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RIVM report 711701 023

Technical evaluation of the Intervention Values for Soil/sediment and Groundwater

Human and ecotoxicological risk assessment and derivation of risk limits for soil, aquatic sediment and groundwater

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Abstract

Intervention Values are generic soil quality standards used to classify historically contaminated soils (i.e. before 1987) as seriously contaminated in the framework of the Dutch Soil Protection Act. In 1994 Intervention Values were published for 70 (groups of) compounds. These values, based on potential risks to human health and ecosystems, are technically evaluated on the basis of recent scientific views and data on risk assessment. Serious Risk Concentrations (SRCs, formerly called SCC) are revised for soil and groundwater; in addition SRCs are derived for sediment. A policy phase will start in 2001 to determine how the results will be implemented for setting Intervention Values.
Starting points for the derivation of SRCs, partly chosen because of the policy context in which the SRCs are used, are mentioned and discussed. The general procedure for deriving these risk limits is partly modified, especially for groundwater. The methodology for deriving SRCs for sediment is new, as sediment had not been considered separately earlier. All parts of the human and ecotoxicological risk assessment were evaluated and revised when necessary. For deriving the human risk limit (SRC_{human}) the model concepts for human exposure pathways (i.e. soil ingestion, crop consumption and inhalation of indoor air), the model input parameters (e.g. physicochemical data), and the human-toxicological Maximal Permissible Risk level (MPR) are revised. For deriving the ecotoxicological risk limits (SRC_{eco}) the HC50s, the concentrations where 50% of the tested species/processes may encounter adverse effects, the procedure and data were revised. The lowest value for each of SRC_{eco} and SRC_{human} is selected as the integrated SRC.
Ecotoxicological risks more frequently determine the integrated SRCs for soil and sediment than human toxicological risks. For groundwater the integrated SRC is often based on ecotoxicological risks and on the maximum concentration in drinking water (when groundwater would be directly used for human consumption). The proposed risk limits for soil and sediment are higher and lower than the current Intervention Values for Soil/sediment. The proposed risk limits for groundwater are more often higher than lower compared to the current Intervention Values for Groundwater. It can be concluded that in the present report consistently derived human and ecotoxicological risk limits are given, which give a solid foundation for setting Intervention Values in the policy phase.

Preface

The Intervention Values for Soil/sediment and Groundwater contamination were published in 1994 as part of the Dutch Soil Protection Act (VROM, 1994). To provide an up to date scientific basis for these values the Directorate General for the Environment commissioned the National Institute of Public Health and the Environment (RIVM) to carry out the project "Evaluation of Intervention Values for soil contamination".

This report represents an integration of the results obtained in subprojects, leading to revised human-toxicological and ecotoxicological risk limits for soil and groundwater, and newly proposed risk limits, especially for sediment. The reports providing the components for this integration are:

- Ecotoxicological Serious Risk Concentrations for soil, sediment and (ground)water: updated proposals for first series of compounds (RIVM report 711701020; Verbruggen et al., 2001);
- Re-evaluation of human-toxicological Maximum Permissible Risk levels (RIVM report 711701025; Baars et al., 2001);
- Evaluation and revision of the CSOIL parameter set; proposed parameter set for human exposure modelling and deriving Intervention Values for the first series of compounds (RIVM report 711701021; Otte et al., 2001);
- Evaluation of the most relevant model concepts for human exposure; proposals for updating the most relevant exposure routes of CSOIL (RIVM report 711701022; Rikken et al., 2001);
- Risk assessment of historical soil contamination with cyanides; origin, potential human exposure and evaluation of Intervention Values (RIVM report 711701019; Köster, 2001);
- Proposal for revised Intervention Values for petroleum hydrocarbons on base of fractions of petroleum hydrocarbons (RIVM report 711701015; Franken et al., 1999);
- Accumulation of metal in plants as function of soil type (RIVM-report 711701024; Versluijs and Otte, in prep.).
- Revision of the Intervention Value for lead; evaluation of the Intervention Values derived for Soil/sediment and Groundwater (RIVM report 711701013; Lijzen et al., 1999).

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Contents

Samenvatting

In 1994 zijn de Interventiewaarden bodemsanering voor de eerste tranche van circa 70 stoffen en stofgroepen vastgesteld, in het kader van de Wet bodembescherming. Interventiewaarden zijn generieke risicogrenzen voor de bodem- en grondwaterkwaliteit, en zijn gebaseerd op potentiële risico's voor de mens en voor ecosystemen. Ze worden gebruikt om bodemverontreiniging (inclusief waterbodem en grondwater) te classificeren als "ernstig". Met het doel gebruik te maken van recente (toxiciteit)data en nieuwe inzichten in risicoanalyse, zijn de Interventiewaarden voor de eerste tranche van stoffen geëvalueerd. In het onderhavige rapport zijn de verschillende deelaspecten van het project "Evaluatie Interventiewaarden" geïntegreerd. Deze integratie richt zich op de technisch-wetenschappelijke fase en niet op de daarop volgende beleidsmatige fase. In deze technisch-wetenschappelijke fase zijn separate studies uitgevoerd voor de evaluatie van de waarden voor minerale olie, cyaniden en lood. In de hierop volgende beleidsmatige fase zal na advies van de Technische Commissie Bodembescherming en de Gezondheidsraad een beleidsmatig voorstel worden geformuleerd en bediscussieerd. Het gebruik van risicogrenzen voor land- en waterbodem en de procedure voor de afleiding van de Interventiewaarde voor grondwater is daarin onder meer aan de orde.

De risicoanalyse is gebaseerd op een aantal uitgangspunten, zoals bijvoorbeeld het gebruik van *realistic case* parameters en scenario's, een standaard blootstellingscenario en het niet beschouwen van achtergrondblootstelling. De algemene procedure voor afleiding van generieke risicogrenzen (in het engels afgekort als SRC: Serious Risk Concentration) voor de bodem is onveranderd. De procedure voor het afleiden van risicogrenzen voor grondwater is aangepast, met name door direct gebruik te maken van aquatische toxiciteitdata in plaats van geëxtrapoleerde toxiciteitdata vanuit de bodem op basis van evenwichtspartitie. Bovendien zijn risicogrenzen voor waterbodems afgeleid.
Ter bepaling van de humane risicogrenzen voor bodem, grondwater en waterbodem (SRC_{human}), werd met het model CSOIL (voor landbodems) en met het model SEDISOIL (voor waterbodems) de blootstelling bepaald en gecombineerd met het humaan-toxicologische Maximaal Toelaatbare Risico voor blootstelling (MTR-humaan).
De ecotoxicologische risicogrenzen (SRC_{eco}) zijn gebaseerd op de HC50. De HC50 is de concentratie waarbij, gebaseerd op laboratorium experimenten, 50% van de soorten en processen in een ecossysteem mogelijke negatieve effecten ondervinden. De laagste van de humane en de ecotoxicologische risicogrens wordt gekozen als de geïntegreerde SRC.

De belangrijkste fysisch-chemische data zijn geëvalueerd. Met name de herziening van de partitiecoëfficiënt voor octanol/water (K_{ow}), voor organisch koolstof/water (K_{oc}) en voor bodem of sediment/water (K_p) voor metalen had invloed op de afgeleide risicogrenzen. Daarnaast zijn de locatie- en blootstellingparameters, zoals opgenomen in CSOIL voor het standaard scenario "wonen met tuin", verbeterd. Als standaard scenario voor de waterbodems is het scenario "mogelijkheid voor recreatie en vissen" in SEDISOIL beschouwd.

Ter verbetering van de SRC_{humaan} zijn de MTR waarden voor orale en inhalatoire blootstelling (respectievelijk TDI/CR_{oraal} en TCA/CR_{inhal}) geëvalueerd en herzien. Daarnaast zijn de meest relevante model concepten van CSOIL, namelijk "inhalatie van binnenlucht" en "consumptie van voedingsgewassen", verbeterd voor de berekening van de blootstelling aan organische stoffen. In het algemeen heeft dit tot een licht verhoogde inhalatoire blootstelling en lagere blootstelling ten gevolge van consumptie van voedingsgewassen geleid. Een andere verbetering is dat de gemodelleerde orale en dermale blootstelling wordt vergeleken met de

toelaatbare orale blootstelling, en de gemodelleerde inhalatoire blootstelling via lucht vergeleken is met de toelaatbare inhalatoire blootstelling. Dit resulteert in beter onderbouwde en in sommige gevallen hogere risicogrenzen voor bodem en grondwater.

De methode van afleiding van de ecotoxicologische risicogrenzen (SRC_{eco}) voor de bodem is aangepast. Methodes voor de afleiding van de ecotoxicologische risicogrenzen voor waterbodems en grondwater (oppervlaktewater) zijn toegevoegd. De data zijn dezelfde als gebruikt in het het project Integrate Normstelling Stoffen voor afleiding van Streefwaarden. Doorvergiftiging via de voedselketen is buiten beschouwing gelaten. Met name de beschikbaarheid van extra toxiciteitsdata resulteerde in herziening van de risicogrenzen. De verschillen tussen de SRC_{eco} voor land- en waterbodem zijn beperkt. Uitzondering zijn de risicogrenzen voor de metalen.

De herziene geïntegreerde SRCs voor bodem zijn voor meer stoffen lager dan hoger, vergeleken met de huidige Interventiewaarden voor bodem. De belangrijkste oorzaak van verhoogde SRCs voor bodem zijn het grotere aantal beschikbare ecotoxicologische toxiciteitsdata en voor humaan onderbouwde waarden een verhoging van de MTR waarden (oraal en inhalatoir), aanpassing in het gebruik van de orale MTR en inhalatoire MTR en een lagere berekende blootstelling (met name als gevolg van herziening van het modelconcept voor opname in planten en herziening van Koc en Kow waarden). De belangrijkste reden voor verlaagde risicogrenzen voor sommige stoffen zijn het grotere aantal beschikbare ecotoxicologische data en voor humaan onderbouwde waarden een verlaging van de MTR-waarden en verhoging van de berekende humane blootstelling (met name veroorzaakt door het herziene modelconcept voor blootstelling via de binnenlucht en de herziene Koc en Kow waarden).
De SRCs voor waterbodem zijn ongeveer voor evenveel stoffen hoger als lager dan de huidige Interventiewaarden en zijn voor relatief veel stoffen hoger dan de afgeleide SRCs voor landbodems. Dit komt onder meer door hogere ecotoxicologische risicogrenzen voor metalen en verschillen in de berekening van humane blootstelling voor landbodems met CSOIL en waterbodems met SEDISOIL.
De SRCs voor grondwater zijn in het algemeen hoger dan de huidige Interventiewaarden voor grondwater. Dit is voor een groot deel terug te voeren op het niet meer hanteren van de verdunningsfactor van 0.1, zoals voor de huidige Interventiewaarden werd gedaan. Daarnaast is het direct gebruik van aquatische toxiciteitdata oorzaak van zowel hogere als lagere waarden. Voor humaan onderbouwde waarden worden hogere SRCs verklaard door de herziene (hogere) MTR waarden, ander gebruik van de orale MTR en inhalatoire MTR en een lagere berekende humane blootstelling. De belangrijkste reden voor de lagere SRC's voor grondwater zijn de herziene MTR waarden en de hogere berekende blootstelling.

De meerderheid van de geïntegreerde SRCs voor de land- en waterbodem worden bepaald door ecotoxicologische SRCs. Voor de meeste gechloreerde alifatische koolwaterstoffen, enkele aromatische stoffen en alle PCBs and dioxines in de bodem is echter de SRC_{human} bepalend (lager dan de SRC_{eco}). De geïntegreerde risicogrenzen voor grondwater worden veelal bepaald ecotoxicologische risico's en de “maximale concentratie in drinkwater” (gebaseerd op direct gebruik van grondwater voor menselijke consumptie).

Voor de berekening van de humane blootstelling is een bodemtype-specifieke correctie beschreven. Er zijn geen voorstellen gedaan voor heziening van de generieke bodemtype correctie van de risicogrenzen. Tot slot zijn aanbevelingen geformuleerd voor verbetering van de risicoanalyse in de toekomst en voor toepassing van de afgeleide risicogrenzen in de dagelijkse praktijk van het beoordelen van de (water)bodem- en grondwaterkwaliteit.

Summary

In 1994 the Intervention Values for soil contamination in the framework of the Dutch Soil Protection Act were established for the first series of about 70 (groups of) compounds. Intervention Values are generic soil quality standards, used to classify historical soil contamination as seriously or not seriously contaminated. They are based on potential human and ecotoxicological risks. The Intervention Values for all compounds of the first series were evaluated in line with the most recent views on risk assessment and (toxicological) data.
The different parts of the “Evaluation of Intervention Values” project have been integrated into this report, forming the scientific phase of the project. In this phase separate studies were carried out for “mineral oil” (Total Petroleum Hydrocarbon: TPH) and cyanides. In the policy phase to follow a proposal for implementation of the results of this report will be presented and discussed. The position of risk assessment for soil versus sediment and the derivation of Intervention Values for groundwater will be part of this proposal.

The risk assessment is based on several starting points, such as a *realistic case* risk level, the standard exposure scenario and the exclusion of background exposure, Some of these starting points have been discussed within this project. The general procedure for deriving generic risk limits for soil (Serious Risk Concentrations, SRC; formerly called SCC) has not been changed. However, the procedure for deriving risk limits for groundwater has been modified, particularly as related to the direct use of aquatic toxicity data vs. extrapolation from soil via equilibrium partitioning. Additionally a risk limit for aquatic sediments has been derived, also on the basis of human and ecotoxicological risks.
For deriving human-toxicological risk limits for soil, sediment and groundwater (SRC_{human}) the human-toxicological Maximal Permissible Risk (MPR) level was used in combination with the CSOIL exposure model (exposure to contaminated soil) or SEDISOIL exposure model (exposure to contaminated sediment). The ecotoxicological risk limits are based on the HC50, the concentration where 50% of the tested species and or processes in an ecosystem may encounter adverse effects, based on single-species laboratory studies. The lowest value of the SRC_{eco} and SRC_{human} is selected as the integrated SRC.

