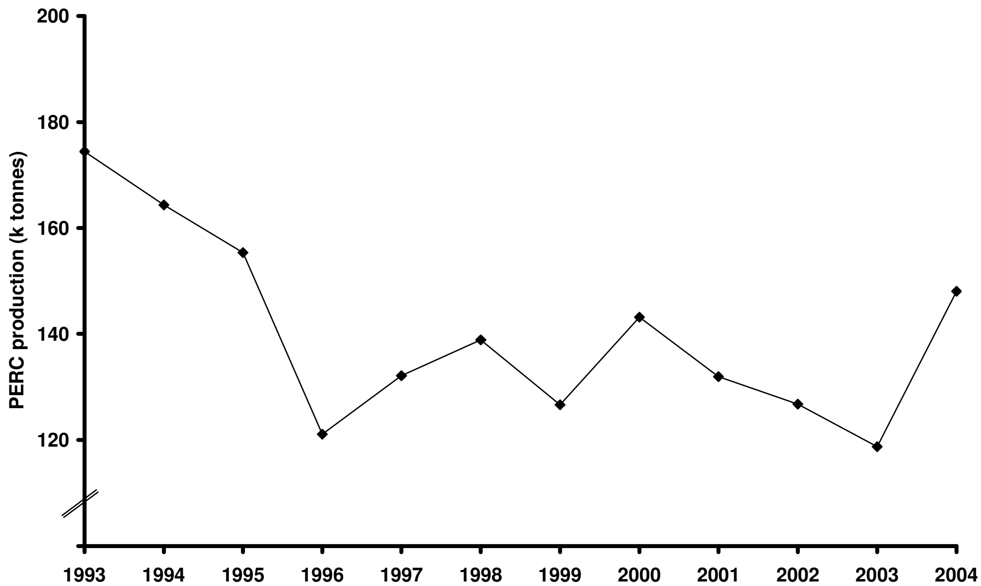
Country	Number of companies
Austria	1
Belgium	1
France	1
Germany	5
Italy	2
Netherlands	3
Spain	1
UK	1

Source: ECB (2000). The current number of suppliers is believed to be different compared to when this information was compiled.

Production plant capacities vary and are typically in the range of 10,000 - 50,000 tonnes per annum. The total production capacity in the EU is in the range of 100,000 - 150,000 tonnes per annum, with actual production reported as 148,074 tonnes per annum in 2004 (ECSA pers comm, 2005).

According to information made available by ECSA (Environment Agency, 2005 A), there was a decline in the production of tetrachloroethylene in Western Europe between 1986 and 1993 from 340,800 to 174,447 tonnes. Production data for the period from 1993 to the latest figures for 2004 (see Figure 1.1) show a fall in production from 1993 to a low of 121,086 tonnes in 1996 and then figures fluctuated between 120,000 and 143,000 tonnes to 2004 where tonnage increased to 148,074 tonnes.

Figure 1.1: Production tonnage of tetrachloroethylene in Western Europe (EU15, Norway, Switzerland and Turkey) for years 1997 to 2004



Source: ECSA

The reported sales tonnage (data from ECSA) is the annual tonnage, which does not include exports to countries outside the EU and chemical intermediate use by the manufacturers. In 1986 sales of tetrachloroethylene were reported as 161,600 tonnes, in 1994 sales were reported as 78,000 tonnes and exports as 56,000 tonnes with the remaining 30,000 tonnes being used by the chemical industry as an intermediate. For 2004, these figures are 53,000 tonnes of sales, 69,000 tonnes of exports and 26,000 tonnes used by the chemical industry as an intermediate. A comparison of sales and production figures for the years for which there is both production and sales data is set out in Table 1.2 below.

Table 1.2 Production and sales volumes for tetrachloroethylene for period 1994 -2004

Year	Production			Sales			
	Tonnage	Tonnage change	% change	Tonnage	Tonnage change	% change	% sales of production
1994	164,329	-	-	78,000	-	-	47.5%
1995	155,390			No data			
1996	121,086			No data			
1997	132,149	-32,180	-19.0	71,000	-7,000	-9.0	53.7%
1998	138,906	+6,757	+5.1	73,000	+2,000	+2.8	52.6%
1999	126,646	-12,260	-8.8	74,000	+1,000	+1.4	58.4%
2000	143,198	+16,552	-13.1	70,000	-4,000	-5.4	48.9%
2001	131,988	-11,210	-7.8	65,000	-5,000	-7.1	49.2%
2002	126,772	-5,216	-4.0	61,000	-4,000	-6.2	48.1%
2003	118,727	-8,045	-6.3	58,000	-3,000	-4.6	44.6%
2004	148,074	29,347	+24.7	53,000	-4,000	-7.0	35.8%

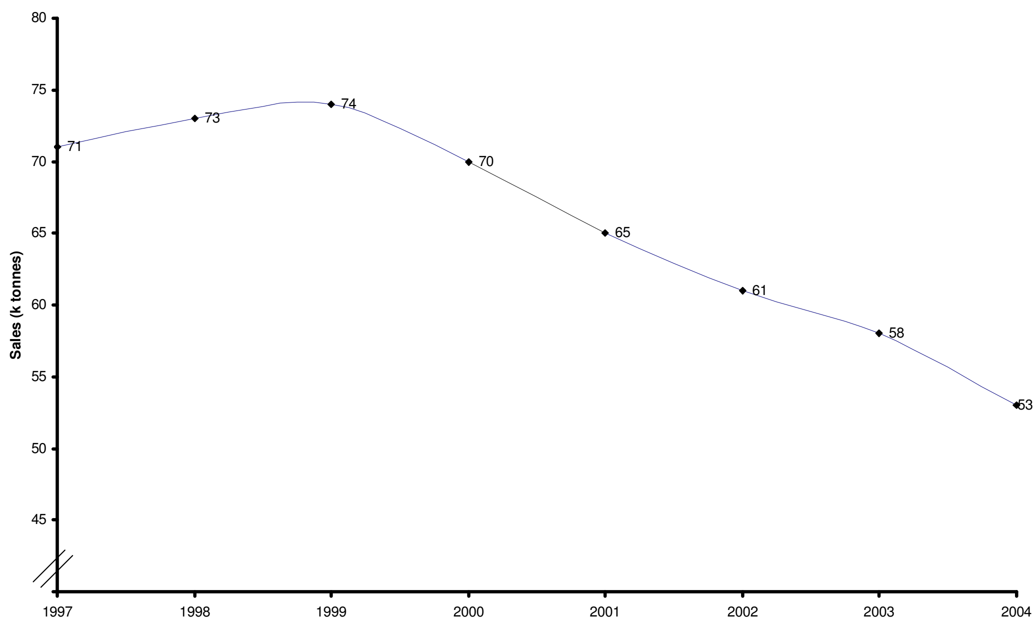
Notes:

Sales and production data are for 'Western Europe' (i.e. EU15 and Norway, Switzerland and Turkey)

Sales tonnage is the annual tonnage, which does not include exports to countries outside the EU and chemical intermediate use by the manufacturers.

Sales of 78,000 tonnes in 1994 decreased to 71,000 tonnes by 1997, however, sales increased to 73,000 and 74,000 tonnes in 1998 and 1999, respectively, with a subsequent decline in sales in the years from 1999 to 2004. The proportion of production tonnage going to sales (i.e. that not exported or used as a chemical intermediate) ranges from 35.8% in 2004 to 58.4% in 1999. The reductions in sales tonnage in recent years are reported by industry to be the result of the use of more efficient dry-cleaning machines, an increased emphasis on recycling, improved housekeeping and the use of enclosed systems. As well as this, the industry report that regulatory pressure on tetrachloroethylene use may encourage dry cleaners and metal cleaners to use other solvents as they invest in new equipment. The trend in sales of tetrachloroethylene is illustrated below in Figure 1.2.

Figure 1.2 Sales of tetrachloroethylene 1997-2003 (data from ECSA, 2003, 2004)



The latest data available for use and sales volumes are for the year 2004 (ECSA 2005), Table 1.3 shows the percent of production volume tonnage for the different uses of tetrachloroethylene. It can be seen from Table 1.3 that in 2004, 47% of total production was exported (compared to 34% in 1994) and 17.5% was used as an intermediate (compared with 18% in 1994). In terms of end-use, the majority of sales (49%) in the EU were used in dry cleaning and 30% of sales were used in metal cleaning.

Table 1.3 Production, use and sales of tetrachloroethylene for 2004 (2003)

Application	Percentage of production volume	Percentage of Sales	Tonnes per annum
Dry cleaning agent	17.5 (19)	49 (43)	26,000 (23,000)
Metal cleaning agent	11 (13)	30 (30)	16,000 (16,000)
Chemical intermediate	17.5 (17)	n/a	26,000 (20,000)
Exports	47 (39)	n/a	69,000 (46,000)
Other and unknown	7 (12)	21 (26)	11,000 (14,000)
Total	100	100	148,000 (119,000)

Source: ESCA 2005.

Note: ECSA collect data on production, sales and exports, but not on intermediate use (intermediate use is production minus sales and exports). Data are rounded to the nearest 1,000 t and are for 'Western Europe' (i.e. EU15 and Norway, Switzerland and Turkey)

1.2.2 Use as an intermediate

In the EU tetrachloroethylene is used as a feedstock for the production of other chemicals such as hydrochlorofluorocarbons (HCFC) and hydrofluorocarbons (HFC). The EU Risk Assessment Report (RAR) stated that tetrachloroethylene is used for the production of H(C)FCs. Since this part of the RAR was written, a number of the chemicals cited in the RAR have been phased out or limited under EU legislation and the Montreal protocol (e.g. CFCs and HCFC). Quantification of the current uses of tetrachloroethylene as a chemical intermediate in terms of tonnage use for the manufacture of particular products is commercially confidential. However, current information suggests that small proportions of the annual production tonnage are used to manufacture HCFC 123 (2,2 dichloro-1,1,1-trifluoroethane) and HFC 125 (pentafluoroethane) at one site, HFC 125 at another site (ECSA, Pers. Comm. 2005). Tetrachloroethylene can also be used to produce HFC 134a (1,1,1,2 tetrafluoroethane). In addition, tetrachloroethylene is used for the production of 1-napthol[1] by at least one site in the EU.

1.2.3 Dry cleaning

Tetrachloroethylene is used in dry cleaning applications as it has a high solvency action on fat and other soils and is not found to be detrimental to garments. In 1994 tetrachloroethylene accounted for approximately 90% of the total solvent used by the dry cleaning industry within the EU. Other solvents such as 1,1,2-trichloro-1,2,2-trifluoroethane (R113), 1,1,1-trichloroethane, trichloroethylene and white spirit were also reported as being used, however, the production of the first two of these other solvents is now prohibited under the Montreal Protocol (Environment Agency, 2005A). Further to this, Regulation (EC) No. 2037/2000 on Substances that Deplete the Ozone Layer, prohibits production of both 1,1,2-trichloro-1,2,2-trifluoroethane (R113) and 1,1,1-trichloroethane and also their use (except for certain specified uses). The use of trichloroethylene as a dry cleaning agent is now limited and its use for ‘spot’ dry cleaning is also reduced as a result of a marketing and use restriction (under Council Directive 76/769/EEC) on consumer use of this substance. It can be seen from Table 1.3 above that dry cleaning accounted for 18% of the production tonnage, 49% of sales, which amounted to 26,000 tonnes in 2004.

The EU Risk Assessment Report states that the UK dry cleaning industry is split between factory dry cleaning and unit shops; the unit shops are split between the major dry cleaning groups and the independent operators. The RAR reports that approximately 1,200 unit shops are in the control of the two major groups, however, further information gathered for the risk reduction strategy suggested that these numbers have since changed.

Current estimates from the Textile Services Association (TSA) in the UK indicate that there are six companies operating around 960 sites, smaller groups operating around 60 sites and 3,000 to 4,000 independent sites. The TSA report that merger of two groups has resulted in a single group operating 640 sites, each with a single machine per site. Another company operates 150 sites, 100 with on-site processing each with an estimated 3 machines per site. A third company with 80 sites has 15 sites with on-site processing and a fourth company operates 30 sites. A fifth company operates 60 sites with most of the processing conducted at one central site. Small operators (with up to 10 sites each) operate a total of 60 sites. The vast majority of the 3000 to

[1] Tetrachloroethylene is used to provide the reactive environment in order to ensure that the hydroxyl group is in the alpha (or 1) position of 1-napthol.

4000 independents have one machine on each site but a small minority (less than 0.5 %) are assumed to have two machines (this may be one using tetrachloroethylene and one using 'hydrocarbon' –see section 5.3.3). In addition, there are so-called central processing units (small factories with a large number of machines and laundry sites processing work-wear as well as NHS hospitals processing patient dry-cleaning on-site).

This situation, however, may not be typical of other European countries; for example in Italy dry-cleaners tend to be smaller and run by the owners. No information was reported for other member states (Environment Agency, 2005A). The EU RAR for the environment has appended to it, further information made available by ECSA on the implications of the Solvents Emissions Directive (SED) on the dry cleaning and surface cleaning sectors with regard to the use and emissions of tetrachloroethylene (Environment Agency 2005B). In that appendix ECSA collated available data on machine numbers in each Member State and this is summarised in Table 1.4.

Table 1.4 Tetrachloroethylene dry cleaning machines in the EU15 (year 2000)- Data from EU RAR (appendix 4)

Member State	Number of Machines
Austria	500
Belgium	610
Denmark	270
Finland	450
France	8,910
Germany	4,700
Greece	2,000
Ireland (Incl. UK province of Northern Ireland)	570
Italy	24,000
Luxembourg	20
Netherlands	900
Portugal	900
Spain	4,800
Sweden	440
UK (Excluding UK province of Northern Ireland)	7,500

Source: ECSA data for Appendix4 of Environment RAR (Environment Agency 2005B)

In addition to the data shown in Table 1.4, data on the type of machine used is also available. Machine technology ranges from 'Type 1' to 'Type 4' machines, with progressively decreasing releases of tetrachloroethylene to the environment. It is possible to calculate emissions from the estimated split of different machine technologies in use in the year 2000 (see Table 1.5) and the data on emissions from each type of machine, overall solvent consumption, and emissions were calculated by ECSA.

Table 1.5 ECSA data for machine technology split in EU 2000 (Data from EU RAR, Appendix 4)

Country	Total Machines	Type 1 (open)	Type 2 (open)	Type 3 (closed)	Type 4 (closed)
Austria	500				500
Belgium	610	10	100	400	100
Denmark	270		270		
France	8910	0	450	8280	180
Greece	2000	800		1200	
Ireland	570	315		180	75
Italy	24000	0	3600	20200	200
Luxembourg	20				20
Netherlands	900		30	500	370
Spain/Portugal	5700	2900	200	1500	1100
Sweden & Finland	890				890
UK	7500	0	2000	2000	3500
West Germany	4700	0	0	0	4700
Total Tetrachloroethylene Machines	**56570**	4025	6650	34260	11635
	100%	7%	12%	61%	21%

Source: Environment Agency 2005B

The total emissions of tetrachloroethylene derived from these data results in a value of 44,309 tonnes per year. ECSA assumed that the dry-cleaning industry will need to invest in Type 4 machines to routinely meet the Solvent Emissions Directive limits.

1.2.4 Metal degreasing

Tetrachloroethylene, along with trichloroethylene and dichloromethane are used in the cleaning (degreasing) of metalwork and ceramics in the engineering industry. Methods of degreasing involve heating solvents and immersion of components in hot solvent or in solvent vapour. Because of its higher boiling point, tetrachloroethylene can be more effective in removing persistent deposits than other solvents (although the costs of heating the solvent can be higher). Degreasing is the second largest industrial use of tetrachloroethylene in the EU and UK, with approximately 16,000 tonnes per annum sold to companies in the EU in 2003. Tetrachloroethylene is the major degreasing solvent used in Germany (Environment Agency, 2005A).

Appendix 4 of the EU RAR for the environment (Environment Agency 2005B), reports that there are a number of technologies associated with surface cleaning processes with corresponding levels of releases of tetrachloroethylene to the environment. These machines range from Type 1 machines, which are open to the atmosphere, to Type 4 machines which are fully enclosed with refrigeration, active carbon filters and without exhaust air. Data on the number and type of machines used within the EU (for year 2000) gathered by ECSA is summarised in Table 1.6.

Table 1.6 Numbers and types of degreasing machines in the EU for year 2000 (Data from EU RAR Appendix 4)

Member State/grouping	Total	Type 1 (full emissive)	Type 2 (enclosed)	Type 3 (closed with exhaust air)	Type 4 (closed without exhaust air)
Austria/ W Germany	1,460	60	0	0	1400
Belgium	30	10	10	20	0
Denmark	0	0	0	0	0
Finland	-	-	-	-	-
France	258	250	0	0	8
Greece	10	10	0	0	0
Ireland/UK	64	14	0	30	20
Italy	2,000	0	0	1,400	600
Luxembourg	10	0	0	0	10
Netherlands	40	0	0	40	0
Portugal/ Spain	510	50	150	300	10
Sweden	15	0	0	0	15
Total number per type	4,397	334	170	1,830	2,063

From the numbers of each type of machine in use in EU during year 2000, ECSA calculated that the annual tetrachloroethylene consumption would be 13,134 tonnes and annual emissions would be 3,527 tonnes. ECSA believes that only Type 4 machines (i.e. enclosed machines fitted with refrigeration, activated carbon and closed loop drying) can meet the emission limits under the Solvent Emissions Directive. ECSA therefore predicts an annual consumption of tetrachloroethylene in metal cleaning of 10,240 tonnes after 2007 and annual emissions to air from tetrachloroethylene used in metal cleaning of 633 tonnes after implementation of the Solvent Emissions Directive in 2007 (assuming no change in the number of tetrachloroethylene machines).

The difference between quantities of tetrachloroethylene consumed and emissions from these applications implies a considerable quantity of tetrachloroethylene solvent remains in residues from the cleaning processes. ECSA states that it anticipates that much of this solvent will be recovered for reuse and hence production of tetrachloroethylene is likely to decrease. This recovery is described by ECSA as 'internal', meaning that it is captured by better recovery mechanisms in the machines and is reused in the same process. It is assumed that residues are currently disposed of (see section 2.2.1 on disposal).

ECSA state that regulatory pressure on tetrachloroethylene use may also encourage metal cleaners to use other solvents as they invest in new equipment (Environment Agency 2005B).

1.2.5 Other uses

Other uses for tetrachloroethylene are set out in the RAR and include:

- Use in spot stain removal during the production of textile fabrics;
- Use as a biocide for the treatment of textiles against insects (now prohibited)[2];
- Use in some spot stain removers;
- In paint removers;
- In heat transfer media;
- In the preparation of photo-polymer plates;
- In oil refineries for regeneration of catalysts;
- As a solvent in paints;
- To degrease electrical components during refurbishment; and,
- To degrease chamois leathers.

All of the above uses are considered to be both minor in comparison with other uses and in decline (Environment Agency, 2005B).

[2] The use of tetrachloroethylene as a biocide has not been notified within the 'Second Review Regulation' (Commission Regulation 2032/2003) under the Biocidal Products Directive (98/8/EC).

2. Risk Assessment

2.1 Hazardous properties and environmental effects

2.1.1 Effects on the environment

Table 2.1 provides a summary of the key ecotoxicological endpoints used in the environmental risk assessment (Environment Agency, 2005A) for derivation of the 'predicted no effect concentration' (PNEC) used in determining the need for limiting the risks.

Table 2.1 Ecotoxicological endpoints used in risk assessment

Environmental Compartment	Endpoint	PNEC
Surface Water	NOEC[1] 0.51 mg/l water flea (*Daphnia magna*); 28 day reproduction test	51 µg/l using assessment factor of 10
Wastewater treatment plants	IC_{50} 112 mg/l nitrifying bacteria (*Nitrosomonas sp*); 24 hour inhibition.	11.2 mg/l using assessment factor of 10
Sediment	Derived by equilibrium partitioning method (using $PNEC_{aquatic\ organisms}$)	318 µg/kg (wet weight)
Terrestrial	NOECs ≤0.1 mg/kg (wet weight) determined for nitrification with loam soil.	0.01 mg/kg (wet weight) using assessment factor of 10
Terrestrial (aerial exposure)	NOEC values for 12 plant species (endpoints related to growth and reproduction). Species sensitivity distribution HC5 (50%) [2] of 41 $\mu g/m^3$	8.2 $\mu g/m^3$ Using assessment factor of 5.
Secondary poisoning	As tetrachloroethylene shows no indications of accumulating in the food chain, an assessment of secondary poisoning was not carried out	N/A

[1] No observed effect concentration;

[2] Hazardous Concentration - the point in the species sensitivity distribution (SSD) below which 5% of species occur (with 50% confidence intervals).

Source: Environment Agency 2005 A

As indicated in the Environmental Risk Assessment Report, the classification of tetrachloroethylene in relation to environmental effects is as follows:

N:R51/53 Dangerous for the Environment; Toxic to aquatic organisms; May cause long-term adverse effects in the aquatic environment

2.1.2 Effects on humans (relevant to exposure via the environment)

The risk assessment including the effects on humans via the environment is to be completed by the UK Health and Safety Executive (HSE). It is believed that this will be not be available before the latter part of 2005 and therefore not within the time-scale of the production of this Risk Reduction Strategy.

2.2 Environmental exposure assessment

2.2.1 Environmental releases of tetrachloroethylene

Releases of tetrachloroethylene may be from both point or diffuse sources and the most significant environmental exposure is by the aerial route.

Point source releases of tetrachloroethylene may occur through its production and use as a chemical intermediate. Other releases of tetrachloroethylene are from its use in dry cleaning and as a metal degreasing agent. As these releases are likely to occur from many different sites release is considered to be diffuse on a regional scale. Section 1 of this report reviewed the current situation with respect to current production and use of tetrachloroethylene in the EU. Although there has been a continued decline in the sales of tetrachloroethylene since 1999 (see Figure 1.2), production figures have fluctuated in recent years (see Figure 1.1). The main releases to the environment continue to be from production and its use as and intermediate (e.g. for the manufacture of HFCs and HCFCs) and from dry cleaning and metal degreasing. Releases to the environment from production and uses are reviewed below.

Production

The EU risk assessment report (RAR) considered one production and processing site, four production only sites and one processing only site. Releases to air and water from these sites, using data from the RAR, are presented in Table 2.2. The RAR concluded that there was a need to limit risks for production and use as an intermediate, furthermore based on site-specific data the conclusion relates to only one site (this is 'Site A' see Table 2.2). However, as mentioned in Section 1.2, there is one further production and processing plant in the expanded EU that was not considered in the RAR. This further tetrachloroethylene manufacturing was assessed through company contact and the use of a detailed questionnaire to gather information regarding production, use, abatement and emissions. Based on the response given to questions, the site has been excluded from further assessment as a result of the small quantities of tetrachloroethylene that is produced annually (6000 te), resulting in an calculated annual release to the environment of approximately 2416 kg. The company is currently working within the defined limits of: 20mg/m^3 for mass flows of tetrachloroethylene above 100 g/h and <30g[3] tetrachloroethylene per kg of cleaned textiles (dry cleaning).