First the most relevant physicochemical data were evaluated. Especially the revised partitioning coefficient for octanol/water (K_{ow}), organic carbon/water (K_{oc}) and sediment or soil/water (K_p) for metals had an impact on the derived risk limits. Second, site and exposure parameters, related to the standard scenario “residential with garden” in CSOIL were evaluated and improved. A standard scenario called “possibility for recreation and fishing” was selected for the SEDISOIL exposure model.

To improve the SRC_{human} the MPR values for oral and inhalative toxicity (respectively TDI/CR_{oral} and TCA/CR_{inhal}) were evaluated and revised. Second the most relevant model concepts of CSOIL, “inhalation of indoor air” and “crop consumption” of organic compounds were evaluated and revised, generally leading to a slightly increased exposure via inhalation and lower exposure via crop consumption. A third modification was comparing the oral and dermal exposure with oral toxicity (TDI/CR_{oral}) and exposure via air with inhalative toxicity (TCA/CR_{inhal}). This leads to a better risk assessment and in some cases to higher risk limits.

The methodology for deriving ecotoxicological risk limits (SRC_{eco}) for soil was slightly changed and a methodology for deriving risk limits for aquatic sediment and for groundwater (surface water) were added, all in line with the derivation of other ecotoxicological risk limits (e.g. Maximal Permissible Concentration). Biomagnification in the food chain was not included. Especially the availability of more toxicological data led to revision of the derived

risk limits. The differences between the SRC_{eco} for soil and sediment are limited; only for the metals the risk limits for sediment are much higher.

The SRCs for sediment are for the same amount of compounds higher as lower. The integrated SRCs for groundwater are for more compounds higher than lower compared to the current Intervention Value for Groundwater. The main reason for the higher risk limits is that “dilution factor” of 0.1 is no longer being used in these values, where it was previously used for deriving the current Intervention Value.

The integrated SRCs for soil are for more compounds lower than higher compared to the current Intervention Value for Soil/sediment. The main reasons for higher SRCs for soil were the larger amount of ecotoxicological data and the revised (higher) human MPR, the more appropriate use of the oral and inhalative MPR, and the lower estimated exposure (mainly due to the revised model concept for uptake of organic compounds in plants and revised K_{oc} and K_{ow} values). The main reasons for the lower SRCs were also the availability of ecotoxicological data, the revised (lower) MPR and the higher estimated exposure (mainly due to the revised model concept of exposure to indoor air and revised K_{oc} and K_{ow} values).
The SRCs for sediment are for the same amount of compounds higher as lower. The derived SRCs for sediment are in general higher than the derived SRCs for soil, partly caused by the higher $SRCs_{eco}$ for metals and the differences between the human exposure modelling with SEDISOIL compared to CSOIL.
The SRCs for groundwater are for more compounds higher than lower compared to the current Intervention Value for Groundwater. The main reason for the higher risk limits is the ‘dilution factor’ of 0.1 is no longer being used in these values, where it was previously used for deriving the current Intervention Value. Besides, the SRC changed because of the direct use of aquatic toxicity data. Human-toxicologically based SRCs are higher because of higher MPRs, the adjusted use of the oral and inhalative MPR and the lower estimated exposure. The main reasons for lower integrated SRCs are the revised (lower) MPR and the higher estimated exposure.

The majority of the integrated SRCs for soil and sediment are determined by ecotoxicological risks. For most chlorinated aliphatic hydrocarbons, some aromatic compounds, all PCBs and dioxins in soil the SRC_{human} is more stringent than the SRC_{eco}. For groundwater the integrated SRCs are more often based on human risks than on ecotoxicological risks; especially the “maximum concentration in drinking water” which has turned out to be a critical parameter.

A proposal for a soil type correction, based on human exposure has been reported. No alternatives have been given for the current generic soil-type correction for the risk limits for soil and sediment. For ecotoxicological risk assessment, the (generic) bioavailability correction with respect to soil type will still have to be discussed.
Finally several recommendations on improvement of risk assessment in the future and on application of the derived risk limits have been made.

1 Introduction

1.1 Position of the Intervention Values in the Dutch Soil Protection Act

In the framework of the Dutch Soil Protection Act, Intervention Values have been developed. Intervention Values are generic risk-based standards, founded on potential risks to humans and ecosystems. They are used to classify historically contaminated (i.e. before 1987) soil as seriously contaminated (Swartjes, 1999). In the case of serious soil contamination the site has, in principle, to be remediated. The remediation urgency is determined on the basis of actual, site-specific risks for humans, the ecosystem and contaminant migration. Specific procedures have been developed to determine the remediation urgency (Swartjes, 1999). If soil/sediment or groundwater contamination is considered both serious and urgent, remediation must be carried out within a certain period of time. Remediation should be attuned to the function and use of the soil, and is allowed to be cost-effective (VROM, 1999; BEVER, 1999). Soil-use specific remediation objectives have been derived for several immobile contaminants (Lijzen et al., 1999b) and implemented in Dutch policy. The place of the Intervention Value relative to other instruments used in the management and protection of soil is given in Figure 1.1.

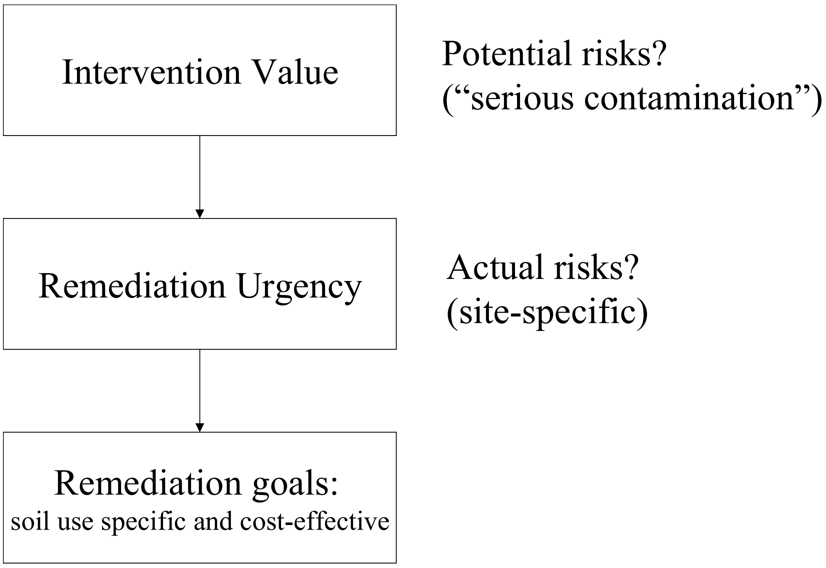

Figure 1.1 Position and significance of the Intervention Value in the management of contaminated soil and subsequent steps for deciding on remediation.

The first series of Intervention Values for Soil/sediment and for Groundwater for about 70 (groups of) compounds was established in 1994 (VROM, 1994). In 1997 Intervention Values for the second and third series of compounds were established (VROM, 1997), followed by the fourth series of compounds in 2000 (VROM, 2000). In total Intervention Values have been established for approximately 85 (groups of) compounds. Indicative Values, less well-founded than Intervention Values, have been established for about 25 compounds. The Dutch National Institute of Public Health and the Environment (RIVM) provided the scientific basis for the proposals for all values (Intervention Values and Indicative Values (see Van den Berg and Roels, 1991; Van den Berg, 1997; Van den Berg et al., 1994; Kreule et al., 1995; Kreule and Swartjes, 1998; Crommentuijn et al., 1995; Denneman and van Gestel, 1991). The human-toxicological and ecotoxicological serious soil contamination concentration, HUMTOX SCC and ECOTOX SCC formed the scientific basis for the Intervention Value for Soil. This information was combined with policy considerations, leading to the officially established Intervention Values for Soil/sediment and Groundwater.

1.2 Evaluation of Intervention Values

1.2.1 Need for evaluation

Since establishing the first series of Intervention Values for seriously contaminated soil in 1994 (VROM, 1994), new scientific views, more scientific data, other exposure models or calculation methods have become available. To satisfy the wish of the Dutch Lower House to evaluate these risk-based standards approximately every five years, the Directorate General of Environment of the Ministry of Housing, Spatial Planning and the Environment commissioned the RIVM to evaluate the first series of Intervention Values for Soil as used in the Dutch Soil Protection Act.

During this period useful responses came from the large group of users of the Intervention Values, e.g. the competent authorities and consultants, concerning specific (groups of) compounds. Besides, since the publication of the first series of Intervention Values for Soil/sediment and Groundwater (VROM, 1994), the policy towards remediation of contaminated soil has been changed (BEVER, 1999; VROM, 1999. A political and scientific evaluation of the Intervention Value was considered necessary to integrate all the new information in the Intervention Values,

The main purpose of the reported project is to derive risk limits (for deriving Intervention Values) according to the most recent views on the exposure assessment to soil contamination. This was done by means of evaluating the exposure models, underlying input-data and human-toxicological and ecotoxicological data. Besides risk limits for soil and groundwater, part of the project was to present risk limits for sediments. To stress that it concerns sediments part of the aquatic ecosystem (no river foreland) the term “aquatic sediment” is used.

1.2.2 Results in this report

The role of this report in the overall evaluation of the Intervention Values is given in Figure 1.2. This report represents the product of the scientific phase of the evaluation of Intervention Values. HUMTOX SCC and ECOTOX SCC are redefined as “Serious Risk Concentrations”, abbreviated as SRC with the subscripts “human” or “eco” for the concentrations related to serious human toxicological and ecotoxicological risks, respectively. The derived risk-limits are related to “serious soil contamination”; in fact the human-toxicological risk level should not be treated as a serious risk since it equals the Maximum Permissible Risk level (see section 1.4.3)

In this report, SRC_{eco} and SRC_{human} are evaluated for 70 compounds or groups of compounds of the first series of Intervention Values for the compartments soil, sediment and groundwater. The purpose of this report is to present the results of the evaluation and to derive SRCs according to the most recent and accepted knowledge on risk assessment.

From the scientific perspective, there are differences in the risks posed to humans and ecosystems by contaminated aquatic sediments compared to contaminated soils. Currently the Intervention Value for Soil/sediment is only derived from risks for soil, where the Intervention Value applies to soil as well as sediments. If and how both risk limits (SRCs) will be used for deriving Intervention Values constitutes part of the political discussion.

Compounds considered in this report are metals and other inorganic compounds, aromatic contaminants, PAHs, chlorinated hydrocarbons (chlorobenzenes, chlorophenols, PCBs, dioxins), pesticides, mineral oil and some other contaminants.

1.2.3 Scientific and policy phases

A general overview of the “Evaluation of the Intervention Values for Soil” project is given in Figure 1.2, showing a scientific and policy phase. The scientific phase started when the Directorate General for the Environment commissioned the RIVM to perform the scientific evaluation. The Expert group on human-toxicological risk assessment (OZBG-humaan) and the Expert group on ecotoxicological risk assessment (OZBG-eco) had an advisory role in this phase. Recommendations that resulted from the political discussion and technical evaluation by the Technical Soil Protection Committee (*TCB*) on the first series (TCB, 1992), the second and third series (TCB, 1997) and the fourth series of Intervention Values (TCB, 1998) have been used in the framework of this project. The TCB advised also on both the revised proposal for the Intervention Value of lead (Lijzen et al., 1999a) and on the RIVM project plan for the “Evaluation of the Intervention Values Soil” project (TCB, 1999a, 1999b). Some aspects of the procedure were also discussed in Working Group UI[1]. The scientific elements of these reports are used in the scientific (first) phase of the project.