[3] This is the current limit imposed by the regulator for this site. The limit under the Solvent Emissions Directive will be 20g tetrachloroethylene per kg of cleaned textiles (see Table 3.2)

Table 2.2 Specific annual releases of tetrachloroethylene to air and water from sites considered in the risk assessment - Data from EU Risk Assessment Report

Site	Production capacity, tonnes/year	Use as an intermediate	Release to air, kg/year	Release to water, kg/year
A	No data [see note 1]	Yes	220,000(00)	244 to on-site treatment
B	65,000 (94)	No	5400 (94)	110
			3000 (Fugitive)	
C	4064 (93)	No	450 (not stated)	30
D	22,246 (93)	No	0.7(not stated)	5
E	21,255 (95)	-	3,600(95)	53
F	-	Yes	400 (not stated)	25

Notes: 1. In the RAR the production capacity for site A was assumed to be 11,000 tonnes per year

2. Numbers in parentheses are year dates of data

The specific daily emission rates for release from production and use as an intermediate used in the risk assessment are set out in Table 2.3

Table 2.3 Summary of specific daily releases to air and water Data from EU Risk Assessment Report

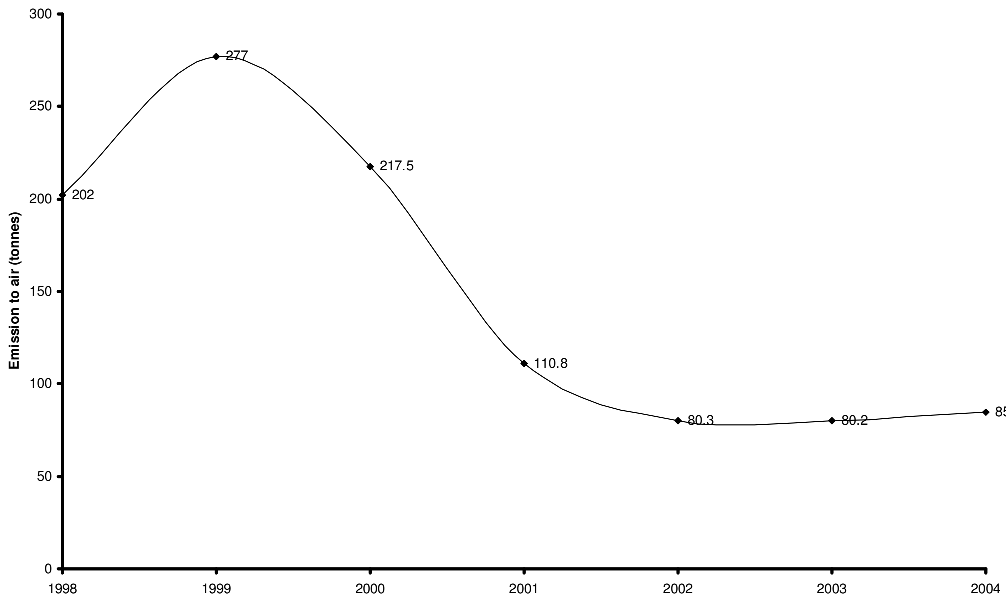
Site	Release to air, kg/day	Release to water, kg/day
A	733	0.81
B	28	0.37
C	1.5	0.1
D	0.002	0.02
E	12	0.2
F	1.3	0.08

Notes: Emissions are based on an assumed 300 working days per year

By comparison, it can be seen from Tables 2.2 and 2.3, that with the exception of Site D, releases to air (atmospheric compartment) are much greater than those to the aquatic compartment. It is also clear that the largest single releases are from Site A. The total emissions to air from production and use as an intermediate for all sites calculated in the RAR were 776 kg/day and 1.6 kg/day to air and water, respectively. In the risk assessment, the highest emission to air and to water was used to calculate the regional emissions. For the continental scenario, the total emissions excluding those for the region were used. For the regional and continental scenarios, emissions were averaged over a full year. (A summary of releases to atmosphere at local, regional and continental scales is set out in Table 2.4.)

The risk assessment concluded a need to control the risk to the environment from production and use as an intermediate existed for one site only (Site A). The emissions data from the year 2000 was used to calculate the emission rate in the risk assessment (see Table 2.3); although the local predicted environmental concentration (PEC) was based on measured monitoring data (the date for this monitoring data is not given in the risk assessment). Available data on emissions to air for Site A are presented in Figure 2.1 below. The chart in Figure 2.1 shows data for emissions to air from the year 1998 to 2004. It can be seen that the emissions from Site A declined from 217 tonnes in 2000 to 85 tonnes in 2004. Based on the emission datum for 2004 of 85 tonnes per year, an emission rate of 220 kg/day can be calculated, assuming 300 emission days (*cf.*733 kg/d for 2000). Assuming a linear relationship between emission tonnage and local exposure concentration, the emissions of 283 kg/day would lead to a PEC of 14 $\mu g/m^3$. Therefore, emissions at 2004 levels would still cause a risk to the environment, albeit at a reduced risk reduction ratio of 1.7 (*cf.* 4.4 in the RAR).

Figure 2.1 Emissions of tetrachloroethylene to air from Site A for years 1998 -2004 (Data from operators of Site A)



Dry cleaning

The risk assessment based its calculations on the 1994 volume of tetrachloroethylene sold for use in the dry cleaning industry, which was 62,400 tonnes per year. It was assumed in the risk assessment that the quantity of tetrachloroethylene used in dry cleaning each year goes to replace that lost (i.e. from all emissions and disposal). The total losses were 62,400 tonnes per year comprising 47,726 tonnes from open machines and 14,678 tonnes from closed machines The total air emissions from dry cleaning were 42,953 tonnes (i.e. 90% of 47,726) from open machines 7,852 tonnes (i.e. 53.5% of 14,678) from closed machines, giving an overall total of 50,805 tonnes emitted to air.

As a worst case, it was assumed that 10% of the total machines (i.e. 6,000) were in the region (i.e. the proportion of the total machines in the EU in one notional Member State) and that they were all open type machines. This gave an emission of 10,309 tonnes/year, or 28,244 kg/day to air. The continental emission was 40,496 tonnes/year (110,948 kg/day). For release to the aquatic compartment the daily releases were estimated at between 3×10^{-4} kg/day and 3.75×10^{-3} kg/day depending upon the type of machine used and quantity processed. The release for open circuit machines with activated carbon filters (3×10^{-3} kg/day) was used in the EU risk assessment.

Metal degreasing

Tetrachloroethylene is used within the metal industry as a cleaning agent. However, the exact pattern of use in the EU and environmental releases was not known at the time that the risk assessment was prepared. For the purposes of calculating a predicted environmental concentration (PEC) from this use, data were derived from the experience of the UK metal finishing industry. In the UK tetrachloroethylene and trichloroethylene are the main solvents used in the metal finishing industry for metal cleaning. Of these, trichloroethylene is thought to have had the widest application in the past. At the time of preparing the risk assessment report tetrachloroethylene was thought to be used mainly by small to medium scale processors, while large scale processors were thought to use trichloroethylene. In the RAR, the tonnage of tetrachloroethylene chosen for the local scenario was thought to be most representative of the local situation in the UK.

For the local scenario a small to medium scale processor using 10 tonnes tetrachloroethylene per year and operating for 210 days per year (i.e. the EUSES default value) was assumed. The tonnage supplied to the metal cleaning industry was estimated to be 14,000 tonnes based on 1994 figures (note that in 2003 this was 16,000 tonnes, see Table 1.3). Regional releases were taken as 10% of the total releases. The release pattern of tetrachloroethylene to the environment is taken as 90% to air, 1% to water and 9% in solid wastes. It was assumed that the solid wastes would typically be disposed of as special wastes though they may be co-disposed of to landfill.

Disposal

The RAR stated that incineration was the preferred disposal option for tetrachloroethylene-containing wastes, such as the solid residues from dry cleaning, and was recommended by ECSA to its members (Environment Agency 2005A). The RAR reports that according to the Hazardous Waste Directive (91/689/EEC), wastes containing less than 25% tetrachloroethylene (as it is classified as harmful) may be disposed to landfill as non-hazardous and that disposal to landfill of tetrachloroethylene-containing wastes may potentially lead to groundwater contamination via leachate; however no information on this potential exposure was reported in the risk assessment report[4]. Current legislation (Council Decision 2000/532/EC[5] of Directive 91/689/ EEC) on the disposal of hazardous wastes sets various limits.. Relevant limits for the disposal of tetrachloroethylene in solid waste to landfill are 2.5% as its hazard is 'H14-ecotoxic' resulting from its R51/53 risk phrase (see Table 3.3) and 1% as it is 'H7 – carcinogenic' resulting from its R40 risk phrase (see Table 3.3). Hazardous liquids are also

[4] The RAR intentionally did not address the risks arising from groundwater contamination.

[5] Subsequently amended by Commission Decisions 2001/118/EC, 2001/119/EC and Council Decision 2001/573/EC

prohibited from disposal to landfill, therefore disposal of tetrachloroethylene to landfill would only be permitted for up to 1% of substance adsorbed onto solid material (such as filter cake).

In the RAR, emissions to air of tetrachloroethylene from landfill sites were estimated at 300 tonnes per annum in the United Kingdom. As no other information on releases from landfill sites was reported, this value was taken as an estimate of regional releases. Continental releases were taken 3000 tonnes a year to the atmosphere (Environment Agency 2005A).

Other uses

Other uses were not reported as having known, quantified or significant releases of tetrachloroethylene to the environment. The releases from production and use with estimated and/or assumed emission factors used in the risk assessment are summarised in Table 2.4.

Table 2.4 Summary of atmospheric releases - Data from EU Risk Assessment Report

Process	Emission factor	Release (kg/day)		
		Local	Regional	Continental
Production and use as a chemicals intermediate	See Note 1	733	602	35
Dry Cleaning	90% open, 53.5% closed	15.5	28,244	110,948
Metal Degreasing	90%	42	3452	31,068
Disposal to landfill	See Note 2		822	7,397
Total			33,120	149,448

Source: Environment RAR (Environment Agency 2005A)

Note 1: Site-specific data were available for all sites and were used in the risk assessment

Note 2: Estimated emissions from a UK source were used in the risk assessment (i.e. not as a percentage of disposed)

2.2.2 Environmental exposure

Tetrachloroethylene is used mainly in dry cleaning, metal degreasing and for the manufacture of other chemicals. Its main release to the environment is through its use in metal degreasing and dry cleaning and from its production and use as an intermediate (production and use as an intermediate were considered together in the risk assessment). Tetrachloroethylene is released mainly to the atmosphere; in the risk assessment, proportions of releases to different environmental media were based on specific data, except for metal cleaning where the release pattern of tetrachloroethylene to the environment was assumed to be 90% to air, 1% to water and 9% in solid wastes. The predicted environmental concentrations (PEC) that were calculated and used in the risk characterisation of the EU RAR are set out in Table 2.5.

Table 2.5 Predicted Exposure Concentrations (PEC) for the environment (Data from EU Risk Assessment Report)

Area scale	PEC value
Local	Surface water (measured) = 5 µg/l
	Sediment (calculated) = 57 µg/kg, Sediment (measured) = 50 µg/kg
	Air (site specific measured concentration) = 36 µg/m^3
	Air (calculated) = 168 µg/m^3
	Agricultural soil (calculated) = 2.5 µg/kg
Region	Surface water (calculated) = 0.011 µg/l
	Air (calculated) = 0.88 µg/m^3
	Agricultural soil (calculated) = 5.3 x 10^{-3} µg/kg
Continent	Surface water (calculated) = 0.0015 µg/l
	Air (calculated) = 0.32 µg/m^3
	Agricultural soil (calculated) = 1.7 x 10^{-3} µg/kg

Source: Environment Agency (2005A)

2.2.3 Exposure of man via the environment

Indirect exposure of humans via the environment may occur by consumption of food (fish, crops, meat and milk) and drinking water, inhalation of air and ingestion of soil (exposure via soil ingestion and dermal contact is not addressed because they represent significant exposure routes only for specific situations of soil pollution). Indirect exposure is assessed by estimating the total daily intake of a substance based on the predicted environmental concentrations for (surface) water, groundwater, soil and air. Combined exposure scenarios, where humans are exposed through the environment and through consumer exposure, are also relevant in this context.

In the EU risk assessment indirect exposure of man via the environment was calculated using a combination of the measured and the predicted levels. The predicted levels of tetrachloroethylene in biota and food products were calculated using EUSES. In the calculations the concentrations resulting from production and processing, dry cleaning and metal cleaning were calculated separately. The calculation for production and processing was based on the largest emissions to air and to water. The highest estimated concentration in water from the site-specific calculations was used to estimate uptake from drinking water and in fish, and the air concentration used was the measured value for Site A. The scenarios were therefore a composite and a worst case combination.

The daily human intake of tetrachloroethylene was estimated using the EUSES program, and the calculations used were in agreement with the procedure described in the EU Technical Guidance Document for assessing the indirect exposure of man via the environment. The estimation was based upon typical human consumption and inhalation rates. The total human dose of tetrachloroethylene was calculated as 0.01 mg/kg/day for the local environment (production and processing) and 2.5 x 10^{-4} mg/kg/day for the regional environment. The regional values as calculated by EUSES are set out in Table 2.6 below.

Table 2.6 Regional human intake of tetrachloroethylene from concentrations in air, water and land (Data from EU Risk Assessment Report)

Concentrations in air, water and biota intake	Human consumption or intake rate per day	Human intake via indirect exposure (µg/kg/day)
Air = 0.88 µg/m^3	20 m^3/d	0.25
Drinking water 0.5 µg/l	0.002 m^3/d	0.014
Fish 0.315 µg /kg	0.115 kg_{wwt}/d	5.2 x 10^{-4}
Plant (leaves) 4.86 x 10^{-3} µg/kg	1.20 kg/d	8.3 x 10^{-5}
Plants (roots) 5.18 x 10^{-3} µg/kg	0.384 kg/d	2.8 x 10^{-5}
Meat 9.2 x 10^{-4} µg/kg	0.301 kg/d	4 x 10^{-6}
Milk ~10 µg/kg	0.561 kg/d	0.08
Total		0.34

Source: Environment Agency (2005A)

Total environmental exposures of 0.34 µg/kg/d for the regional model[6] and 1,443 µg/kg/d for local model (i.e. living near a dry cleaner) and 23.7 µg/kg/d (i.e. living near manufacturer), were estimated. It can be seen from Table 2.6 that the regional intake is dominated by aerial exposure as is the local model (see Table 2.7).

[6] i.e. 2.5 µg/kg/d estimated by EUSES (see Table 2.6) plus the background drinking water value (see Table 2.7)

Table 2.7 Human intake of tetrachloroethylene from concentrations in air, water and land- (Data from EU Risk Assessment Report)

Concentrations in air, water and biota intake	Human consumption or intake rate per day	Human intake via indirect exposure ($\mu g/kg_{bw}$/day) [1]
Air: Fugitive emissions from dry cleaners 0.88 µg/m^3	20 m^3	1,429
Air: production plants 36 µg/m^3	20 m^3	10
Drinking water (reasonable worst case) 12.2 µg/l	0.002 m^3	0.35
Fish (reasonable worst case) 200 µg/kg	0.115 kgwwt	0.33
Leaf/stem crop (reasonable worst case) 2 µg/kg	1.20 kg	0.03
Root crop (reasonable worst case) 2 µg/kg	0.384 kg	0.011
Meat (reasonable worst case) 5 µg/kg	0.301 kg	4.95
Milk/Dairy products (high background levels) ~10 µg/kg	0.561 kg	0.08
Milk/Dairy products (reasonable worst case) ~1000 µg/kg	0.561 kg	8.01
Total daily intake		
Living near dry cleaners		1,443 [2]
Living near manufacturer		23.7 [2]

Notes:

[1] Assumes 'standard body weight' of 70 kg and intake of 100%;

[2] Reasonable worst case assumption

Source: Environment Agency, 2005A

The human health risk assessment is currently only available in draft form (it is currently being finalised by the UK Health and Safety Executive). Information from the draft report dated October 2004 was used for the current report. The key health effects of potential concern relevant for indirect exposure via the environment are repeated dose toxicity, mutagenicity, carcinogenicity and reproductive toxicity. Repeated dose toxicity, mutagenicity and carcinogenicity, however, are still under consideration by the UK HSE.

The human health risk assessment report states that the most significant human exposure via the environment is likely to occur in flats above dry-cleaning establishments. Exposure to a person living above a dry-cleaning establishment and eating food that has been stored in the vicinity is regarded as a foreseeable worst-case scenario for exposure via the environment. This gives a predicted exposure of approximately 1,429 µg/kg/day from air and 15.7 µg/kg/day from food. This is equivalent to a total predicted exposure of 1,445 µg/kg/day (1.45 mg/kg/day).

For this scenario in relation to reproductive toxicity, in humans there was no clear evidence that exposure to tetrachloroethylene results in an increased risk of developmental toxicity including spontaneous abortion. One hundred ppm (690 mg/m^3) was selected as the developmental toxicity NOAEC to take forward to the risk characterisation.

The predicted worst case exposure for humans via the environment is 1.45 mg/kg/d. This is a factor of 49 below the internal NAEL of 71 mg/kg/d identified for this endpoint. This margin of safety (i.e. the NOEAL/total daily intake) is not considered to provide sufficient reassurance that adverse effects on development will not occur. Therefore, the report proposes a conclusion (iii) (*There is a need for limiting the risks; risk reduction measures which are already being applied shall be taken into account*) for this scenario

For combined exposure, consideration was given to a consumer who may also be exposed indirectly via the environment. A worst case scenario would be a consumer exposed daily from wearing freshly dry cleaned clothes (1.2 mg/kg/day for a 70 kg individual), and who also lives in the vicinity of a dry cleaning establishment and consuming food stored in the vicinity (1.45 mg/kg/day), which is equivalent to a total of 2.65 mg/kg/day. The key health effects of potential concern relevant for combined exposure are repeated dose toxicity, carcinogenicity and reproductive toxicity.

The predicted worst case exposure for a consumer who may also be exposed indirectly via the environment is 2.65 mg/kg/d. This is a factor of 27 below the internal NAEL of 71 mg/kg/d identified for this endpoint. Again, this margin of safety was not considered to provide sufficient reassurance that adverse effects on development will not occur. Therefore conclusion (iii) was also proposed for this scenario.

As stated above, the human health risk assessment for repeated dose toxicity and carcinogenicity is not currently complete and in addition, **the risk assessment for human health is yet to be finalised and published by the Commission**. Consideration of the above conclusions on human exposure through the environment is not taken further in this risk reduction strategy as the conclusions are draft and have not been agreed. Further to this, the agreed scope of this risk reduction strategy development did not include the consideration of endpoints for human health through the environment.

2.3 Environmental risk characterisation

2.3.1 Environment

In the risk assessment, exposure concentrations were calculated for each of the environmental compartments at local, regional and continental scales. The predicted no-effect concentration (PNEC) and the predicted environmental concentration (PEC) for each environmental compartment have been set out in Tables 2.1 and 2.5, respectively. The only risk ratio (i.e. PEC/PNEC) that is greater than unity (i.e. indicating a need for limiting the risk) is that for aerial exposure to plants (the PNEC being 8.2 $\mu g/m^3$), arising from production and use as an intermediate at a particular site (Site A), the PEC being the measured value of 36 $\mu g/m^3$, with a resultant risk ratio of 4.4. A summary of the risk characterisation for each environmental compartment is set out in Table 2.8 below.

Table 2.8 Summary of risk characterisation for each environmental compartment (Data from EU Risk Assessment Report)

Compartment	PEC value	PNEC value	PEC/PNEC
Surface Water	5 µg/l	51 µg/l	0.1
Sediment	57 µg/kg	318 µg/kg	0.18
Sewage Treatment	16 µg/l	11.2 **mg**/l	0.001
Terrestrial - soil	0.39 µg/kg (production)	10 µg/kg	0.039
	0.06 µg/kg (dry cleaning)		0.006
	2.5 µg/kg (metal cleaning)		0.25
Atmosphere	36 µg/m^3 (production)	8.2 µg/m^3	4.4
	4.4 µg/m^3 (dry cleaning)		0.53
	7.7 µg/m^3 (metal cleaning)		0.94
	0.88 µg/m^3 (regional background)		0.11

Source Environment Agency 2005A

3. Current Risk Reduction Measures

3.1 Overview

This section reviews the measures that are currently in place that address the risks to the environment associated with tetrachloroethylene. Table 3.1 below summarises these measures that are then discussed in turn.

Table 3.1 Current risk reduction measures for tetrachloroethylene

Current measure	Life cycle stages affected
Integrated Pollution Prevention and Control (IPPC)	Production and use as an intermediate
Solvent Emissions Directive	Dry Cleaning and metal degreasing/cleaning
Classification and labelling	All production and use
Emission Limit Values	All production and use
National legislation	Variable

3.2 Control of air emission under IPPC

Integrated Pollution Prevention and Control was introduced through Directive 1996/61/EC. The IPPC Reference Document on Best Available Techniques (BREF) in the Large Volume Organic Chemicals Industry (European Commission, 2003) has been consulted in order to review guidance on emission limits for the production of tetrachloroethylene and its use as an intermediate in the production of other chemicals, such as HFC and HCFCs.

In the BREF, it is noted that the UK has indicated that best available techniques (BAT) can be used on point releases of different classes of VOCs from new processes to achieve so-called 'Benchmark Levels' (country-specific guidance may override the EU benchmark levels). The German TA-Luft classification system is used by several member states as a basis for permitting within national legislation or guidance. It is also the basis for a system developed in the UK (UK Environment Agency, as cited in the BREF) that identifies three classes of VOC and requires a commensurate level of prevention and control of each class. The three classes are:

- Extremely hazardous to health - such as benzene, vinyl chloride and 1,2-dichloroethane
- Class A compounds - that may cause significant harm to the environment (e.g. acetaldehyde, aniline, benzyl chloride)
- Class B compounds - that have lower environmental impact.

In the UK, the Environment Agency has classified tetrachloroethylene as a 'medium risk', Class A VOC for the purposes of a number of regulatory roles including IPPC (Environment Agency, 2004B). Therefore, a benchmark emission level of 20 mg/m^3 applies to a mass threshold flow of greater than 100 g/h. These limits are the same under TA-Luft for Class I substances and are also the same as those set out in the Solvent Emissions Directive (1999/13/EC)[7].

The calculated emission values in the risk assessment, as set out in Section 2 of this document, give a local scale emission rate of 0.733 tonnes per day from production and use as an intermediate (= 30.5 kg/h). The concentration in local air emission reported in the risk assessment was estimated using a Gaussian plume model in the RAR giving a C_{local} (local concentration) of 204 µg/m^3, this value was used to derive the local PEC of 168 µg/m^3, although a monitored concentration of 36 µg/m^3 was used as the PEC in the risk characterisation (see Table 2.5).

With regard to the IPPC permitting process at member state level, in the UK for example, the Environment Agency guidance for IPPC installations for Environmental Assessment and the Appraisal of BAT (Environment Agency 2002B), sets out the methodology for assessing the direct impacts of substances released to air on human and ecological receptors. This is done by estimating the concentration of each substance as dispersed into air (the Process Contribution) and comparing it against the appropriate environmental benchmark concentration. The 'environmental benchmark' is either the Environmental Quality Standard (EQS) or an Environmental Assessment Level (EAL). As there is not an air EQS for tetrachloroethylene, an EAL is adopted.