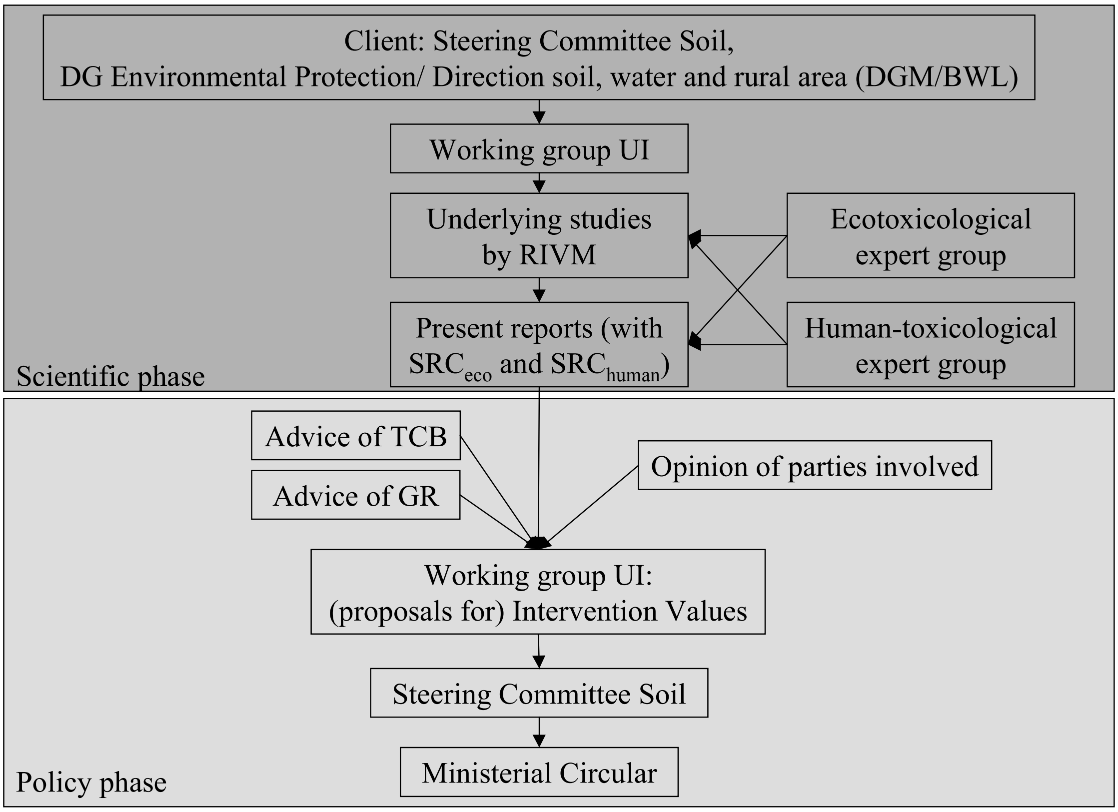

Figure 1.2 Diagram of the organisation of the scientific and policy phases of the project “Evaluation of the Intervention Values for Soil”

The policy phase of the Evaluation of the Intervention Values will start after publication of this report. The derived SRCs will be reviewed by the Technical Soil Protection Committee (*TCB*) and (partly) by the Health Council of the Netherlands (*Gezondheidsraad*). Besides scientific arguments, the implications for the daily practice of soil quality assessment will also play a role. Policy issues will be discussed in Working group UI and revised Intervention

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[1] Working Group UI (“Procedure on remediation urgency and Intervention Values”) is chaired by the Ministry of Housing, Spatial Planning and the Environment. Representatives of the Ministry of Agriculture, Nature Management and Fisheries, the Ministry of Transport, Public Works and Water Management, the provincial and municipal authorities, the National Institute for Inland Water Management and Waste-Water Treatment (RIZA) and the National Institute of Public Health and the Environment (RIVM) are participating in Working Group UI.

Values will be proposed by this policy Working group and be subject to a political discussion before they can be implemented as Intervention Values by means of a Ministerial Circular.
The other series of compounds (second to fourth) will be extensively evaluated in the future. In order to keep the methodology of all series of compounds attuned, a limited revision will be carried out shortly.

1.3 Components of the evaluation

In Table 1.1 the parts of, and important components for the project "Evaluation Intervention Values for Soil" are summarised as described in the Project plan (Lijzen et al., 1998). The present report integrates these different parts of the Evaluation. This report also presents Serious Risk Concentrations for humans and ecosystems (SRC_{human} and SRC_{eco}) for the first series of compounds (see 1.2.2. for the compounds considered) for soil, sediment and groundwater. The SRCs are based on the following components:

- evaluation of the most relevant model concepts for human exposure to soil (Rikken et al., 2000) and an evaluation of human exposure to sediment (Otte et al., 2000a);
- evaluation of underlying input data for the human exposure models (Otte et al., 2001);
- evaluation of the Maximum Permissible Risk (MPR) for humans (Baars et al., 2001);
- evaluation of the ecotoxicological SRC_{eco} (Verbruggen et al., 2001);
- evaluation of the accumulation of metal in plants as a function of soil type (Versluijs and Otte, in prep.);
- evaluation of the Intervention Value for historical soil contamination with cyanides (Köster, 2001);
- a proposal for revised Intervention Values for petroleum hydrocarbons ("mineral oil") on the basis of petroleum hydrocarbon fractions (Franken et al., 1999);
- evaluation of the Intervention Values for lead derived for soil/sediment and groundwater (Lijzen et al., 1999a); only the accumulation of lead in plants (BCF) is modified for deriving risk limits in this study, compared to the mentioned report.

Table 1.1 Parts of the project "Evaluation of Intervention Values for Soil" used in this report and underlying reports

Part of evaluation	Reference
Procedures and starting points	
Soil type correction	this report
Derivation of the Intervention value for Groundwater	this report
Model concepts	
Model concepts in CSOIL: indoor air concentration, uptake of organic compounds in plants and soil ingestion	Rikken et al, 2000
Use of toxicological risk limits for deriving the SRC_{human}	this report
Human exposure to sediment with SEDISOIL	Otte et al., 2000a
Toxicological data	
MPR-human	Baars et al, 2001
HC50	Verbruggen et al., 2001
Input-parameters	
Physicochemical data and other compound-specific data	Otte et al., 2001; Otte et al., 2000b
Accumulation of metal in plants	Versluijs and Otte, in prep.; Otte et al., 2001
Absorption in the human body	Lijzen et al., 1999a
Human exposure parameters CSOIL	Otte et al., 2001
Human exposure parameters SEDISOIL	Otte et al., 2000a
Specific compounds	
Total Petroleum Hydrocarbon	Franken et al.,1999
Cyanides	Köster, 2001
Lead	Lijzen et al., 1999a
Chromium	this report

1.4 Starting points for the evaluation and derivation of risk limits (Serious Risk Concentrations)

1.4.1 Introduction

The Intervention Values for Soil/sediment and Groundwater are used in a defined policy framework (Dutch Soil Protection Act), i.e. they are used for judgement of historical contamination. Besides, they are generic values (not function-specific) and are applied to contaminated sites. This policy framework guides the choice for starting points for the derivation of Serious Risk Concentrations (SRCs).
Next, since Intervention Values are in use since 1994, historically starting points already have been chosen by policy and in the risk assessment. Some were beyond discussion and others are discussed in the present report. In the policy phase of the project choices still have to be made. Most of the starting points can be discussed, and might influence the value of the SRCs. Therefore, chapter 8 discusses the meaning of the chosen starting points for the value of the SRCs. Figure 1.3 gives an overview of the starting points. Some important starting points are discussed in the following sections.

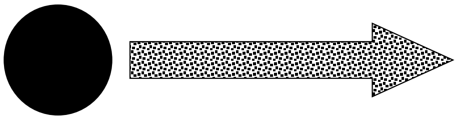
1.4.2 Realistic or worst case?

In this report, the choice of parameters is realistic and based upon an average situation and average human behaviour where possible. In the management of contaminated soil, sediments and groundwater, the current role of Intervention Values is to give the classification “seriously contaminated”. After this classification is given, the urgency of remediation is determined (for contaminated soil, sediment or groundwater), followed by a remediation plan, see Figure 1.1. This means that at this moment the Intervention Value has both an absolute meaning (i.e. to give the classification “seriously contaminated”), and is used as a trigger value to activate the determination of urgency. The role of Intervention Values is connected with the underpinning of SRCs; a more conservative approach would match with the use as a trigger value. The parameters used in the derivation of SRCs all have uncertainty margins, therefore the choice for an average situation or for a worst case situation will influence the value of SRCs. In chapter 8 some deviations from realistic case are discussed.

1.4.3 Protection goals for humans and ecosystems

In agreement with “Premises for risk management” (VROM, 1988) the human toxicological definition for “serious soil contamination” is taken as the soil quality resulting in exceeding of the Maximum Permissible Risk for intake (MPR_{human}). The MPR_{human} (see chapter 4) forms together with the exposure modelling the basis for the SRC_{human}. For genotoxic carcinogens the acceptable excess lifetime cancer risk was set at 1 per 10,000 individuals; for all other compounds the MPR_{human} does not result in any adverse health effects during lifetime exposure (70 yr.).
Thresholds for odours are not used for deriving risk limits in this report. In the Expert group on human risk assessment and in the Working group UI it was advised and decided to report the available data, but not to use them for in risk assessment, because this would not lead to risk-based values. The available thresholds for odours are summarised in section 4.3. Nevertheless they could be used in the remediation urgency and for setting remediation goals.

For ecosystems for the compartments soil, aquatic sediment and groundwater the protection goal is set at the HC50, the concentration at which 50% of the species and/or processes in an ecosystem may encounter adverse effects. The effects considered in the toxicity tests that form the basis of the HC50 are usually growth, reproduction and mortality; effects linked with the population dynamics of a species. The implication is that the more sensitive species are not protected at the level of SRC_{eco}. For the ecosystem, processes (e.g. microbial processes and enzymatic activity) and species are considered separately. The lower HC50 (species or processes) is the basis for SRC_{eco} (see chapter 6). The policy decision to use these protection goals, made in earlier work related to Intervention Values, has not been revised.



Starting points

- realistic case (average situation and average behaviour)
- standard scenario for human exposure as in CSOIL and SEDISOIL
- no human background exposure
- intake of groundwater as drinking water
- no biomagnification
- Maximal Permissible Risk (MPR) for humans (including excess lifetime cancer risk 10^{-4})
- potential hazard for 50% of the species and processes in an ecosystem

Figure 1.3 Summary of the starting points as used for the derivation of SRCs (see text for further explanation)

1.4.4 Human exposure scenario and exposure routes

Exposure of humans to contaminated soil, sediment or groundwater can occur via various routes, and also depends on the function or use of the site. However, the Intervention Value is a generic value and is applied to soils with various uses (see Figure 1.1). Historically, the choice has been made to base the Intervention Value for Soil/sediment upon the scenario “residential with garden”. This scenario is worked out in the human exposure model CSOIL (Van den Berg, 1995), and includes several exposure routes (see also section 5.2):

- ingestion, inhalation and dermal uptake of soil;
- inhalation via air;
- intake of drinking water, dermal contact and inhalation during showering;
- consumption of homegrown crops, comprising 10% of the total consumed vegetables.

The exposure routes to be taken into account have been discussed in policy in an earlier stage of the derivation of Intervention Values and there were no reasons to reconsider these routes. The choice to base the SRC_{human} on average lifelong exposure of 70 years, of which 6 years as a child has also not been revised. An exception is made for lead (Lijzen et al., 1999a), where the SRC_{human} was and will be based upon children as the most vulnerable group. It was recommended to consider focusing on children and/or the foetus when it is critical for other contaminants as well (TCB, 1999b), but this was not found applicable for other contaminants.

For aquatic sediment separate SRCs have not been presented earlier. Currently the Intervention Value for Soil/sediment is only based on the human-toxicological and ecotoxicological risks for soil. It was decided to derive separate risk limits for sediments, because exposure of humans to contaminants in sediments is different from soil.

The exposure routes included to model exposure of humans to sediment, via the model SEDISOIL, are described in chapter 5. This model was proposed by Bockting et al. (1996) and was revised by Otte et al. (2000a). The model includes the exposure routes:

- ingestion of sediment, surface water and suspended matter;
- dermal uptake via sediment and surface water;
- consumption of fish.

For human exposure to groundwater, first the exposure routes as described in CSOIL are taken into account, using equilibrium partitioning. Secondly, although the direct use of groundwater is not common practice in the Netherlands, the direct consumption of groundwater is included by using a daily consumption of 2 and 1 litre for adults and children, respectively. It still is a strategic and policy decision to use a maximal concentration in drinking water for setting (human) groundwater quality styandards.

1.4.5 Exposure routes for ecosystems

For soil and sediment direct exposure to the ecosystem is taken into account. Separate SRCs for sediment have not been presented earlier. A separate risk limit for aquatic sediments was derived, because the risks to sediment (and water) organisms and processes can differ from the estimated risks in soil. In the policy phase of this project the use of this risk limit will be discussed.
The risks that occur after bio-magnification in the food chain are not included in the SRC_{eco}. Reason is that seriously contaminated sites are often limited in their surface area, and most organisms in the top of the food-chain forage in a larger area than a contaminated site only. However, there are examples of predators with only a small home range, that might get a high part of their prey from one or more seriously contaminated sites. Furthermore, in some cases (e.g. river foreland) areas of serious contamination can be large (see also chapter 8).
For groundwater, the direct exposure of the groundwater-ecosystem and the potential effect of groundwater on surface water are considered, being a new element in the risk assessment (see section 2.4 and chapter 6).

1.4.6 Human background exposure

The background exposure (e.g. via food or air) by other routes than (indirectly) via the contaminated soil is not included in the SRCs. This policy starting point was in contrast with the opinion of the Expert group on human risk assessment, which advised to include the background exposure in the risk assessment. From the policy point of view it was found important to only assess the additional exposure due to soil contamination, because Intervention Values are not meant as an instrument to regulate other sources of contamination than historically contaminated soil, sediment or groundwater (see also TCB, 1999b).
In fact the air, water, food and soil are supposed to be free of contaminants before they come in contact with the contaminated soil/sediment. Because these assumptions do in many cases not describe reality, the actual exposure can be higher than the modelled exposure, resulting in higher risks. The difference between the actual and modelled exposure varies per compound and per specific situation. This information can be taken into account in the actual (site-specific) risk assessment and in the determination of remediation goals. Currently only for remediation goals background exposure is considered. Together with the evaluation of the MPR more data on the background exposure have become available (see Appendix 9) (Baars et al., 2001).

1.4.7 Other starting points

There are a few other starting points for this evaluation:

- The volume criteria for serious soil and groundwater contamination of 25m^3 and 100m^3, respectively, are no part of the evaluation and are a starting point for the Intervention Values for Soil.
- Intervention Values for Soil will be expressed as total soil content.
- It was shortly discussed if breakdown of compounds should be taken into account in deriving Intervention Values. Because it is uncertain if and how fast compounds will be eliminated from the soil system, in co-ordination with policy and the expert groups it was decided not to incorporate this process in the risk limits. Especially for potential risk assessment there is no reason for implementing such a site-specific aspect. In relation to toxicity breakdown products can arise in the exposed organism; then they are taken into account in the underlying toxicity tests. However, the risks of -more toxic- breakdown products that arise in an exposure route (e.g. metabolisation of a compound in crops, subsequently eaten by humans) are not considered.
- Sum values for groups of contaminants, as currently used, are only given in this report when scientifically defensible (see section 2.6).

1.5 Reading guide

Chapter 2 focuses on the recommended adjustments of the procedure of deriving risk limits leading to Intervention Values, compared to the procedure used in the first, second, third and fourth series of compounds.
Chapter 3 describes the revised physicochemical properties of all substances and the revised exposure parameters needed for the human exposure models.
Chapter 4 presents the revised MPR$_{human}$.
Chapter 5 includes the results of the evaluation of the main model concepts for human exposure, and secondly presents the derivation of the SRC$_{human}$.
In chapter 6 the revised SRC$_{eco}$ of the compounds are summarised.
Chapter 7 focuses on the integration of both SRC$_{human}$ and SRC$_{eco}$, resulting in integrated SRCs for soil, aquatic sediment and groundwater.
Finally chapter 8 presents the general discussion, recommendations for future developments and conclusions.

2 Procedures for deriving SRCs for soil, aquatic sediment and groundwater

2.1 General procedure for deriving integrated SRCs

The general procedure for deriving risk limits for soil and groundwater is shown in Figure 2.1. For both compartments integrated SRCs, based on both human-toxicological and ecotoxicological risk assessment, are derived. The HC50 forms the basis of the SRC_{eco} and the MPR_{human}, together with the exposure modelling (CSOIL for soil and groundwater), form the basis for the SRC_{human}. In principle, the lower value is chosen as the integrated SRC. However, the reliability of both SRC_{eco} and SRC_{human} is taken into account.

The SRCs for soil and groundwater are revised with respect to to earlier published HUMTOX SCCs, ECOTOX SCCs and proposals for Intervention Values for Groundwater. In principle, for soil and groundwater the procedure followed for the fourth series of Intervention Values was used (Swartjes, 1999; Kreule and Swartjes, 1998). The changes to the procedures are described in section 2.2 for soil and section 2.4 for groundwater. For groundwater the description is more extensive, because some changes are proposed. Furthermore, policy still has to decide on the elements to be used in the procedure in the policy phase of the Evaluation Intervention Values for Soil project.

So far, for sediment no specific values were derived before to indicate potential risks because it was chosen to apply the risk limit for soil to both soil and sediment. Additionally for soil and groundwater a separate SRC for aquatic sediment has been derived analogous to the procedures for soil. In the policy phase of this project the use of this risk limit will be discussed.
The procedure for deriving SRCs for sediment is described in section 2.3.

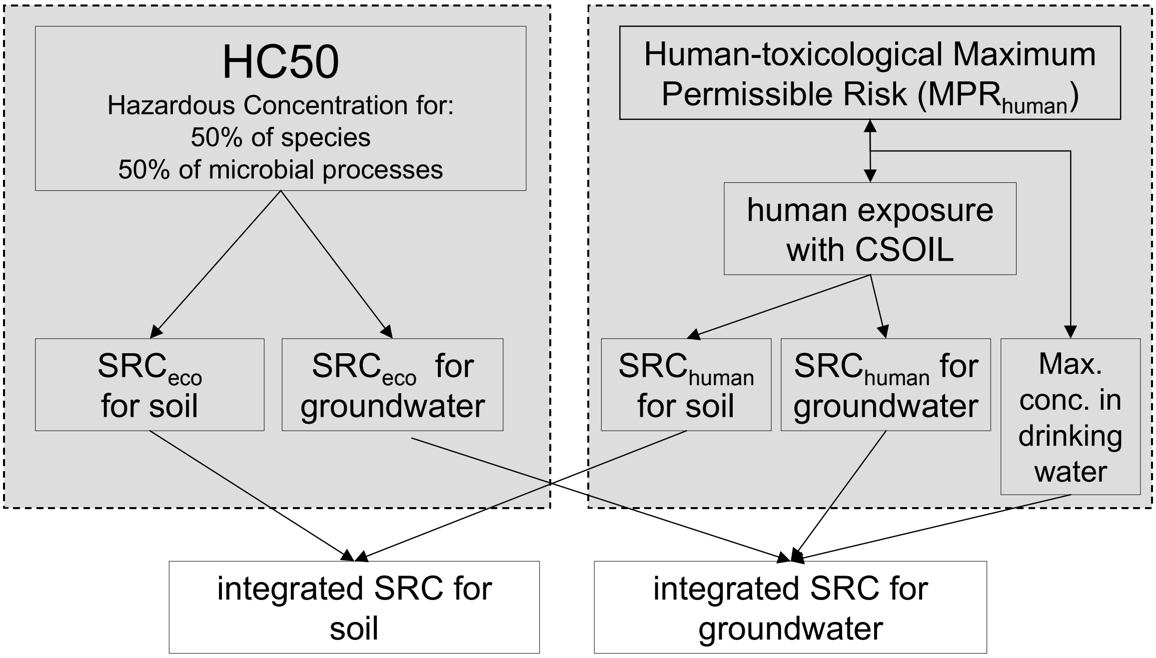


Figure 2.1 Diagram of the derivation of risk limits (integrated SRCs) for soil and groundwater; SRC= Serious Risk Concentration

2.2 SRC for soil

The $SRCh_{uman}$ for soil is derived using the modified CSOIL-exposure model, the revised compound-specific data and the revised Maximum Permissible Risk levels for human intake. The revised SRC_{eco} for soil is based on the revised HC50 for species and processes. It was beyond discussion that the risk limit for potential risks for ecosystems should be the level where 50% of the species and 50% of ecological and enzymatic processes are possibly affected (see section 1.4.3).

The general procedure for deriving SRCs for soil has not been changed (see Figure 2.1). The derived SRC_{human} for soil has been changed because of:

- the revision of physicochemical data for all compounds, and the revision of the most important site and exposure parameters (chapter 3);
- revision of human-toxicological Maximal Permissible Risk, the MPR_{human} (chapter 4);
- modification of model concepts for calculating human exposure with CSOIL (section 5.2);
- the way in which the oral toxicological risk limit (TDI or CR_{oral}) and inhalative risk limit (TCA or CR_{inhal}) are used (section 5.3).

The derived SRC_{eco} for soil has been changed because of:

- adjustments of the procedure for deriving SRC_{eco}, when compared to the procedure used for deriving the current Intervention Values for Soil;
- revision of the underlying ecotoxicological data.

Chapter 6 describes the procedure and adjustments.

Integration of SRC_{eco} *and the* SRC_{human}

The SRC_{eco} and the SRC_{human} for soil can be integrated to one SRC for soil. In principle the lowest value of both risk limits is chosen. When there are large differences between the estimated reliability of the SRC_{eco} and the SRC_{human} (high versus low) and the more stringent risk limit has a low reliability, expert judgement is used to make a definitive proposal, based on available data on uncertainty and the consequences.

A qualitative indication of the reliability (or uncertainty) of the human and ecotoxicological SRCs is given for this purpose and to obtain insight into the general reliability (uncertainty) of the derived values. A full uncertainty analysis was not performed, because the reliability could not be quantified for all data and model concepts used. The methods to qualify the reliability are described in chapter 5 and Appendix 4 for the SRC_{human} and in chapter 6 for the SRC_{eco}. The method is to a large extent the same as used in the 2nd to 4th series of compounds (e.g. Kreule and Swartjes, 1998). The criteria used for the method were that:

- the assessment for the ecotoxicological and the human risk limit should be comparable;
- the method should give information about the reliability, without suggesting too much accuracy.

This method is applied in chapter 7.

2.3 SRC for aquatic sediment

The risks to sediment-bound organisms and processes can differ from the risks to terrestrial organisms and processes; exposure routes of humans to contaminated sediments also differ from the routes to soil. To get more insight into the differences in risks from contaminated soils or sediments, separate SRCs for sediment are presented here for all compounds of the first series of Intervention Values. In the field only part of the compounds is frequently found. The current Intervention Values apply to both soil and sediment, but are based on the risk assessment for soil and not on specific risk assessment for sediments. Figure 2.2 shows the general procedure for deriving risk limits for aquatic sediments.

The SRC_{human} for aquatic sediment is derived using the human exposure model SEDISOIL (Bockting et al., 1996), which was evaluated and revised in 1999 (Otte et al. 2000a). This revised model is used, together with the revised compound specific input data and the revised MPR_{human}.

The SRC_{eco} for sediment is based mainly on the equilibrium partitioning (EqP) method because sediment ecotoxicity data are lacking. The EqP method uses an aquatic risk limit together with a sediment/water partition coefficient (K_p) to derive a risk limit for sediment (chapter 6).

Just as for soil, the SRC_{eco} and the SRC_{human} for sediment are integrated to one SRC for aquatic sediment by choosing the lowest value of both risk limits (see chapter 7). No scores for the reliability of the SRC_{human} for sediment were given because it is difficult to qualify the reliability of the estimated exposure. Excluding the uncertainty in the exposure scenario, in general the reliability can be quantified as medium to low, depending on the dominant exposure route. If there are large differences between the estimated reliability of the SRC_{eco} and the SRC_{human}, expert judgement should be involved in the definitive choice.

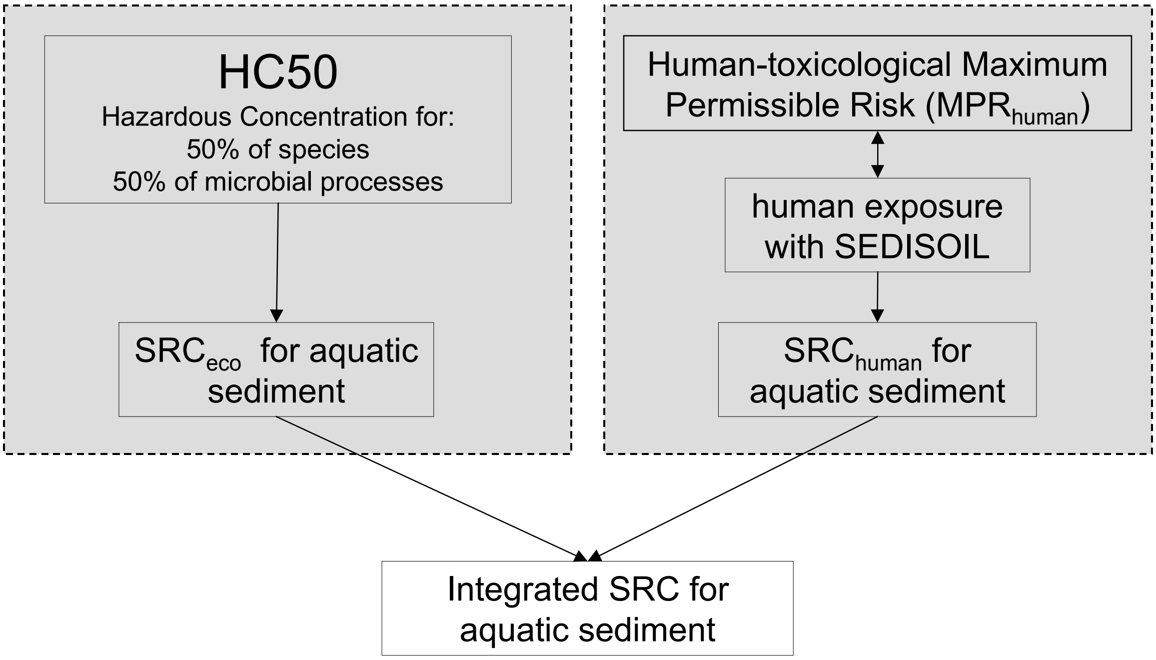


Figure 2.2 Diagram of the derivation of risk limits (integrated SRCs) for aquatic sediment (SRC= Serious Risk Concentration)

2.4 Integrated SRC for groundwater

2.4.1 Introduction

Current method

The purpose of the Intervention Value for Groundwater is currently primarily to signal serious contamination in the soil. The current Intervention Value for Groundwater was derived from the Intervention Value for Soil applying the equilibrium-partitioning concept (EqP-concept). The calculated concentration in the pore-water was subsequently divided by a factor of 10 (see Van den Berg and Roels, 1991). This was done because of:

- large variability in partition coefficients;
- lack of equilibrium and/or only equilibrium between soil and water over a small distance;
- heterogeneity of the soil;

- possible lower concentration in the deeper groundwater, because of the lateral dilution with clean groundwater.

The groundwater concentration derived in this manner could be corrected for several reasons:

- if the exposure due to daily consumption of 2 and 1 l of groundwater by adults and children, respectively exceeded the human Maximal Permissible Risk (MPR_{human}) a correction downwards would follow. For the first series of compounds the groundwater concentration was corrected for about 1/3 of the compounds;
- if the derived concentration was below the Target Values for groundwater or the data from the National Groundwater Monitoring Network (LMG), a correction upwards followed. The minimum value, as set by policy, was a concentration of 5 times the Target Value;
- if the derived concentration was below the detection limit, the value for groundwater was set at the detection limit.

Revised method

The elements that should be included in the method were discussed in the "human-toxicological and ecotoxicological expert groups". Besides, the TCB has given her opinion on this subject in several advices (TCB, 1992; 1999a).

In this report, the SRC groundwater is based on a direct human-toxicological and ecotoxicological risk assessment, based on the following targets:

- prevention of impermissible risks because of human exposure to groundwater (section 2.4.2.)
- prevention of impermissible risks for (ground)water organisms (section 2.4.3);
- attuning SRCs for groundwater with SRCs for soil using equilibrium partitioning (section 2.4.5) to prevent the achievement of the SRC in one compartment from leading to exceedance of the SRC in the other compartment.

In the policy phase of this project it has to be decided which of these elements will be used in deriving a risk limit for groundwater.