The EAL is the concentration of a substance which, in a particular environmental medium, the regulators regard as a value to enable a comparison to be made between the environmental effects of different substances in that medium and between environmental effects in different media and to enable the summation of those effects. Ideally, EALs defined should:

- Be based on the sensitivity of particular habitats or receptors (in particular three main types of receptor should be considered, protection of human health, protection of natural ecosystems and protection of specific sensitive receptors, e.g. materials, commercial activities requiring a particular environmental quality);
- Be produced according to a standardised protocol to ensure that they are consistent, reproducible and readily understood;
- Provide similar measure of protection for different receptors both within and between media; and,
- account of habitat specific environmental factors such as pH, nutrient status, bioaccumulation, transfer and transformation processes where necessary.

---

[7] The BREF indicates that although LVOC processes are not covered by the scope of the Solvent Emissions Directive, it nonetheless provides some useful guidance on the prevention and reduction of air pollution from solvent emissions. An emission limit of 2 mg/Nm^3 applies for carcinogenic, mutagenic or toxic VOCs, where the mass flow exceeds 10g/h. For halogenated VOCs with risk phrase R40 (which applies to tetrachloroethylene) an emission limit value of 20 mg/Nm^3 applies where the mass flow exceeds 100g/h.

EALs derived in this consistent manner are not always available; therefore, interim values based on published information have been adopted. The EAL for tetrachlroethylene is 3,450 µg/m^3 for long term and 8,000 µg/m^3 for short term.

The Process Contribution (PC) is the product of release rate and a dispersion factor (which is dependent on the effective height of emission). Within the UK guidance for IPPC (Environment Agency 2002A), a decision to undertake further assessment of emissions is based on the Process Contribution being greater than 1%, of the long term EAL and 10% of the short term EAL. A decision to undertake modelling of long-term effects may be appropriate if the Predicted Environmental Concentration (PEC, i.e. the sum of the PC and the background concentration) is above 70% of the EAL, and modelling of short-term effects may be appropriate if the short-term PC is more than 20% of the difference between the (long-term) background concentration and the relevant short term environmental benchmark (EQS or EAL).

The normal operation of the site relates to the situation in which abatement equipment is in operation and for this situation the long-term EAL applies. However, from time to time abatement equipment may not be available for a number of reasons (for example, for maintenance); in this situation the emissions to the environment are at a maximum. This relates to the short-term PC and therefore the short-term EAL applies. Further to this, the IPPC assessment of a site assumes that it is operating at its maximum capacity.

Based on information provided in consultation (see Appendix A), at Site A the PC was less than 1% of the long-term EAL (i.e. 3,450 µg/m^3) and the short-term PC was less than 10% of the short-term EAL (i.e. 8,000 µg/m^3). This being the case, under the guidance of the IPPC regulator for Site A, no further assessment of the emissions is required.

With regard to the above, it should be noted that an IPPC permit may be reviewed at any time by the regulator. The regulator can impose stricter requirements for emissions and may impose conditions to monitor the environmental concentrations of regulated substances. Within IPPC, account can be taken of the conclusion of the RAR as well as monitoring of local environmental concentrations. Consideration of the PNEC from the RAR could also be made in the development of the EALs for use within IPPC.

3.3 Solvent Emissions Directive

3.3.1 Overview of legislation

Directive 1999/13/EC was implemented with the intention to prevent or reduce the direct and indirect effects of emissions of volatile organic compounds (VOCs[8]) on the environment and human health. It provided measures and procedures to be implemented for the activities defined in Annex I to the Directive (where such activities are operated above certain solvent consumption thresholds).

Operators of new plants covered by the Directive have the following options:

---

[8] VOCs include any organic compound having at 293.15 K a vapour pressure of 0.01 kPa or more, or having a corresponding volatility under the particular conditions of use.

- An emission limit compliance option involving either adherence to certain emission limits specified in relation to process and fugitive[9] emissions; or
- A ‘reduction scheme’ where emissions reductions at least equivalent to those under the emission limit option are achieved through other means (this mainly relates to use of low VOC coatings).

All new qualifying installations (coming into operation after 11th March 1999) are required to comply with the main requirements of the Directive immediately and existing installations have until 31st October 2007 to comply with the majority of the requirements. Both new and existing installations covered by the Directive must be registered or undergo authorisation by the competent authorities in the Member States.

In addition to the main requirements on compliance with general emission limits for VOCs or the reduction scheme, there are specific requirements related to certain substances. Substances and preparations based on VOCs and classified as carcinogens, mutagens, or reproductive toxins[10], are required to be replaced as far as possible by less harmful substances or preparations within the shortest possible time. Where the mass flow of these compounds is greater than, or equal to, 10 g/h, an emission limit value of 2 mg/Nm^3 is specified (for the mass sum of the individual compounds).

For discharges of halogenated VOCs which are assigned the risk phrase R40, where the mass flow of the compounds is greater than, or equal to 100 g/h, an emission limit value of 20 mg/Nm^3 applies. The discharge of the above types of compounds (often termed ‘risk phrase solvents’) is required to be controlled by use of contained conditions as far as technically and economically feasible to safeguard public health and the environment. As previously stated, tetrachloroethylene comes into the second of these two groups, as it is classified R40.

3.3.2 Application of the Solvent Emissions Directive to tetrachloroethylene uses

The Directive applies to a range of activities that generally require significant quantities of solvents, including:

- A range of coating and coating manufacturing activities;
- Surface cleaning;
- Dry cleaning;
- Wood impregnation;
- Footwear manufacture;
- Rubber conversion;
- Vegetable oil and animal fat extraction; and

---

[9] Fugitive emissions are any emissions not in waste gases of volatile organic compounds into air, soil and water as well as solvents contained in certain products. They include uncaptured emissions released to the outside environment via windows, door, vents and similar openings.

[10] Those required to carry the risk phrases R45, R46, R49, R60, R61.

- Manufacture of pharmaceutical products.

In relation to the uses for tertachloroethylene identified in the risk assessment, the specific activities and associated thresholds are as shown in Table 3.2.

Table 3.2 Activities covered by SED and relevant to tetrachloroethylene

Activity	Solvent Consumption Threshold	Emission Limit in Waste Gases and Fugitive Emission	Comments
Surface cleaning	1 tonne/ year [1]	20 mg/m^3 for stack emissions, 10/15% limits for fugitive emissions	No environmental risk identified
Dry Cleaning	All installations must meet maximum overall emissions to air of 20 g/kg of textile cleaned.		No environmental risk identified
Other coating and coating manufacturing activities	Various		Use of tetrachloroethylene in such activities is no longer believed to occur [2].

[1] Using solvents with risk phrases R45, R46, R49, R60, R61 or R40.

[2] Other possible or previous uses identified in the risk assessment include use for textile scouring, in leather preparation, spot stain removers, as a heat transfer agent, preparation of photo-polymer plates, as a solvent in paints, degreasing electrical components during refurbishment, in oil refineries for regeneration of catalysts, as a biocide for the treatment of textiles against insects. It is of note that many of these would be covered by the Directive (if they were still to occur, which is not believed to be the case).

The Solvent Emissions Directive requires Member States of the EU to implement controls on the emissions of volatile organic compounds and tetrachloroethylene is included. The two major disperse use areas for tetrachloroethylene, dry cleaning and metal cleaning, are both identified in the Directive. For dry cleaning, equipment is required to meet an emission rate of 20 g of tetrachloroethylene for every kilogram of product cleaned and dried. For surface cleaning, there are emission limit values for the concentration in waste gas (for all emitted compounds together) and limits to the fugitive emissions as a percentage of the solvent input. These vary with the quantity of solvent used on site each year. In each area, new equipment is to meet this standard on installation, while existing equipment has to be brought up to the standard by 2007.

For dry cleaning, in Appendix 4 of the Environmental Risk Assessment (Environment Agency, 2005B), ECSA assume that the dry-cleaning industry will need to invest in Type 4 machines (see Section 1.2.3) to routinely meet the Solvent Directive Limits. Although Type 3 equipment might be able to meet the 20 g/kg, the range of emissions (20-40 g/kg) suggests that they typically operate above this. The Solvent Emission Directive requires an overall operation within these limits. ECSA calculated, based on the assumptions that there is no change in the number of machines from year 2000 and that all machines convert to Type 4, dry cleaning applications emissions will be decreased to 8,553 tonnes tetrachloroethylene per year by the end of 2007 in order to meet the 20 g/kg textiles limit.

For surface cleaning, also set out in Appendix 4 of the Environmental Risk Assessment (Environment Agency, 2005B), on the basis of year 2000 data ECSA calculated the tetrachloroethylene consumption as 13,134 t/y, and emissions as 3,527 t/y. Also based on the year 2000 data for the numbers of machines in use ECSA predicted emissions to air from tetrachloroethylene used in metal cleaning after implementation of the Solvent Emissions Directive to be 633 t/y. However, ESCA noted that meeting the emission limits under the Solvent Emissions Directive or escape controls, through consumption being reduced below the 1 t/y threshold could only be achieved by use of enclosed machines fitted with refrigeration, activated carbon, and closed loop drying (i.e. Type 4 machines).

3.4 Classification and labelling of tetrachloroethylene

3.4.1 Overview of current classification and labelling

Table 3.3 summarises the current classification and labelling requirements for tetrachloroethylene. These requirements were fully introduced in the 22nd Adaptation to Technical Progress[11] of Directive 67/548/EEC of 30th July 1996.

Table 3.3 Current classification and labelling requirements for tetrachloroethylene

Requirement	Description
Classification	
Carc Cat 3: R40	Limited evidence of a carcinogenic effect.
N: R51/53	Dangerous for the Environment: Toxic to aquatic organisms; May cause long-term adverse effects in the aquatic environment
Labelling	
Xn, N	Harmful
R: 40, 51/53	As above
S (2), 23, 36/37, 61	Do not breathe dust.
	Wear suitable protective clothing and gloves.
	Avoid release to the environment. Refer to special instructions/safety data sheet.

3.4.2 Implications for producers and users

Under Directive 92/85/EEC (the ‘pregnant workers directive’), exposure of pregnant workers is prohibited to all substances listed in Annex II to the Directive, and also before being listed in Annex II, all substances and preparations classified with R40, R45, R46 and R47. This includes tetrachloroethylene as it is classified R40 (see Table 3.3 above).

11 OJ L 248, 30.9.1996, p. 1.

3.5 National legislation

3.5.1 Denmark

Tetrachloroethylene is included by the Danish Environment Protection Agency on its "List of Undesirable Substances" resulting from its classification for carcinogenicity: Carc. Cat 3. The list, which identifies industrial chemicals of very high concern, has no legal status but is a signal to industry to, as far as possible, avoid these chemicals when choosing chemicals for their production (Danish EPA 2004).

3.6 Preliminary conclusions on existing measures

As previously stated (Section 2.3.1), the only area where a need for limiting the risk to the environment was identified in the risk assessment is to terrestrial plant life from exposure to aerial emissions from production and use as an intermediate, this risk relates to only one site (Site A) in the risk assessment.

3.6.1 Integrated Pollution Prevention and Control (IPPC)

In terms of control under IPPC, although the regime assessed the emissions to the environment the environmental assessment levels (EALs) for tetrachloroethylene do not currently account for the PNEC developed within the RAR. Based on the emissions for Site A, with comparison to the relevant EALs, no further assessment of the emissions is required, largely as a result of the large dilutions afforded by the stacks at the site. However, if the PNEC is accounted for, and predicted environmental concentration under normal conditions of operation, and under condition in which emission abatement is not functioning are compared to the PNEC, a risk, is not indicted under normal (long-term) conditions, but there is an indicative risk with maximum emissions (without abatement). Therefore, even though account has not currently been taken of the conclusion of the RAR the risk to the environment is controlled under the normal operating conditions.