Finally, the most critical concentration is in principle taken as the SRC for groundwater.

This report also indcates if:

- the derived SRC is below the Target Value for groundwater. A lower SRC for groundwater than the Target Value is possible; the SRC is underpinned by information on both ecotoxicology and human toxicology, while the basis for the Target Value is formed by the risks for the ecosystem and background concentrations.
- the derived SRC is below the detection limit. In this case the SRC for groundwater should be set at the detection limit.

2.4.2 Human exposure to groundwater

Exposure of humans to contaminated groundwater can occur:

- via the exposure routes as modelled in CSOIL. Especially inhalation of (indoor) air and crop consumption are of importance;
- by consumption of groundwater as drinking water.

1. Potential exposure based on CSOIL

Contrary to earlier work for underpinning of Intervention Values, a SRC_{human} for groundwater is also derived directly for groundwater, as contamination might also be exclusively present in this compartment. For the risk assessment for exposure via air it is assumed that the contaminant is present in the top of the saturated zone and that this concentration is equal to the concentration in the groundwater. For the other exposure routes the concentration in pore-

water is equal to the concentration in groundwater. Depending on the exact location of the contamination the risks can be higher or lower than in the used standard scenario; that is part of the actual (site-specific) risk assessment.
The SRC_{human} for groundwater is derived using the modified CSOIL-exposure model, the revised compound-specific data and the revised Maximum Permissible Risk levels for human intake (see chapter 5).

2. *Consumption of groundwater as drinking water*
In the Netherlands it is not common practise to have a private well which is used for drinking water. Nevertheless private wells exist and, they are used to water cattle, gardens or crops, and human exposure is possible. The Technical Committee Soil (TCB, 1999a) subscribed the use of groundwater as drinking water as criteria for deriving Intervention Values. As a starting point (see section 1.4) the MPR_{human} should not be exceeded at a daily consumption of 2 and 1 litre water for adults and children, respectively. The derived concentration for groundwater is indicated as the “maximum concentration in drinking water”.

An option not carried out in this report, is the tuning of the derived risk limit for groundwater with guideline values for drinking water. It should be stressed that these values are not derived for groundwater, but for tap water. Earlier mentioned reasons not to use the drinking water values are 1) that they are often based on detection limits and 2) that the Intervention Values should not be changed when the drinking water values are changed (Van den Berg & Roels, 1991). Because of the limited toxicological base, it is and was recommended not to use these drinking water values for deriving Intervention Values for Groundwater.
Two references for values for drinking water regulation are mentioned as background information (for which values are summarised in Appendix 5B):

- the WHO Guidelines for drinking-water quality (WHO, 1993, 1998) are based on the human TDI (tolerable daily intake) or the NOAEL (No observed Adverse Effect Level) and equal (mostly) 10% of the TDI with consumption of 2 l water per person per day;
- the EC Drinking-water Directive, issued in December 1998, which will be implemented within 2 years in national legislation, the Water Supply Act 2000 (*Waterleidingbesluit: WLB*). The proposals for the Water Supply Act 2000 are almost complete in line with the values mentioned in the EC Drinking-water Directive (Versteegh et al., 1999). Besides requirements for concentration of compounds, requirements for pathogenic protozoa, viruses and microbiology are set.

2.4.3 Ecotoxicological risks for (ground)water organisms and processes

Currently groundwater organisms are indirectly protected, via equilibrium partitioning of the Intervention Value for Groundwater with the Intervention Value for Soil (van den Berg and Roels, 1991). Contrary to this underpinning of the Intervention Values for groundwater, a direct risk assessment of organisms in the groundwater is preferred (TCB, 1992, 1999a). In a direct risk assessment the -uncertain- soil-water partition coefficient (Kp) does not influence these values.
Ideally the risk limit should be based on toxicity data for groundwater organisms. As these data are almost lacking, the best alternative is a risk limit based on aquatic toxicity data. Several alternatives are possible, i.e. to use all available aquatic toxicity data, or to use only toxicity data of organisms of taxonomic groups that are known to occur in groundwater (e.g. crustaceans, protozoa, micro-organisms). Notenboom et al. (1999) advised to use data for crustaceans specifically, as a large part of the groundwater organisms belong to this group. This author argued that data for fish or algae, which are generally abundant, are of little significance for the groundwater compartment.

In the present report, available aquatic toxicity data for all species were taken into account to derive SRC_{eco} for groundwater. Reasons were the small amount of data on crustaceans for most compounds, limited knowledge of the sensitivity of various taxonomic groups of groundwater organisms in general, and uniformity with the risk-levels used for surface water. This approach is worked out by Verbruggen et al. (2001) and reported in chapter 6, together with ecotoxicological data for soil and aquatic sediments.

2.4.4 Direct/indirect exposure to groundwater for plants and livestock

Currently the (in)direct exposure of animals and plants to groundwater is not included separately in the currently used Intervention Value. This exposure can occur when cattle or crops are watered with groundwater, or in situations where plants or animals are exposed to groundwater. In this report, no new risk limits are derived for these situations, because it is considered to be more in the field of the actual, i.e. site-specific risk assessment by both expert groups. Guidelines that are derived for the mentioned purpose, the quality of (surface) water for irrigating plants and watering cattle (Huinink, 1987; IKC-L, 1996), are given for comparison in Appendix 5B.

2.4.5 Equilibrium partitioning (EqP)

The current use of equilibrium partitioning (EqP) is described in section 2.4.1. For organic compounds EqP is part of the human exposure model CSOIL. For metals, the equilibrium concentration in groundwater is derived from the SRC_{human} for soil (calculated with CSOIL). The used Kp for soil/groundwater is given in section 3.2.7 and the derived SRC_{human} for groundwater is given in section 5.6. It is proposed not to use EqP for deriving an integrated SRC for groundwater from the integrated SRC for soil, but to use it only for deriving the SRC_{human}. The SRC_{eco} is directly based on aquatic toxicity.

It must be stated that often there will be no equilibrium between the soil phases under field circumstances (e.g. because of ageing) or that site-specific circumstances lead a different partitioning. Nevertheless for generic risk assessment and modelling risks it is a widely accepted approach.

Contrary to the current underpinning of Intervention Values for Groundwater, the extra dilution factor of 10 (see section 2.4.1) is not proposed in the present report. Reasons to use the extra factor in the past, were 1) the uncertainty in the soil/water partition coefficient, 2) the possible lack of equilibrium, 3) the heterogeneity of the soil and 4) the possible lateral dilution with clean groundwater. As the SRCs are aimed at an average situation, it was not found appropriate to account for these uncertainties in this stage.

When the Intervention Value for Groundwater would be seen as a trigger for soil contamination (in the unsaturated zone) or a more conservative approach is found necessary (from a policy point of view), a safety or correction factor could be applied, because of the earlier mentioned reasons. To assess the concentration in the groundwater that correspondents with a total content in soil equal to the Intervention Value in soil at a specific site, model calculations or measurements could be performed.

2.5 Soil type correction

Current method

The SRCs are adjusted for soil characteristics (organic matter and clay content and pH). The human and ecotoxicological risk limits are derived for a “standard soil”, currently with 10% organic matter (OM) and 25% clay and a pH of 6 (see section 3.3.1). Because the exposure of humans and the risks for ecosystems depend to some extent on the soil characteristics, the SRCs should be adjusted for these soil characteristics.

Currently the Intervention Values for Soil for organic compounds are corrected on the basis of the organic matter (OM) content of the soil, with a minimum of 2% and a maximum of 30%. An exception is made for Polycyclic Aromatic Hydrocarbons. Here no correction on the OM content lower than 10% is carried out because PAHs are often found in a granular form. This correction method is widely accepted because the OM content plays an important role for the bioavailability of organic compounds in soil.
The Intervention Values for Soil for metals are currently corrected on the basis of empirical relations of the Dutch background concentrations with the OM and clay content. These relationships are given in Table 2.1. No restrictions are given for the minimum and maximum values of clay and OM.

For metals, corrections to "standard soil" are based on empirical relationships of background concentrations in Dutch soils to the OM and clay content (VROM, 2000). The following equation is used to determine the Intervention Value:

$$IV_{soil} = IV_{s\tan dardsoil} \frac{a + b \cdot \%clay + c \cdot \%OM}{a + b \cdot 25 + c \cdot 10}$$

The values of *a, b* and *c* are given in Table 2.1. For metals, no restrictions are given for the minimum and maximum values of clay and OM.

Revision
If, and how, the bioavailability of metals for organisms in different soil types should be taken into account is still under discussion and will therefore not be revised in this report. Generally, it is believed that in sandy soils (with low organic matter and clay content) metals are relatively more available to organisms than in clay and peat. A lower pH can lead to higher bioavailability of metals to organisms. Differences between organisms are very large, because the bioavailability depends on the exposure pathways of organisms (direct contact with soil and porewater, or indirect exposure via food and soil particles).

For human risk assessment the soil type correction is linked to the extent to which the exposure is influenced by the soil characteristics. In section 5.7 a relationship is worked out, which is recommended to implement for the SRC_{human}.

Table 2.1 Soil type correction currently used for correction of the Intervention Values (and Target Values) for Soil.

Compound	*a*	*b*	*c*	Correction "minimum" 0.5% clay 0.5% OM	Correction "maximum" 50% clay 30% OM
Arsenic	1	0.4	0.4	0.53	1.62
Barium	30	5	0	0.21	1.81
Cadmium	0.4	0.007	0.021	0.53	1.76
Chromium	50	2	0	0.51	1.50
Cobalt	2	0.28	0	0.24	1.78
Copper	15	0.6	0.6	0.43	1.75
Mercury	0.2	0.0034	0.0017	0.67	1.39
Lead	50	1	1	0.60	1.53
Nickel	10	1	0	0.30	1.71
Zinc	50	3	1.5	0.37	1.75
Molybdenum	1	0	0	-	-

2.6 Sum values for groups of compounds

For some groups of compounds, it will be desirable to take into account the combined toxic effects (or mixture toxicity). In this report values for groups of contaminants are only presented if it there is sufficient scientific evidence. The most important criterion is that the individual compounds act via the same toxic mechanism (the same mode of toxic action). Concentration-addition, related to both ecotoxicological (Deneer et al., 1988) and human-toxicological effects, is then assumed. Difference can be made between the toxic unit approach and sum values.

Toxic unit (TU) approach. When compounds within one group (probably) have the same toxicological effect it is recommended to use the "TU approach" (or "fraction approach"). Not applying this approach for compounds with the same mode of action can lead to exceedance of the protection goals. Only individual risk limits are presented when there are indications that within one group of chemicals *different* modes of actions are important for different compounds or when, for integrated SRCs, the individual SRCs are based on human as well as ecotoxicological risks.

For human exposure the sum of the ratios of the estimated dose and the MPR-level should not exceed 1, as in the following equation:

$$\sum_{1-n} \frac{dose_1}{MPR_1} + \frac{dose_2}{MPR_2} + \ldots + \frac{dose_n}{MPR_n} \leq 1$$

When the relation between the exposure and the soil concentration is (almost) linear, the formula can be simplified to the formula for the toxic unit approach, that is also used in the ecotoxicological risk assessment (exceptions are compounds for which the solubility is exceeded, e.g. for most PAH in soil).

The TU approach implies that the sum of the ratios of the measured concentration (in soil/sediment or groundwater) and the SRC of each compound should not exceed 1:

$$\sum_{1-n} \frac{C_1}{SRC_1} + \frac{C_2}{SRC_2} + \ldots + \frac{C_n}{SRC_n} \leq 1$$

This approach is proposed for groups of compounds with a similar toxic mode of action, but with different environmental behaviour, such as the chlorobenzenes.

Sum values. When compounds have, besides the same mode of action, also the same human MPR value ànd a relatively small difference between the derived $\text{SRCs}_{\text{human}}$ (*because of comparable environmental behaviour*), the geometric mean of the $\text{SRCs}_{\text{human}}$ of a group of compounds is used.

A geometric mean of the derived individual SRCs_{eco} is presented when compounds probably have the same mode of action and have similar physicochemical properties. When the physicochemical properties are different, a sum value can be derived for soil/sediment only if the BSAF (biota-to-sediment/soil-accumulation-factors) of the individual compounds are comparable, otherwise the effect concentrations will be different. For example for compounds that can be biotransformed quickly, effect concentration in soil will be higher. Because no information on these BSAF values is collected, sum values in this report are only derived for isomers (mostly having a similar physicochemical behaviour). The use of one value for the sum of similar compounds has the advantage that the influences of uncertainties in the derivation of the risk limits for individual compounds are decreased. A sum value for an integrated SRC is only presented when all individual SRCs are based on ecotoxicological or human-toxicological risks.

Besides the sum values presented, values for a group of compounds can be determined for practical and policy reasons; however this is not within the scope of this report.

2.7 Summary of the general procedure for deriving SRCs

The general procedure for deriving SRCs for soil is not changed and based on human-toxicological and ecotoxicological risk assessment. The changes in deriving the SRC_{human} and SRC_{eco} are described in the chapters 5 and 6.
The proposed procedure for deriving a risk limit for groundwater differs from the derivation of the current Intervention values. The most important modifications are the use of aquatic toxicity data (HC50), not using the equilibrium method on the integrated SRC for soil (only on the SRC_{human}) and not using a factor of 10 between the pore-water and groundwater concentration. In the policy phase of Evaluation Intervention Values for Soil policy still has to decide on the procedure to be followed.
Besides risk limits for soil and groundwater, an integrated SRC for aquatic sediments is derived, based on human-toxicological and ecotoxicological risk assessment. The procedures for deriving the SRC_{human} and SRC_{eco} are described in chapter 5 and 6. In the policy phase of the project still has to be decided on the use of these risk limits for setting Intervention Values.

3 Revisions of parameters used for exposure modelling

3.1 Introduction

Deriving ecotoxicological and human toxicological risk limits, requires for each compound physicochemical, toxicological and other compound specific data. For the quantification of the human exposure also site and exposure parameters are required.

The toxicological information is dealt with in chapters 4 (human toxicological) and 6 (ecotoxicological). The SRC_{human} is derived with two exposure models; SRC_{human} for soil is derived with the CSOIL model and the SRC_{human} for aquatic sediment is derived with the SEDISOIL model. Both models use physicochemical, site and exposure parameters. The most important data in the risk assessment have been evaluated and are, if necessary, revised. The evaluation of the CSOIL parameter set is reported by Otte et al. (2001). That report also includes information presented in Van den Berg (1997), concerning small revisions carried out before VROM (1994) was published. The evaluation of the SEDISOIL model was carried out in a co-operation between RIZA and RIVM (Otte et al., 2000a). That report dealt with all aspects of the exposure model and reports possible exposure scenarios and the resulting risk limits.

In section 3.2 the revised physicochemical and compound-specific data are presented and in section 3.3 the results of the evaluation of the site and exposure parameters are summarised.

3.2 Physicochemical parameters

3.2.1 Introduction

Table 3.1 gives an overview of the evaluated physicochemical- and compound specific parameters used for the derivation of the different risk limits. The exposure modelling with CSOIL and SEDISOIL requires the bulk of the parameters. Partition coefficients are used for the derivation of SRC_{eco} and SRC_{human} for aquatic sediment.

The evaluation of parameters encloses all the contaminants of the first series of Intervention Values. The set was in a later stage completed with additional chlorophenols, more PAHs, PCBs and phthalates.

The evaluation was carried out on the basis of literature search for the most important parameters. The most important parameters for evaluation are selected on the basis of the sensitivity and uncertainty analysis (Vissenberg and Swartjes, 1996) and on the analysis of the CSOIL model performance (Otte et al., 2001). This chapter summarises the method for the derivation of physicochemical and compound specific data for human exposure modelling. The revised CSOIL data set, concerning the compound specific (physicochemical) data is tabulated in Appendix 2.

Table 3.1 Evaluated physicochemical and compound specific parameters and its use for the derivation of risk limits

Physicochemical properties used for determination of SRC	SRC_{eco} for soil	SRC_{eco} for aquatic sediment	$SRC_{human,}$ for soil	SRC_{human} for ground-water	SRC_{human} for sediment **3)**
Molecular weight (M)			used		used
Solubility (S)			used		used
Vapour pressure (Vp)			used		
Henry's law constant (H)			used		
Acid dissociation constant (pKa)			used		used
Octanol-water coefficient (Kow)			used		used
Organic carbon normalised soil-water partition coefficient (Koc)	used **2)**	used	used	used	used
Bio Concentration Factor metals for vegetables (BCF)			used		
Bio Concentration Factor metals for fish (BCF-fish)					used
Soil-water partition coefficient (Kp metals)	only Ni **1)**	used	used	used	used
Permeation coefficient (Pe)			used		
Relative oral absorption factor for soil (Fag)			used		used

1) For other metals the Kp is used only to compare by EqP method (Verbruggen et al., 2001)
2) Except for pentachlorophenol (Verbruggen et al., 2001)
3) For a description of the derivation of human risk limits for sediments and the used exposure model SEDISOIL see the report of Otte et al. (2000a).

3.2.2 Molecular Weight, Solubility, Vapour Pressure, Henry's law Constant and Acid Dissociation Constant

Physicochemical data were retrieved from selected databases and reviews as summarised in Table 3.2. The retrieved data were examined for completeness and remaining data were corrected for soil temperature (solubility and vapour pressure data). The geometric mean was taken as the best estimate.

Table 3.2 Selected databases and used (review) articles for standard data searches

Name of database
ASTER Hazardous Substance Database (HSDB) Beilstein Epiwin
additional
Merck database Chemiekaarten Merck Safety Data Sheet International Chemical Safety Cards Ohmstads Cheminfo CESARS: Chemical Evaluation Search and Retrieval System Pesticide manual 11 ed. Medchem (1996)
Review article or report
Bockting et al. (1993) Mackay database, CD-ROM 1999 Sabljic, A. et al. (1995) Van den Berg, R. (1997)

Table 3.2 shows the databases and reviews routinely referred to. Occasionally additional references were used for extracting physicochemical data. A detailed description of data

retrieval, the selection criteria and computation of the determined values can be found in Otte et al. (2001).
The most important changes between the 1995 data set and the revised 2000 data set are mentioned in the next sections.

Molecular weight (M)
The molecular weight of seven contaminants, as reported by Van den Berg (1997), is corrected. The revised molecular weight values are given in Appendix 2.

Solubility and Vapour Pressure (S and Vp)
According to the described methodology (Otte et al, 2001) a revised data set was built (see appendix 2). Otte et al. (2001) compared the data of Van den Berg (1995) with the revised data. Concerning solubility and vapour pressure data, substantial differences were observed for several compounds. Model calculations demonstrate that only for four compounds the revision of solubility and vapour pressure can lead to a relevant effect on the SRC_{human} level. Table 3.3 gives the compounds for which the differences exceed a factor 3 (solubility) or 5 (vapour pressure and H constant). The chosen factors for solubility and vapour pressure are based on the estimated uncertainty for these parameters (Otte et al., 2001) The Henry's law constant (see next item) is calculated from the vapour pressure and solubility. The effect on the SRC human concerns only the effect of the revised solubility and vapour pressure data, other revised parameters were not considered.

Table 3.3 Differences between current and revised data (> a factor of 3 or 5) and the effect on the SRC_{human} *(> a factor of 2 difference) because of these differences (*in italics*).*

solubility Δ > factor 3	vapour pressure Δ > factor 5	H constant Δ > factor 5	effect on SRC human Δ > factor 2
Catechol	Catechol	Catechol	Resorcinol
Resorcinol	*Resorcinol*	*Resorcinol*	Hydroquinone
Hexachlorobenzene	*Hydroquinone*	*Hydroquinone*	a-HCH
2-Chlorophenol	Anthracene	Anthracene	Di(2-ethylhexyl)phthalate
2,3,4-Trichlorophenol	Benzo(a)anthracene	Benzo(a)anthracene	
2,3,4,5-tetrachlorophenol	Benzo(a)pyrene	Fluoranthene	
Pentachlorophenol	Fluoranthene	Phenanthrene	
PCB153	Phenanthrene	Benzo(k)fluoranthene	
Endrin	PCB 28	2-Chlorophenol	
b-HCH	*a-HCH*	2,3,4-Trichlorophenol	
d-HCH	b-HCH	2,3,4,5-Tetrachlorophenol	
Di(2-ethylhexyl)phthalate	g-HCH	PCB 28	
	d-HCH	*a-HCH*	
	Maneb	b-HCH	
		d-HCH	
		g-HCH	
		Endrin	
		Maneb	

Henry's law constant (H)
The Henry's law constant (also called the air-water partition coefficient) is the proportionality constant between the vapour pressure of a solute above an aqueous solution and the concentration in solution. The common method for the derivation of the Henry's law constant, as used for the evaluation of substances (EUSES, 1997), for deriving environmental quality standards (EC, 1996) and for the evaluation of the environmental aspects of pesticides (Mensink et al., 1995) was adopted. The Henry's law constant is calculated from the vapour pressure and the solubility by:

$$H = Vp*M\ /\ (S*R*T)$$

with H = Henry's law constant (-)
Vp = Vapour pressure (Pa)
M= molecular weight (g/mol)
S = Solubility (g. m^{-3})
R = 8.3144 (Pa . m^3 mol^{-1}. K^{-1})
T = Temperature (K)

The Henry's law constants for all compounds are given in Appendix 2.

Acid Dissociation Constant (pKa)
The Acid Dissociation Constant has effect on the determination of the Koc for dissociating contaminants. The effect on the Koc value depends on the pKa value and the defined pH of the CSOIL standard soil. The recommended changes (Otte et al., 2001) will have an effect on the risk limits for some trichlorophenols, some tetrachlorophenols and pentachlorophenol.

3.2.3 Octanol-water partition coefficient (logKow)

It was decided to use the LOGPSTAR Kow data from the Medchem database (1996). LOGPSTAR Kow data are considered to be the most reliable set of experimental log Kow data. If the LOGPSTAR log Kow value was not available the computed estimate (the CLOGP value) was selected. In general, the average values based on the data derived from the selected databases are near the LOGPSTAR or CLOGP value. Differences were only observed for some PCB's, aldrin and tetrachloroethene (Otte et al., 2001).
Differences with the present log Kow data (Van den Berg, 1995) are more frequent.
Table 3.4 gives the compounds for which substantial differences (Δ > standard deviation) were encountered. Compounds with low, medium and high Kow values are listed when the difference exceeds respectively 0.2 log unit 0.5 log unit and 0.7 log unit. The used standard deviations for low, medium and high log Kow values are based on Jager et al. (1997). Whether these differences will provoke substantial (> a factor 2) alterations of the current exposure levels depends also on the revision of other parameters and the importance of the route "consumption of homegrown crops". If only the revision of the log Kow is considered the effect on the SRC human is found more than a factor 2 for ten compounds. The report of Otte et al. (2001) discusses the possible source of observed differences.

Table 3.4 Differences of current and revised log Kow (> 0.2, 0.5 and 0.7 log unit) and the effect (> a factor of 2) of the revised Kow on the SRC_{human}.

Log Kow < 4 Δ > 0.2 log unit	log Kow 4-5.5 Δ > 0.5 log unit	Log Kow > 5.5 Δ > 0.7 log unit	effect on SRC_{human} Δ > factor 2
Dichloromethane Tetrachloroethene Vinylchloride o-Monochlorophenol 2,3,4-Trichlorophenol Atrazine Carbofuran Carbaryl Cyclohexanone Tetrahydrofuran Tetrahydrothiophene Pyridine	2,3,4,5-Tetrachlorophenol Dieldrin	Chrysene Benzo(k)fluoranthene PCB 153 DDE DDT Aldrin Di(2-ethylhexyl)phthalate	2,3,4,5-Tetrachlorophenol PCB 153 DDE DDT Dieldrin Carbaryl Carbofuran Pyridine Tetrahydrofuran Di(2-ethylhexyl)phthalate

3.2.4 Organic carbon normalised soil-water partition coefficient (logKoc)

The current Koc values of Van den Berg (1995) were derived from a QSAR on the basis of measured Kow values (Karickhoff, 1981). The revised Koc values were derived using a "Koc-guideline" which was developed in agreement with other working groups within the RIVM and the RIZA. In contrast with the CSOIL 1995 log Koc data set, priority is given to measured data. The derived log Koc values are mainly extracted from the databases and reviews from Table 3.2. For dissociating contaminants the **overall Koc** for a standard soil is computed, taking into account both neutral and negatively charged forms. The CSOIL 1995 log Koc data (Van den Berg, 1995) considered only the sorption of the neutral form.

In Otte et al. (2001) the 1995 Koc data set (Van den Berg, 1995) was compared with the revised Koc data. Differences with the Koc of Van den Berg (1995), based on the Kow, are numerous. The revised values however are considered more realistic than the current Koc values. *Table 3.5* gives the compounds for which substantial differences were encountered.

Table 3.5 Comparison of current and revised log Koc data and the effect of the revised Koc on the SRC_{human}

log Koc < 3.5 $\Delta > 0.3$	log Koc 3.5-4.5 $\Delta > 0.5$	log Koc > 4.5 $\Delta > 0.7$	effect on SRC human $\Delta >$ factor 2
Phenol	Pentachlorobenzene	Benzo(ghi)perylene	Phenol
M-Xylene	Hexachlorobenzene	Indeno, 1,2,3-cd pyrene	M-Xylene
Catechol	2,3,4,5-Tetrachlorophenol	Maneb	Catechol
Resorcinol	Aldrin		Resorcinol
Hydroquinone	Dieldrin		Hydroquinone
1,2-Dichloroethane	Endrin		1,2-Dichloroethane
Tetrachloromethane			Tetrachloromethane
Vinylchloride			Vinylchloride
1,2,4-Trichlorobenzene			1,2,4-Trichlorobenzene
2,3,4-Trichlorophenol			1,2,3,4-Tetrachlorobenzene
Pentachlorophenol			Pentachlorobenzene
g-HCH			Hexachlorobenzene
Atrazine			2,3,4-Trichlorophenol
Carbofuran			2,3,4,5-Tetrachlorophenol
Carbaryl			Pentachlorophenol
Cyclohexanone			PCB 28
Pyridine			Aldrin
Tetrahydrofuran			Dieldrin
			Endrin
			g-HCH
			Atrazine
			Carbofuran
			Carbaryl
			Cyclohexanone
			Pyridine
			Tetrahydrofuran

Compounds are listed when the current and revised log Koc values differ more than 0.3 log, 0.5 log and 0.7 log unit for compounds with respectively low, medium and high Koc values. The used criteria are based on the estimated standard deviation. Because the Koc influences the partitioning over the soil phases (and so the exposure via crop consumption and inhalation of indoor air), the revised log Koc data influence the calculated exposure and the SRC_{human} for soil substantially (> factor 2) for 27 compounds (*Table 3.5*; right column). *Table 3.5* considers only the effect of the revision of Koc.

The revised Koc data were also compared with the so-called INS Koc data (De Bruijn et al., 1999), using the same criteria as described before. Substantial differences are less frequent and discussed in the report of Otte et al. (2001).