IPPC assessments consider a situation in which the maximum capacity of the installation is assessed, this therefore accounts for possible increases in production for plants not working at capacity. However, should a process change, or new plant be installed this would generally require a review of the IPPC permit and therefore assessment of emissions.

For IPPC, the regulator can impose stricter requirements for emissions and may impose conditions to monitor the environmental concentrations of regulated substances. Therefore, account could be taken of the conclusion of the RAR as well as monitoring on local environmental concentrations. Consideration of the PNEC from the RAR could also be made in the development of the EALs for use within IPPC.

3.6.2 The Solvent Emissions Directive

Although no risks from use of tetrachloroethylene in dry cleaning and metal degreasing were identified in the risk assessment it is noted that the Solvent Emissions Directive (SED) is expected to cause a significant reduction in use and emissions of tetrachloroethylene in dry cleaning and metal cleaning due to the requirement to impose limits on emissions to atmosphere. The SED is due to be implemented by 2007.

It may also be relevant that there is also a general trend away from the use of trichloroethylene as a result of the revised classification and labelling and the requirement to substitute trichloroethylene where practicable under the SED. One substitute for trichloroethylene is tetrachloroethylene; therefore decreasing the use of trichloroethylene could result in increased usage of tetrachloroethylene, although this is only of relevance to the metal cleaning sector.

4. Possible Further Measures

4.1 Range of available measures and screening

The Technical Guidance Document (European Commission, 1998) provides a range of different suggestions regarding measures that may be suitable for addressing various identified risks. Table 4.1 summarises the measures that could be used to control emissions of tetrachloroethylene from manufacture and industrial use (measures that would not impact upon the identified risks are excluded).

Table 4.1 Summary of possible risk reduction measures relevant for tetrachloroethylene

Possible Measures	Comments on Applicability for Further Consideration
Restrictions on marketing and use under Directive 76/769/EEC	Could remove all risks associated with manufacture or use of tetrachloroethylene.
Re-design of the process or changing substances/materials used in it	Could potentially reduce risks but this measure would form part of an overall policy measure (e.g. permitting in relation to emissions limits).
Classification and labelling	Classification already implemented and is already affecting use. Do not consider as a specific measure but ensure effects are taken into account in the baseline.
Monitoring and maintenance of equipment	Not considered to be directly relevant to addressing risks (which arise through the nature of the processes and equipment in place rather than the maintenance).
Licensing of operators or of certain operations	Producers and users for production of other chemicals will already be licensed (under IPPC). However, further controls could potentially be introduced through addition of specific requirements.
"End of pipe" controls to minimise, neutralise or render less harmful any emissions that cannot practically be avoided otherwise	Could (and are) be used to reduce emissions. Should be considered as part of regulatory requirements on emissions controls.
Environmental quality standards and/or monitoring	Generally more applicable to wider environmental concentrations (rather than local concentrations that are of interest here). However, consideration will need to be given to meeting concentration limits which adequately address the risks.

Source: European Commission (1998).

In addition, there is a range of policy tools that could be used to implement the chosen risk reduction measures, including:

- Information programmes and other EC/Government initiatives;
- Unilateral action by industry;

- Voluntary agreements;
- Technical standards and authoritative guidance;
- Economic instruments;
- Regulatory controls.

It was agreed by the steering group for this risk reduction strategy that the following four risk reduction options should be considered in detail:

- **'Do nothing'**. Based on the above analysis, it may be the case that the measures already in place will be sufficient to adequately limit the risks when fully implemented (e.g. Integrated Pollution Prevention and Control) Consideration should be given to quantifying whether these measures will be sufficient.
- **Emission limits or quality standards**. Whilst there are emission limits already in place through the IPPC Directive, these could potentially be strengthened to ensure that emissions are controlled enough to reduce the risks to an acceptable level (if existing measures are not sufficient).
- **Prohibit marketing and use**. A ban on marketing and use for production and use as an intermediate could remove the risk to the environment.
- **Voluntary emissions controls**. Rather than further limit emissions through legislation, voluntary action by the industry, negotiated with the authorities, could be taken to address the risks.

The views of producers and users as an intermediate of tetrachloroethylene were sought as part of this process (see Appendix A). In the remainder of this section, a brief background is provided on how these measures could be implemented for the sectors of interest in this risk reduction strategy.

4.2 Description of identified measures

4.2.1 Do nothing option

There is evidence, based on sales figures, that use of tetrachloroethylene is decreasing (Section 1) and also that emissions (in particular from production Site A) have decreased in recent years (see Figure 2.1).

Based on the assumptions set out in Section 3.2, IPPC alone may not be sufficient to control the risk identified for the environment. However, if consideration was given to the risk (as set out in the risk assessment) within the IPPC permitting process, this could include consideration of more recent monitoring and emission data to determine if emissions bring about environment risks and if so, for emissions to be controlled to below this level. Therefore, an analysis of the legislation that is currently being implemented could lead to the conclusion that the existing measures are sufficient to limit the risks.

4.2.2 Emission limits or quality standards (legislative)

Further quantitative limits on emissions from sites or on concentrations in the environment could potentially be introduced if the existing measures are not sufficient to limit the risks to an acceptable level.

Possible legislative means through which such controls could be introduced might include limits specified in European and national guidance for processes regulated under the IPPC regime. The main basis for setting emission limit values under the IPPC Regulations is the application of BAT, however where an environmental quality standard (EQS), as set out in community legislation, requires stricter emission limit values (ELVs) than those achievable under BAT, the regulator must impose those stricter limits. Tetrachloroethylene has an EQS for water quality (under Directive 76/464), but not for air quality. Specific legislation could be introduced in relation to tetrachloroethylene, for example under the air quality framework directive. As noted in Section 3.2, in the absence of an EQS value for air for tetrachlroethylene, the UK have adopted the use of interim Environmental Assessment Levels (EAL).

4.2.3 Marketing and use restriction

If it represents the most appropriate balance of advantages and drawbacks, restriction could be imposed on uses leading to an environmental risk, i.e. production and use as an intermediate. This could be achieved under Directive 76/769/EEC. As marketing and use restrictions can be highly specific, restrictions could apply at a site (or sites) involved in production and use as an intermediate, in order to limit the risk to the environment. The analysis of this option should therefore include consideration of the technical, economic, and environmental/health implications of the imposition of such restrictions, including the use of substitutes. Having stated this however, it should be noted again that the identified need for limiting the risk relates to only one site in the EU. Therefore, marketing and use restrictions may be unfairly detrimental to sites which have not been shown to pose a risk to the environment. Moreover, other legislative mechanisms and regimes may be more appropriate for the control of emissions (such as within IPPC, see above).

4.2.4 Voluntary emissions controls

Voluntary action could be taken by the industry concerned to ensure emissions from the relevant sector (i.e. production and use as an intermediate) are controlled to an acceptable level. The European Commission (2004) has indicated three possible means by which such agreements may arise:

i) Purely spontaneous decisions initiated by stakeholders where the Commission has neither proposed legislation nor expressed an intention to do so;

ii) A response by stakeholders to an expressed intention of the Commission to legislate; or

iii) Agreements initiated by the Commission.

Although voluntary agreements involve self-regulation by relevant organisations and are therefore not legally binding, the Commission may recognise such agreements. For self-regulation encouragement and/or acknowledgement is given by Commission where the Commission may stimulate an agreement by means of an exchange of letters with the relevant industry representatives or a Commission Recommendation. This could also involve a

Parliament and Council Decision on monitoring of the agreement. For co-regulation, the European Parliament and the Council Directive may stipulate that a precise, well-defined environmental objective must be reached on a given target date, including conditions for monitoring compliance. This may also include a follow-up mechanism in case of failure to deliver the objectives (e.g. legislation). Furthermore, where the Commission proposes co-regulation, it may include key elements based on existing or proposed voluntary agreements, which are satisfactory from the Commission's point of view. These may then be pursued in discussions with the other institutions.

5. Assessment of Possible Further Measures

5.1 Overview of assessment

The Stage 2 assessment relates to the production and use of tetrachloroethylene at one manufacturing site and provides an overview of the advantages and drawbacks of introducing possible further risk reduction measures. It is based on a combination of qualitative and quantitative data.

During the Stage 2 assessment, a further tetrachloroethylene manufacturing plant that was outside the scope of the risk assessment report (RAR) was assessed (see Appendix A), however, due to the relatively small quantity of tetrachloroethylene that is produced annually (6,000 tonnes), resulting in a calculated annual release to the environment of approximately 2,416 kg this has not been considered further in this study. The company is currently working within the defined limits of: 20mg/m^3 for mass flows of tetrachloroethylene above 100 g/h and <30g tetrachloroethylene per kg of cleaned textiles (dry cleaning)[12].

Section 5.2 provides a summary of the advantages and drawbacks of tetrachloroethylene itself. Section 5.3 details the assessment of risk reduction options against the production of tetrachloroethylene at Site A. It also provides an evaluation against a number of key decision criteria suggested in the Technical Guidance Document (European Commission, 1998), as well as a summary of the advantages and drawbacks for the possible measures. The decision criteria are as follows:

- *Effectiveness* - Measures must be targeted at those significant hazardous effects and routes of exposure where risks that need to be limited have been identified by the risk assessment; and must be capable of reducing the risks within and over a reasonable period of time;
- *Practicality* - Measures should be able to be implemented, enforceable and as simple as possible to manage (such that smaller enterprises are able to comply);
- *Economic impact* - This should include the impact of the measures on producers, processors, users and other parties; and
- *Monitorability* - Monitoring possibilities should be available to allow the success of the risk reduction to be assessed.

Appendix A provides a summary of some key information obtained from consultation with relevant industry representatives. This information should be referred to as appropriate when reading the following sections.

---

[12] As well as produce tetrachloroethylene and use it as a chemicals intermediate, it understood that it is also used for dry cleaning on the same site. It is understood that the value of >30g is that value currently applied by the regulator, however it is notes that this will reduce under the Solvent Emissions Directive.

In undertaking consultation with industry for this risk reduction strategy, information has been sought on current levels of emissions, as well as existing control techniques in place to limit the risks. This information is intended to provide a background on the current risk reduction measures in place, as well as a basis for estimating the technical and financial implications of different risk reduction measures. In no way does the information presented in this report bring in to question the conclusions of the environmental risk assessment, which was based on a realistic worst case assessment of the risks using the data available at the time[13].

5.2 Advantages and drawbacks of tetrachloroethylene

The key advantages of tetrachloroethylene relate to its technical properties in use, particularly in degreasing of metals and as a solvent for dry cleaning of textile products. Tetrachloroethylene and other chlorinated solvents are often the most effective method for cleaning metal components (ECSA, 2002). In economic terms, tetrachloroethylene is more expensive to purchase than some other solvents (for example, trichloroethylene).

The disadvantages of tetrachloroethylene, for the purposes of this risk reduction strategy, relate to its potential for adverse effects on the environment, albeit the risk to plant life from deposition of tetrachloroethylene from atmospheric sources. Technical and economic disadvantages of the substance itself are not considered.

5.3 Production and use as an intermediate of tetrachloroethylene

5.3.1 Do nothing option

In terms of *effectiveness*, whilst the 'do nothing' option would not sufficiently reduce the risks, regulation of the sites producing and using tetrachloroethylene as a chemical intermediate, under the IPPC regime may provide a vehicle to allow significant reduction of emissions to air as a result of the requirement to use the best available techniques (BAT) in controlling emissions. The technique identified for reducing emissions during production of tetrachloroethylene is thermal oxidation, i.e. incineration, as used at Site A. Furthermore, it is evident from historic data that significant reductions in emissions have been achieved using this technique.

Communication with relevant personnel at Site A (see Appendix A) has revealed that recent modifications to the solvent plant's ventilation system which mean that currently, the vast majority of solvent emissions are routed to the incinerator. However, a small percentage (2-3%) is vented directly to atmosphere. This is in order to maintain a positive pressure in the vents for safety reasons. Examination of the most recent monitoring data shows that emission of tetrachloroethylene from Site A to the environment in 2004 was approximately 85 tonnes per year[14]. Using a linear extrapolation of data given in the risk assessment (i.e. assuming that

[13] The risk assessment conclusions of interest state that "there is a need for limiting the risks; risk reduction measures which are already being applied shall be taken into account". Additional research undertaken for this risk reduction strategy is intended to address the latter point of this statement.

[14] Source: Information from Site A operator

environmental exposure is directly proportional to total emissions) it is possible to calculate a PEC of 10.71 µg/m^3, equating to a PEC/PNEC ratio of 1.3 (cf. 4.4 in risk assessment).

Moreover, under normal conditions of operation, calculation of the process contribution of the plant indicates that emissions would not be in excess of the PNEC, although, there would be a risk to the environment, based on the PNEC value, when abatement equipment is not in place (see Section 3.2).

It is possible therefore, that existing legislation and its continuing implementation will be sufficient to reduce the risks to an acceptable level given that the PEC/PNEC ratio is much reduced from the level reported in the risk assessment and that it is currently controlled under normal operation of the plant. Furthermore, it is also likely that the trend for reduced VOC emissions across the site in general will further reduce the annual mass emission of tetrachloroethylene and hence the risk.

There are no additional issues relating to *practicality* of implementation, nor for *economic impacts* for industry associated with the 'do nothing' option (since no additional actions are required). However, it would be appropriate to *monitor* the success of the continuing implementation of legislation and regulation in the Member States to ensure that risks to the environment are adequately limited.

5.3.2 Emission limits or quality standards (under legislation)

All of the EU sites where production and processing as an intermediate of tetrachloroethylene takes place are controlled under the Integrated Pollution Prevention and Control regime, which within its framework, sets out emission limits as detailed in Section 3.2.

In terms of the *effectiveness* of this measure, specifying an emission limit to be complied with within the legally binding permits issued by the Member State Competent Authorities could be sufficient to effectively address the risks associated with this use. Since the limit is concentration-based, this measure would also remain valid for reducing the risks, should the production of tetrachloroethylene increase over time. It has been noted within the response from one site that, because of the tightening of emission controls on other similar chlorinated solvent substances (e.g. trichloroethylene), the use of tetrachloroethylene could increase as users switch over from solvents subject to increasing controls on their emissions and use.

The *practicality* of this measure is demonstrable through the existing means for Member States to introduce emission limit values under the Directive.

However, in terms of *economic impact*, the costs of implementation could vary significantly. For example, the capital costs of introducing an additional incinerator for certain vents where incineration does not already take place could be significant. This would be approximately €56 million for Site A alone (see Appendix A), which is a substantially larger amount than the revenue that would be expected from annual sales for the amount of tetrachloroethylene produced at the site. Even if this cost is borne over a period of a few years, it would still be expected to be significant compared to the environmental risk posed. Nonetheless, there could potentially be other means of achieving further emissions reductions at lower cost but these would need to be investigated between the regulator and the relevant company. It is also of note that Site A's safety provisions set out under the Control of Major Accident Hazards Regulations necessitate a procedure that leads to some venting of emissions, which form the major contributor to total mass emissions of tetrachloroethylene.

In specifying emission limits under the IPPC Directive and techniques to be used in the determination of what constitutes the best available techniques, a range of factors should be taken into account, including the costs and benefits of the measure. It could be appropriate, therefore, to ensure that regulators are fully aware of the conclusions of the environmental risk assessment and that this is taken into account in the determination of whether an emission limit value is appropriate.

It could be expected that *monitorability* of this measure would not be problematic, given that the sites are already regulated and are required to report emissions to the regulatory authorities.

5.3.3 Prohibition on marketing and use

A ban on the marketing and use of tetrachloroethylene would be *effective* in reducing the risks associated with production and use as an intermediate, given that the risks associated with the substance would be eliminated. However, there would be risks introduced for the substitutes that would not necessarily be significantly lower than for tetrachloroethylene (this would depend upon the substances with which tetrachloroethylene would be replaced and the production sites, including increases in production at existing sites).

For use as an intermediate, it is understood is that there is no alternative to tetrachloroethylene for the production of HCFC 123 (2,2 dichloro-1,1,1-trifluoroethane) and HFC 125 (pentafluoroethane). However, there is a process using tetrachloroethylene for HFC 134a (1,1,1,2 tetrafluoroethane) production, where the alternative feedstock is trichloroethylene.

Possible substitutes (other than trichloroethylene) for tetrachloroethylene for use in metal degreasing are dichloromethane (methylene chloride) and 1-bromopropane. Neither 1-bromopropane nor dichloromethane are classified as dangerous for the environment, while tetrachloroethylene is classified as N;R51/53 ('Toxic to aquatic organisms' and 'May cause long-term adverse effects in the aquatic environment'). Both 1-bromopropane and dichloromethane are classified for hazards to human health. The substance 1-bromopropane is classified as harmful (Xn) owing to the danger of serious damage to health by prolonged exposure through inhalation (R48/20) and as an irritant (Xi) to eyes, respiratory system and skin (R36/37/38). Furthermore, 1-bromopropane is a reproductive toxin (i.e. a chemical that produces or increases the incidence of non-heritable effects in progeny and/or an impairment in reproductive functions or capacity) category 2, on the basis that it may impair fertility (R60) and category 3 as it presents a possible risk of harm to the unborn child (R63). Like tetrachloroethylene, dichloromethane is a category 3 carcinogen on the basis of limited evidence of a carcinogenic effect. As 1-bromopropane is classified as highly flammable (R11), it would not be of use in hot vapour degreasing.

Possible substitutes for tetrachloroethylene for dry cleaning include solutions based on decamethylcyclopentasiloxane (marketed as '*GreenEarth*' dry cleaning fluid) and so-called hydrocarbon fluids. The hydrocarbon fluids mixtures are either petroleum distillates or synthetic hydrocarbon mixtures. These are replacements for Stoddard solvent and contain very little or no aromatic hydrocarbons. Other dry cleaning processes are based on liquid carbon dioxide and glycol ethers.

Since emissions tetrachloroethylene have already decreased significantly in recent years and emissions are to be controlled under the Solvent Emissions Directive, the benefits of this measure are not likely to be very significant.

In terms of *practicality*, the implementation of marketing and use restrictions would be relatively simple, since the appropriate measures have been developed under Directive 76/769/EEC.

The *economic impact* of marketing and use restrictions for producers would be significant, with at least €58 million[15] in turnover lost per year if use was banned. This could be a significant part of the turnover at each site and could potentially lead to losses in employment if alternative products could not be manufactured at the sites concerned. There would, however, be an increase in sales of substitutes which might offset the losses associated with tetrachloroethylene.

It is likely to be relatively simple to *monitor* this measure, given that there are only a limited number of current producers.

5.3.4 Voluntary emissions controls

Whilst introduction of voluntary emissions controls could potentially be as *effective* as introduction of emission controls through existing legislation (IPPC), in *practical* terms, it would be difficult to implement given that neither of the two producers has expressed a willingness to sign up to voluntary controls and they have also suggested that such an approach would not be workable. Therefore, this approach is not considered further for production of the substance.

5.3.5 Summary of advantages and drawbacks

Table 5.1 provides a summary of the advantages and drawbacks of each of the options for production of tetrachloroethylene in the EU.

[15] Based on sales of 127,000 tonnes and an average value of £440-515/tonne, the total revenue lost through prohibition would be between Euro 56M-65.34M

Table 5.1 Advantages and drawbacks of options - Production of tetrachloroethylene

Option	Advantages	Drawbacks
Do nothing	• Would require no additional legislation. • Costs for affected sites would be limited. • Option would support on-going measures	• Lack of certainty on sufficiency of existing emissions reductions for all sites. • No regulatory driver for continuous reductions
Emission limits/quality standards	• Existing regulatory regime under IPPC. • Gives regulatory certainty of reducing risks. • No increase in risks from substitutes. • Implementation through IPPC would enable BAT considerations at a site-specific level to avoid disproportionate costs.	• Strict emission limits could pose excessive costs for some sites (e.g. €56m capital cost for one site). • Additional costs for regulatory actions related to enforcement. • Additional costs for company compliance assurance under regulations (environmental/process monitoring)
Prohibition	• Removes risks for tetrachloroethylene.	• Introduces risks for solvent substitutes, all of which are considered higher risk to the environment. • Loss of market of around €100m per year in the EU. • Downstream consequences in terms of product quality.
Voluntary emission controls	• Could potentially be as effective as regulatory emissions controls.	• Manufacturers not convinced that this would be a workable solution.

Based on the information available to date, it appears that there have been significant emissions reductions at the site identified in the risk assessment. It appears that emissions have already been limited sufficiently to remove the concern, under the normal operation of the installation.

Sites producing tetrachloroethylene are already (or will be) regulated under the IPPC regime. Therefore, irrespective of whether existing legislation is considered to be sufficient, it would also be appropriate to ensure that the relevant regulators of affected processes are fully aware of the conclusions of the environmental risk assessment. This would enable regulators to determine whether there is any potential to further reduce emissions.

6. Conclusions and Recommendations

6.1 Conclusions

6.1.1 Uses and environmental risks of tetrachloroethylene

The EU risk assessment concluded that environmental risks existed from the production and use as an intermediate of tetrachloroethylene from a single site[16]. The environmental risk assessment identified a need for limiting the risks to plant life from atmospheric exposure associated with production and as an intermediate of tetrachloroethylene (PEC/PNEC ratio = 4.4).

It is therefore concluded that at present, the risk to plant life is from the production of tetrachloroethylene. It is concluded that the risk posed to plant life is significantly lower than stated within the risk assessment owing to reductions in tetrachloroethylene emission from Site A (70% reduction from 2000), as a result of abatement of emissions through the use of incineration (with energy recovery). Emissions are currently controlled by this abatement to a level below that of the PNEC. The majority of the remaining tetrachloroethylene emissions (2-3% of total) are as result of the safety-case requirement to maintain positive pressure to reduce explosion risk at the solvents plant.

6.1.2 Current risk reduction measures

A range of existing risk reduction measures have been considered, including:

- Take no action (do nothing);
- Control of air emissions under the IPPC regime (applies to tetrachloroethylene production and use as an intermediate);
- A prohibition on sales of tetrachloroethylene to consumers;
- Use of voluntary controls to limit the risks.

It is considered highly probable that compliance with the requirements of the Pollution Prevention and Control Regulations will be sufficient to adequately limit the risks to the environment in relation to production and use as an intermediate, under normal operating of the installation. The regulatory controls, emission limits and monitoring requirements will enable adequate control of the associated environmental risks by restricting the concentration of the emissions and the application of Best Available Techniques to reduce levels of tetrachloroethylene emitted from the production process.

[16] It has been detailed in correspondence between Entec and appropriate site contacts that Site A does not currently use tetrachloroethylene as an intermediate, although it is understood that the future use of the chemical as an intermediate in the manufacture of other chemical compounds, cannot be ruled out.

6.1.3 Assessment of possible further measures

It was agreed by the steering group for this risk reduction strategy that the following four risk reduction options should be considered in detail:

- '**Do nothing**' option, relying on current legislation and its continuing implementation over the next few years.
- **Emission limits or quality standards** introduced through legislation and/or official guidance for implementation of that legislation (Solvent Emissions Directive, Integrated Pollution Prevention and Control).
- **Marketing and use restrictions**, extending the existing restriction upon use in consumer products.
- **Voluntary emissions controls** as an alternative to a legislative approach.

These options have been considered for each of the sectors where a need for limiting the risks has been identified. The relative advantages and drawbacks of these measures have been considered, based on a range of criteria set out in the Technical Guidance Document on Development of Risk Reduction Strategies.