3.2.5 Bioconcentration factor crop/soil for metals (BCF)

The current BCF values (Bockting and Van den Berg, 1992) were derived from a wide range of plants, including plants irrelevant for consumption. No attention was paid to a relevant metal contamination level. The current BCF values were derived from field data, laboratory experiments and estimations, from which the geometric mean was used.
Since then new data became available, which could be used in a modified method.
An improved model for the assessment of metal uptake by homegrown crops was developed within the RIVM project “Accumulation of soil contaminants in crops”. The revised BCF values, used for the potential risk assessment of consumption of homegrown crops, resulted from this project (Versluijs and Otte, in prep). This report of gives full details; Otte et al. (2001) summarises the practicability of the derived models for potential risk assessment.
The BCF is defined as the ratio of the metal concentration in the edible part of the plant and the total metal concentration in the soil. Some revised BCF values for metals were derived on the basis of a Freundlich model, in which the contaminant concentration in the crop can be calculated on the basis of total metal content in soil and the soil characteristics. For these metals the metal accumulation is described on the bases of a *Freundlich* model:

$$\log [\text{C-plant}] = \text{constant} + b*\log(\ Q\ ) + c*\text{pH} + d*\log(\ \%\text{OC}) + e*\log(\%\text{clay})$$

with:

C-plant: metal concentration in the edible part of the plant in mg/kg d.m.
Q: total metal concentration in the soil in mg/kg d.m.
pH: $-{}^{10}\log [H^+]$
% clay: clay content of the soil
% OC: organic carbon content of the soil

The model is based on relevant consumption crops only. For each metal and crop available, the plant-soil accumulation model was derived. Due to insufficient field data on plant metal accumulation for certain metals, it was not possible to derive accumulation models for all metals or to take all identified metal accumulation factors into account. In case it was not possible to derive a significant Freundlich model for specific metals, the BCF value is based on the geometric mean of the available data that were found significant.

Table *3.6* gives a fundamental comparison for the derivation of BCF values between the Bockting and Van den Berg approach (1992) and the Versluijs and Otte approach (in prep). The table gives a general sketch of the underlying data and concepts, the assumptions made and practicability. The revised BCF values are tuned to the defined soil type and the contamination level. This is in contrast with the current BCF values, which were derived from a wide range of plants, including irrelevant plants and paying no attention to the relevant contaminant level. New BCF data are exclusively based on field data and average consumption pattern of vegetables and potatoes, where the current BCFs values were derived on the basis of field data, laboratory experiments and estimations. The results for specific crops, calculations for different soils, an evaluation of the uncertainties and a comparison with other accumulation models are described in the report of Otte et al. (2001).
Table 3.7 tabulates the revised bioconcentration factors for the derivation of SRC_{human}. The BCF values are given for the current standard soil. In appendix 7 the revised BCF values of the alternative standard soil are given. The soil characteristics of the alternative soil represent more the average vegetable garden.

Table 3.6 Details of derived bioconcentration factors

APPROACH	**Bockting and Van den Berg (1992)**	**Versluijs and Otte (in prep)**
general character	average or median BCF based on field data	plant – soil accumulation relation, obtained by linear modelling of field data
dependent on degree of contamination	no	yes
soil characteristic dependent	no	yes, pH, clay and organic matter
consumption pattern considered	no, only the consumption of potatoes and vegetables	yes, based on the average consumption pattern; calculation for deviant patterns possible
UNDERLYING DATA		
data sets	data set completed with estimations and data from pot experiments	field data from different sources
field data	dominant	exclusive
home grown crops	dominant	exclusive
consumable parts	sometimes	exclusive
VALIDITY/ USE		
potential risk assessment	yes	yes
metal content range	probably around Target Value level	depends on metal content. Range is determined
site specific risk [2]	no	yes, within certain ranges for pH, clay and organic matter
actual risk[3]	no	limited

Table 3.7 Revised BCF values for metals ($kg_{dw\ soil}$. $kg^{-1}_{dw\ plant}$)

metal	**current BCF (Bockting and Van den Berg, 1992)**	**Revised BCF standard soil**
soil type	*no relation with soil characteristics*	**pH 6** **OM 10 %** **clay 25 %**
As	*0.021*	**0.009**
Ba *)	*0.043*	**0.017**
Cd	*0.37*	**0.31**
Cr *)	*0.009*	**0.011**
Co *)	*0.021*	**0.58**
Cu	*0.10*	**0.20**
Hg	*0.02*	**0.15**
Pb	*0.013*	**0.017**
Mo *)	*0.129*	**0.12**
Ni	*0.025*	**0.028**
Zn	*0.22*	**0.18**

*) The BCF is based on geometric mean; there is no relation with the standard soil

3.2.6 Bioconcentration factor fish/surface water for metals (BCF fish)

The SEDISOIL exposure model uses a bioconcentration factor for the calculation of the metal concentration in fish. The BCF fish is defined as the ratio between the metal content in the fish and the metal concentration in surface water. The BCF values are provided by RIZA and RIVO and based on expert judgement (Table 3.8). In the report about the evaluation of the SEDISOIL model (Otte et al., 2000a) it was concluded that on the bases of available data the current BCF values could be maintained.

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[2] Site specific risk: soil type dependent risk (pH, clay% and OC%)

[3] Actual risk: risk assessment for different soil types and deviant receptor characteristics (e.g. crop specific approach)

Table 3.8 BCF fish values for metals according to RIZA / RIVO (Otte et al., 2000a)

metal [1)]	BCF fish (l/kg dry weight)
As	50
Cd	100
Cr	200
Cu	1000
Hg	1000
Pb	5000
Ni	200
Zn	10000

[1)] For barium, cobalt and molybdenum no BCF values are known

3.2.7 Kp metals for soil

The current Kp set of Van den Berg and Roels (1991) is based on both measured and calculated Kp values. These calculated Kp values (geometric means) are, among others, estimated[4] from empirical Bioconcentration Factors (Baes et al., 1984). However the current data lack a solid foundation and a relation with the soil type.
Kp-values are also used for the derivation of the SRC_{eco} for soil with equilibrium partitioning from the SRC_{eco} in case not enough ecotoxicological data for soil are available (chapter 6). For that purpose currently the Kp-values of Bockting et al. (1992) are used (Crommentuijn et al. 1997).

The Kp set to be derived is in the first place used for estimating the concentration in pore-water /groundwater for the deriving risk limits for groundwater. For this purpose the Kp should represent the fraction of contaminants in the pore water that is subject to transport. The Kp is defined as:

$$Kp = \text{total soil content} / \text{total pore water concentration}$$

In the second place the derived Kp-values are used for the derivation of the SRC_{eco} for metals in soil or sediment with equilibrium partitioning from the risk limits for (surface) water, when soil or sediment data are lacking (see chapter 6).

For the derivation of a Kp set, four data sets were evaluated and several methods for Kp derivation were investigated. More information and discussion concerning the derivation of Kp values, assumptions and the foundations of used selection criteria are presented in a separate report (Otte et al., 2001). The Kp values of the four data sets were judged on five criteria, namely:

- quality of the underlying data sets;
- the matching with the agreed Kp definition (metal content);
- the compatibility with Dutch soils;
- the experimental set-up;
- the current use or status of the set.

Based on these criteria a revised Kp set was composed, based on the next rule of thumb:
- ⇒ a sorption model compatible with average Dutch soil characteristics, if possible;
- ⇒ a geometric mean of the available data, in case a sorption model is not available or applicable.

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[4] Used Kp formula: $\ln Kp = 2.38 - 0.89 * \ln BCF$

The revised Kp values for the current standard soil are given in Table 3.9. These values apply to soil, for aquatic sediments different Kp-values are used (see section 3.2.8). Only for cadmium, lead and zinc a soil type dependent Kp was proposed, based on the data set of Otte et al (2000b).

Table 3.9 Current and revised Kp values, including references (l/kg)

metal	**current Kp for groundwater (Van den Berg and Roels, 1991)**	**current Kp for deriving SRC_{eco} (Bockting et al, 1992)**	**revised Kp (pH 6, OM% 10, clay% 25)**	**reference**
As	980	191	**1800**	Sauvé et al., 2000
Ba	60	60	**2500**	Sauvé et al., 2000
Cd	190	200	**2560**	Otte et al. 2000b
Cr	14400	110	**4800**	Sauvé et al., 2000
Co	120	40	**120**	Van den Berg and Roels, 1991
Cu	540	977	**2120**	Sauvé et al., 2000
Hg	3300	170	**7500**	Sauvé et al., 2000
Pb	2380	1905	**36000**	Otte et al. 2000b
Mo	20	871	**40**	Sauvé et al., 2000
Ni	560	120	**2000**	Janssen et al., 1997a
Zn	250	158	**2600**	Otte et al. 2000b

3.2.8 Kp metals for aquatic sediment

The evaluation of the SEDISOIL model included the assessment and revision of the current partition coefficients (Otte et al., 2000a). The Kp values for aquatic sediment used in the 1996 version of SEDISOIL were equated with the Kp values for soils as determined by Van den Berg and Roels (1991). It was realised that these Kp values only have indicative value for sediments. However, because of the lack of measured or calculated Kp values for sediments this approach was implemented in the first version of the SEDISOIL exposure model (Bockting et al., 1996).
In the evaluation of the SEDISOIL model it was concluded that, as for the selection of Kp values for soil, the use of measured partition coefficients sediment-water are preferred. However, measured Kp values, reflecting average sediment characteristics are hardly available. Therefore it was proposed to use the Kp set reported by Stortelder et al. (1989) which concerns partition coefficients for suspended matter – surface water.

From the Stortelder set, the Kp for sediments-surface water can be derived by dividing the reported Kp suspended matter–surface water with a factor of 1.5. This factor is based on the fact that the metal content in standard suspended matter is 1.5 times higher than the metal content in standard sediment. The higher percentage organic carbon and clay (Stortelder et al., 1989) probably causes the higher metal content in suspended matter. The Kp values for aquatic sediment (Table 3.10) are determined by using the median values and dividing by 1.5. For barium, cobalt and molybdenum partition coefficients were derived by Bockting et al. (1992) from Kp data for suspended matter from different sources using the described approach.

Table 3.10 gives the revised Kp data for aquatic sediment. The current Kp values, also used in the 1996-version of the SEDISOIL model and within the current Urgency of Remediation Methodology (VROM, 1995) are also given.

Table 3.10 Partition coefficients for aquatic sediment (l/kg)

metal	**current Kp (Van den Berg and Roels, 1991)**	**revised Kp (Stortelder, 1989; Otte et al. 2000)**
arsenic	980	**6670**
barium	60	**1000**
cadmium	190	**86700**
chromium	14400	**193000**
cobalt	120	**3980**
copper	540	**33300**
mercury	3300	**113000**
lead	2380	**427000**
molybdenum	20	**850**
nickel	560	**5300**
zinc	250	**73300**

The proposed Kp values for aquatic sediment are much higher than the current values. This implies a lower mobility and in general a lower exposure. The proposed Kp sediment data (Table 3.10) are also used for the derivation of MPCs and NCs (Crommentuijn et al., 1997) and will be used for the derivation of SRC_{eco} (Verbruggen et al., 2001).
Like Kp values for soils, the Kp for sediments show a wide range of variability. For site-specific risk assessment measured Kp values are recommended. At this moment RIZA investigates the mobility of heavy metals in sediments and it is expected that in short time methods to determine partition coefficients under anaerobe conditions will become operational for site-specific risk assessment (see also section 8.7).

3.2.9 Permeation coefficient (Pe)

The permeation coefficient (expressed in $m^2.day^{-1}$) is a measure of the affinity for transport of a compound through a membrane. It is used to calculate the concentration of soil contaminants in drinking water after permeation of the compound through the tube. The water tube is specified as a Low-Density Polyethylene (LDPE) tube, as permeation through this material is found higher than with other materials.
The permeation coefficient values are based on reports of Vonk (1985) and Van der Heijden and Hofman (1987). A description of the procedure for derivation is evaluated and described by van den Berg (1997).

The revised data as reported by Van den Berg (1997) is adopted. Based on the data of Van den Berg concerning the permeation coefficient for alkanes a value for Total Petroleum Hydrogen (TPH) fractions was estimated. All data are tabulated in Appendix 2.

3.2.10 Relative oral absorption factor for soil (Fag)

The current relative absorption factor will be split in an oral factor for soil intake (Fag) and a factor for other routes (Fa). The relative absorption factor Fag is the fraction of a contaminant in soil absorbed in the body. In Vissenberg and Swartjes (1996) it was identified as a parameter that contributes substantially to the uncertainty of the exposure. The present concepts for human exposure assessment (CSOIL and SEDISOIL) set the relative adsorption factor to 1.0 for all contaminants. Although the relative absorption factor for many substances probably is lower than 1 (Ruby et al., 1999; Sips et al., in prep.) only for lead contaminated soil more extensive data are available. These data have been summarised and discussed in Lijzen et al. (1999a) and Sips et al. (in prep.). Large site-specific differences are found. From the presented data there is enough evidence to conclude that the relative absorption factor for Pb in soil (compared to Pb in food) is lower than 1 and that provisionally a value of 0.6 can be recommended. The SEDISOIL exposure model maintains a relative absorption factor of 1 for all cases.

3.3 CSOIL site and exposure parameters

3.3.1 Soil parameters

Because the soil characteristics influence the calculated risk limits to a large extent, these parameters have been evaluated. In general, the sensitivity of the site input parameters decreases in the following order (Vissenberg and Swartjes, 1996; Otte et al., 2001): pore air fraction > contribution of crop consumption from own vegetable garden to total vegetable consumption > organic matter content, depth of contamination, depth of groundwater table > density of the solid phase. The clay content and organic matter content only are important input parameters if they are incorporated in correction formulae for specific soil types.