For **production and use as an intermediate of tetrachloroethylene**, information has been provided by relevant EU-based producers on current emissions, and environmental concentrations, in one case. By comparison with the results of the risk assessment, it is considered likely that there have been significant reductions in emissions at the relevant production site. Therefore, it may be the case that emissions have already been limited sufficiently to remove the concern.

These sites are already regulated under the IPPC regime and, irrespective of whether existing legislation is considered to be sufficient, it would also be appropriate to ensure that the relevant regulators of affected processes are fully aware of the conclusions of the environmental risk assessment in order to determine whether there is any potential to further reduce emissions, as well as to ensure that emissions are well controlled.

6.1.4 Conclusions on the most appropriate risk reduction strategy

For sites producing tetrachloroethylene and using the substance as an intermediate in the production of other chemicals, it is concluded that the most appropriate action would be to ensure that regulators under the IPPC regime take into account the conclusions of the environmental risk assessment in developing emission limits for sites. This should include consideration of whether techniques could be adopted under economically and technically viable conditions, taking into consideration the costs and advantages on a site-specific basis.

6.2 Recommendations

It is recommended that the conclusions of this report are taken into account by the UK Government and the European Commission in determining the most appropriate strategy to address the environmental risks associated with tetrachloroethylene in the European Union.

7. References

Danish Environmental Protection Agency (2004) List of Undesirable Substances, Environmental Review no.15, 2004

ECB (2000): *IUCLID Dataset for Tetrachloroethylene*, European Commission - European Chemicals Bureau, 2000.

ECB (2001) European Union Risk Assessment Report: Tetrachloroethylene, (Draft final environment report, August 2001)

ECSA (2001): *Response to UK Environment Agency regarding Perchloroethylene Emission Reduction from the Solvent Emissions Directive (1999/13/EC)*, European Chlorinated Solvent Association, 30th April 2001.

ECSA (2002): *Plain Facts about Chlorinated Solvents*, European Chlorinated Solvents Association internet site (updated June2002), accessed May 2005 (http://www.eurochlor.org/chlorsolvents/news/tri_en.htm),

ECSA (2003): *Solvents Digest 24*, European Chlorinated Solvent Association, December 2003

ECSA (2004): *Solvents Digest 25*, European Chlorinated Solvent Association, July 2004.

ECSA (2005), ECSA comments on PER environmental RAR, 28 February 2005

EEA (2004): European Pollutant Emission Register, European Environment Agency internet site (http://eper.cec.eu.int/eper/emissions_pollutants.asp?), accessed 26 October 2004.

Environment Agency (2002A) Guidance for the Large Volume Organic Chemicals Sector (Sector Guidance Note IPPC S04.01) Issue 3.

Environment Agency (2002B) Integrated Pollution Prevention and Control (IPPC) Environmental Assessment and Appraisal of BAT (Horizontal Guidance Note IPPC H1)

Environment Agency (2004A): Pollution Inventory, Environment Agency for England and Wales internet site (http://www.environmentagency.gov.uk/maps/960669/?version=1&lang=_e), accessed 9th March 2004.

Environment Agency (2004B): Review of the Categorisation of Volatile Organic Compounds (VOCs)

Environment Agency (2005A): European Union Risk Assessment Report: Tetrachloroethylene, (Final environment report, March 2005)

Environment Agency (2005B): European Union Risk Assessment Report: Tetrachloroethylene, (Final environment report, March 2005) Appendix 4: Potential tetrachloroethylene emission reductions due to implementation of the Solvent Emissions Directive (1999/13/EC), prepared by ECSA

European Commission (2004): *Environment and Sustainable Development - Voluntary Approaches: Environmental Agreements*, European Commission internet site

(http://europa.eu.int/comm/enterprise/environment/index_home/emantool_indic_prodrel_vappr/voluntary_approaches.htm)

European Commission (2003): *Integrated Pollution Prevention and Control - Reference Document on Best Available Techniques in the Large Volume Organic Chemicals Industry*, European Commission, February 2003.

European Commission (1998): *Technical Guidance Document on Development of Risk Reduction Strategies*, Office for Official Publications of the European Communities, Luxembourg.

Appendix A
Background Information and Consultation (confidential)

3 pages

A1. Production and Use as an Intermediate of Tetrachloroethylene

A1.1 Summary of consultation

For the purposes of this risk reduction strategy, two EU-based producers of tetrachloroethylene have been consulted in relation to the quantities of the substance produced; current emissions controls and potential for further reductions; and views on the most appropriate risk reduction strategy for this stage in the life-cycle ('Site A' as identified in the EU RAR and 'Site J' that was not considered within the RAR). This consultation was undertaken by dissemination of a questionnaire to each of the companies involved.

Both of the companies consulted are considered to be 'large' companies, with greater than 250 employees and an annual turnover greater than €50 million.

Annual sales from Site A is roughly 32,000 tonnes, with no current use as intermediate, and annual sales from the site within the new EU-25 (which was not considered within the risk assessment report) is 6,000 tonnes with only 11 tonnes per annum used as an intermediate.

Site J, by virtue of its location, was outside the scope of the risk assessment report and therefore it was important to gather basic data on production in order to assess the potential for the emissions from this facility to harm the environment. In response to the questionnaire, the company have indicated that sales from production amounts to 6,000 tonnes with 11 tonne used as an intermediate as well as on site use of tetrachloroethylene for industrial dry cleaning. Emission of tetrachloroethylene was reported as of 2,400 kg annually. When compared with the much larger scale of production (65,000 tpa in 1994) and emission levels (8,400 kg/year to air) reported for at Site B considered within the risk assessment (which later concluded that this site posed no risk), this site would appear not to pose a risk to the environment from emissions of tetrachloroethylene.

A1.2 Current controls and potential for further emission reductions

Table A1.1 summarises the emissions controls and current emissions at each of the two sites for which information was provided for the purposes of this study.

Table A1.1 Estimated emissions at EU production sites

Site	Emissions Controls	Emissions
A	Vents refrigeration on the main reactor vents, followed by incineration of residual vent gases with recovery of both energy and hydrochloric acid.	80.2 tonnes (2003) 85 tonnes (2004)
J	Currently limited through state legislation setting ELVs. Emissions are independently monitored and legislation is enforced by the Environmental Protection Agency. No abatement equipment is referenced as being in operation.	2,416 kilograms (majority of this is made up from emissions from dry cleaning)

As noted in Table A1.1, the emissions from Site J are primarily from the dry cleaning (laundry) activities undertaken at the site and therefore no further consideration is given to reduction of these emissions within the scope of production.

The emission values for Site A are significantly different than those reported in the risk assessment, due to continuous reductions in tetrachloroethylene emissions from Site A (57.7% reduction in 3 years).

The producer has indicated that a significant part of the emissions arises as a result of the need to maintain a positive pressure on the vent incinerator inlet, requiring positive pressure and a continuous bleed of small quantities of vent gas and hence leading to emissions of 2-3% of the vent gases. This requirement is based upon the safety case for the site and the operator has indicated that a basis of safety could not be established for connection of all the vents because of concerns related to ingress of air into a fuel rich vent. Thus, the capital expenditure for this site would be significant and would relate to installing a standby incinerator.

- A capital cost of around €56 million and annual operating costs of around €1.4 million for installation of a standby incinerator to capture emissions resulting during downtime of the existing incinerator for vents and potentially to capture emissions from the bleed vent system.

The producers have also provided information on measures taken towards reducing emissions at sites of downstream users. These include offering special containers for secured delivery, storage and handling, including closed loop product transfer; providing suitable stabilisers and stabiliser monitoring for use in closed systems; and ensuring that distributors are audited under the ESAD scheme[17], with subsequent information provision on techniques for emissions reduction.

[17] This scheme is an industry led initiative to assess chemical suppliers and distributors to give a measurement of the commitment of distributors to their Responsible Care Programme and a common tool for suppliers to evaluate, against their individual requirements, the safety, health and environmental performance of their distributors.

A1.3 Industry views on appropriate risk reduction strategy

Both of the producers have indicated that they would accept guidance on emission limit values under the IPPC regime, for which permits must be in place during 2007. They would not support the introduction of mandatory emission limit values due to the differences in plant construction.

The two companies contacted indicated that they do not believe that marketing and use restrictions for manufacture and intermediate use of tetrachloroethylene would be appropriate.

Neither of the producers would support any additional controls introduced through voluntary means as they do not believe that this would be workable.

Appendix B
Confidential Annex: Site A

2 Pages

Control of Air Emission from Site A under IPPC

The emission mass flow calculated from data presented in the RAR (i.e. emission of 0.733 t/day) is 30.5 kg/h. Based on current mass emission values from Site A for 2004 (85 tonnes), the mass flow of tetrachloroethylene is 11.8 kg/h (assuming 300 working days and 9.7 kg/h based on 365 working days). Using emission information from Site A, provided by the operators, the combined mass flow (i.e. the combination of all emission points) for Site A is 6.13 kg/h under normal conditions (i.e. with abatement in place). The combined mass flow exceeds the defined benchmark mass release rate for class A VOCs of 100g/h in EA guidance, in which case the VOC concentration level of 20mg/m^3 (for class A VOCs) is relevant.

Using information on emissions for Site A in 2004 (from publicly available information and data supplied by the operator of Site A), both the long-term and short-term Process Contribution (PC) have been calculated, these can be compared to the respective EALs. The normal operation of the site relates to the situation in which abatement equipment is in operation and for this situation the long-term PC and EAL applies. However, from time to time abatement equipment may not be available for a number of reasons (for example, for maintenance), in this situation the emissions to the environment are at a maximum. This relates to the short-term PC and therefore the short-term EAL applies. Further to this, the IPPC assessment of a site assumes that it is operating at its maximum capacity.

For Site A, the instantaneous rate of release, i.e. the mass flow from the tetrachloroethylene emission points exceeded the benchmark level of 100 g/h and the actual emission level was also well in excess of the benchmark emission level of 20 mg/m^3[18]. The PC was calculated, taking into account the stack height of emission points (and hence the corresponding dispersion factor); the long-term PC was less than 1% of the long-term EAL (i.e. 3,450 µg/m^3) and the short-term PC was less than 10% of the short-term EAL (i.e. 8,000 µg/m^3). This being the case, under the guidance, no further assessment of the emissions is required.

In the current IPPC application for Site A, no account was taken of the conclusion of the RAR and the PNEC value for the risk to plant life (i.e. 8.2 µg/m^3). However, with regard to Site A, the PC is equivalent to the PEC since the background concentration (excepting the contribution from the site itself) can be assumed to be zero. Comparing the long-term PC (i.e. for normal operation, with abatement) to the PNEC from the RAR did not indicate a risk, however, the short-term PC (i.e. for maximum emissions, without abatement) did indicate a risk (with a risk ratio of 10).

[18] It is noted that UK IPPC sector guidance (Environment Agency, 2002A) allows a benchmark of 10 times of the long-term EAL to be used as a benchmark emission level i.e. for tetrachloroethylene i.e.34.5 mg/m^3.

Data from the Environment Agency (in its role as IPPC regulator) indicated that predicted concentrations at the boundary of Site A were 20.7 $\mu g/m^3$ long-term PC (i.e. under normal operating conditions with abatement in place) and 173 $\mu g/m^3$ for the short-term PC (i.e. maximum emissions, where abatement is not operational). The site operator reported the average measured concentration in the nearest residential area to the site as 1.7 $\mu g/m^3$.

With regard to the above, it should be noted that an IPPC permit may be reviewed at any time by the regulator. The regulator can impose stricter requirements for emissions and may impose conditions to monitor the environmental concentrations of regulated substances. Therefore, account could be taken of the conclusion of the RAR as well monitoring of local environmental concentrations. Consideration of the PNEC from the RAR could also be made in the development of the EALs for use within IPPC.