New values have been recommended to account for average soil characteristics of the topsoil. In Table 3.11 the current and revised values for the evaluated parameters for soil are presented. Because the organic matter content, clay content and pH also relate to the soil type correction of the Intervention Values and currently no new method for soil type correction is proposed, it is recommended to maintain the parameters currently used in the soil-type correction (OM=10%, clay = 25%, pH=6).

In case the soil-type correction is adjusted it is proposed to revise the “standard soil” for calculating risk limits and therefore to:

- lower the organic matter content (OM) to 5%, representing better the Dutch soil than the current standard soil (OM=10%);
- decrease the clay content from 25% to 15%;
- lower the standard pH from 6 to 5, because the soil pH of 6 is found to be relatively high and could lead to underestimation of the accumulation of metals in plants;

To give an impression of the influence of the proposed revised values for organic matter, clay and pH on the risk limits for soil, the alternative risk limits are presented in Appendix 7**.**

3.3.2 Site parameters

All parameters concerning the description of the contaminated site are related to the calculation of the indoor air concentration. One parameter (flux of evaporating water, Ev) is eliminated from the concept. Because a convective flux has been added (see paragraph 5.2.3), also three parameters are added: the depth of groundwater table (dg), the air pressure difference soil to crawlspace (ΔP_{cs}) and the air permeability of the soil (κ).

The mean depth of the contaminant is related to the mean depth of the groundwater table. The median groundwater table in the Netherlands is 1.6 m below surface. Taking into account the groundwater table under built-up areas this parameter is set at 1.75 m below surface. Because the average capillary transition boundary (CTB) is 0,5 m above the groundwater, the average depth of the (volatile) contaminant is set at 1.25 m below surface.

The average air pressure difference between soil and crawlspace (ΔP_{cs}), used for calculating the convective flux to the crawlspace, is estimated to be 1 Pa. This value strongly changes in time (due to wind and temperature effects) and on the location (which side of the house) and can be higher (4 Pa), much lower or even be negative. As a conservative value 4 Pa could be chosen (Rikken et al., 2000).

The air permeability of the soil (κ) strongly depends on the type of soil. This can be set between 10^{-10} m^2 for coarse sand to 10^{-16} m^2 for clay. For this purpose a value for medium sand is chosen being 10^{-11} m^2. In the actual risk assessment (with VOLASOIL) the most appropriate value has to be used (Rikken et al., 2000).

The air exchange rate of the crawlspace (Vv) depends on the ventilation holes and the wind and weather conditions. A large data set has lead to a small correction of the current value 1.1 h^{-1} (former value 1.25 h^{-1}) (Otte et al., 2001).
The height of the crawl space (Bh) has not been changed and remains 0.5 m.
The contribution of crawl space air to indoor air (fbi) was 0.1. Although this value depends on the ventilation and quality of the floor, it is decided to keep a fixed value for potential risk assessment. From tracer experiments from relatively new houses a contribution of 0.07 was found. Taking into account all Dutch houses the contribution remains 0.1. More detailed information can be found in Otte et al. (2001).

3.3.3 Exposure parameters

Exposure parameters concern parameters that are related to human characteristics, human behaviour, including residence time at the location, in the house, garden, etc. Input parameters related to human behaviour are amount of soil ingestion for children and adults, amount of total crop consumption. Input parameters related to human characteristics concern body weight and (covered) body surface. Evaluation, leading to revisions of the exposure input parameters, has been done on the basis of literature search for the most important parameters. The importance of the parameter is derived from the sensitivity of the calculated exposure to the input parameters and is contaminant-specific. In general sensitivity of the exposure parameters is assumed to decrease in the following order (Vissenberg and Swartjes, 1996; Otte et al., 2001): residence time > amount of soil ingestion for adults and children > body weight > total crop consumption > covered part of the body surface > body surface > matrix factor (dermal uptake) ≈ absorption velocity (dermal uptake).

The amount of soil ingestion by adults and children is evaluated extensively in Otte et al. (2001). Because especially young children ingest more soil, it is important to distinguish between both groups. Nevertheless for all substances, except lead, a lifelong exposure is used in the risk assessment. Based on available literature, mainly tracer studies, the yearly average (daily) soil intake for children is 100 $mg.d^{-1}$ (75-125 being the 95% confidence limit of the average). The 95th-percentile of the soil ingestion by children is about 200 $mg.d^{-1}$. These values are in line with the values used in international models. Because in principle average exposure parameters are chosen, it is recommended to use the value of 100 $mg.d^{-1}$. If it is found appropriate to use a more safe value, 125 or 200 $mg.d^{-1}$ could be used.
For adults much less data on soil ingestion are available. Based on 2 references the soil ingestion by adults remains 50 $mg.d^{-1}$. An upper percentile could not be derived.
Not taken into account is acute exposure and toxicity due to deliberate soil ingestion of children (see section 5.2.2).

Table 3.11 Current and revised values of relevant parameters of the selected exposure routes in CSOIL

parameter	**code**	**relevant for exposure route**	**unit**	**current value**	**revised value**
soil parameters					
volume fraction air	Va	indoor air	$m^3.m^{-3}$	0.2	0.2
volume fraction water	Vw	indoor air	$m^3.m^{-3}$	0.2	**0.3**
fraction organic carbon	foc -	indoor air, crop consumption, drinking water	$kg.kg^{-1}$	0.058	0.029[1]
fraction clay	SD	crop consumption	$kg.kg^{-1}$	25	15[1]
mass volume of dry soil	-	drinking water	$kg.dm^{-3}$	1.5	**1.2**
pH		crop consumption	-	6	5[1]
site-specific parameters					
flux of evaporating water	Ev	indoor air	$dm^3.m^{-2}.d^{-1}$	0.1	-
mean depth of the contamination	dp	indoor air	m	1.25	1.25
depth of groundwater table	dg	indoor air		-	1.75
air pressure difference soil crawlspace	Δp_{cs}	indoor air	Pa	-	**1**
air permeability of the soil	κ	indoor air	m^2	-	**1E-11**
air-exchange rate of crawlspace	Vv	indoor air	h^{-1}	1.25	**1.1**
height of the crawl space	Bh	indoor air	m	0.5	0.5
contribution of crawl space air to indoor air (fraction)	fbi	indoor air	-	0.1	0.1
Exposure parameters					
daily intake amount soil by child	AIDc	soil ingestion	$mg.d^{-1}$	150	**100**
daily intake amount soil by adult	AIDa	soil ingestion	$mg.d^{-1}$	50	50
fraction contaminated root crops	Fvk	crop consumption	$kg.kg^{-1}$	0.1	0.1
fraction contaminated leafy crops	Fvb	crop consumption	$kg.kg^{-1}$	0.1	0.1
consumption root crops adult	Qka	crop consumption	$g.d^{-1}$	137	**122**
“ child	Qkc	crop consumption	$g.d^{-1}$	74.8	**59.5**
consumption leafy crops adult	Qba	crop consumption	$g.d^{-1}$	158	**139**
“ child	Qkc	crop consumption	$g.d^{-1}$	76.1	**58.3**
fraction dry weight root crops	fdwr	crop consumption	-	0.202	**0.167**
fraction dry weight leafy crops	fdws	crop consumption	-	0.117	**0.098**

[1] the proposed values foc= 0.029, fraction clay= 0.15 and pH=5 in Otte et al. (2001) are not incorporated in the exposure calculations. The proposed values will be incorporated only when decisions are being made about the soil-type correction (see section 2.5).

The fraction of contaminated crop (Fvk, Fvb) is the fraction of vegetables eaten from the kitchen or allotment garden. Although there is limited quantitative information, there are very large differences. Many people never eat homegrown crops, whereas others eat these crops almost every day. On the other hand people with an allotment garden eat more vegetables in total. For the exposure scenario “residential with garden” it is decided to maintain both fractions at 0.1, although the average value probably is lower. In other (international) models these fractions are often higher (Rikken et al., 2000).

The consumption of root crops and leafy crops by adults and children (Qk and Qb) is updated with the most recent data concerning the Dutch consumption patterns. In general the amount of fresh vegetables eaten has decreased, leading to slightly lower values. The fraction dry weight of vegetables influences the calculated accumulation of metals by plants. It is slightly lower, representing a weighted average for consumption crops.

All parameters related to dermal exposure still should be evaluated in combination with the evaluation of the current concept for estimating the dermal exposure.

3.4 SEDISOIL site and exposure parameters

3.4.1 Sediment parameters

The standard sediment characteristics, determined by Bockting et al. (1996) were maintained. It was considered that sediment and suspended matter characteristics will not differ much from the defined standard soil which was used for the derivation of Intervention Values (Van den Berg, 1995). An organic matter content of 10 % for sediment and an organic matter content of 20 % for suspended matter were assumed as a representative average value. The pH value of 8 was specified by RIZA. Table 3.13 gives an overview of the parameter values.

3.4.2 Exposure and site parameters

The evaluation of the SEDISOIL exposure model included an analysis of possible user scenarios (human behaviour) and the most relevant exposure parameters (Otte et al., 2000a). Six possible user scenarios were formulated; the scenario *"possibility of recreation and fishery"* was proposed as the "standard scenario" for potential risk assessment to the expert group on human risk assessment and the "Working Group UI" and agreed upon (see Table 3.12). This scenario reflects the majority of Dutch surface waters and assumes an average (10 days per year) use for recreational activities as sunbathing, swimming and fishery. The consumption of fish is based on food consumption surveys of 1988 and 1993 and compared with other (international) references. The default SEDISOIL scenario concerns the average consumer and is not applicable in the case of fishing waters. Bockting et al. (1996) supposed that anglers consume five times as much fish than the average consumer. Moreover, for the risk assessment it is considered that the angler consumes 50% from own catch against 10% for the average consumer. The data concerning the consumption of own catch, as determined by Bockting et al. (1996) were maintained.

Table 3.12 Sediment standard scenario parameter values (Otte et al., 2000a)

scenario description	frequency (days / year)	fish consumption (g/day) adult	fish consumption (g/day) child	fish cons. from contaminated site (%)
possibility of recreation and fishery	10	11	3	10

The amount of soil ingestion by adults and children during recreational activities is not evaluated and maintained on the level of 350 mg for adults and 1000 mg for children per occasion (Bocking et al., 1996). These values are higher than determined for the standard scenario for soils, because recreational activities imply a more intense contact. In contrary with the derivation of the SRC_{human} level for other metals the SRC_{human} level for lead contaminated sediment is based on the exposure and MPR for intake for children. The relative absorption factor for contaminants in the human body is maintained at 1, except for lead in soil (0.6; section 3.2.10). Not taken into account is acute exposure and toxicity due to deliberate soil ingestion of children.

Concerning dermal exposure via sediment, the exposed surface area of the skin is revised to: 0.28 m^2 for children (was 0.17 m^2) and to 0.95 m^2 for adults (was 0.28 m^2). Concerning dermal exposure via surface water, the exposed surface area of the skin is revised to 0.57 m^2 for children (was 0.95 m^2) and to 1.8 m^2 for adults (was 1.8 m^2) (Otte et al., 2000a).

Table 3.13 gives an overview of the SEDISOIL parameter values.

Table 3.13 Current and revised values of relevant parameters of the selected exposure routes in SEDISOIL or (Otte et al., 2000a)

parameter	**code**	**unit**	**current value**	**revised value**
sediment parameters [1)]				
volume fraction water	Vw se	$m^3.m^{-3}$	0.4	0.4
fraction organic carbon	foc se	$kg.kg^{-1}$	0.058	0.058
mass volume of dry sediment	SD se	$kg.dm^{-3}$	1.3	1.3
pH	-	-	8	8
suspended matter parameters				
fraction organic carbon	foc sm	$kg.kg^{-1}$	0.116	0.116
site parameters				
concentration suspended matter	Pc	$mg.dm^{-3}$	30	30
Exposure parameters [2)]				
intake amount sediment by child	AIDsec	mg	1000	1000
intake amount sediment by adult	AIDsea	mg	350	350
relative absorption factor soil	fag se	-	1	1
ingestion surface water	AIDsw	ml	50	50
matrix factor	fm	-	0.15	0.15
exposed skin surface child	Aexpc	m^2	0.17	**0.28**
exposed skin surface adult	Aexpa	m^2	0.28	**0.95**
total skin surface child	Atotc	m^2	0.95	**0.57**
total skin surface adult	Atota	m^2	1.8	1.8
degree of coverage skin, child	DAEc	$mg.cm^2$	0.51	0.51
degree of coverage skin, adult	DAEa	$mg.cm^2$	3.75	3.75
dermal absorption factor child	DARc	h^{-1}	0.01	0.01
dermal absorption factor adult	DARa	h^{-1}	0.005	0.005
dry weight fraction fish	fdw fish	-	0.1	0.1
fat fraction fish	Ff fish	-	0.1 [3)]	**0.05**
fish consumption child	Qfi c	$g\ fresh.d^{-1}$	3	3
fish consumption adult	Qfi a	$g\ fresh.d^{-1}$	11	11
contribution of own catch to total fish consumption	FV fi	%	10	10
exposure frequency	tf se	$day.yr^{-1}$	10	10
period dermal exposure sediment	tb se	$h.d^{-1}$	8	8
period dermal exposure surface water, child	tb swc	$h.d^{-1}$	2	2
period dermal exposure surface water, adult	tb swa	$h.d^{-1}$	1	1

1. The percentage clay is not defined
2. For missing exposure parameters it is referred to Table 3.11
3. The methodology of remediation urgency considers a fraction fat of 0.2.

3.5 Principal revisions of input parameters

The most important changes of the compound-specific input-parameters are found for the Koc and the Kow (for organic compounds) and the Kp for soil and the Kp for sediments. The other parameters give only for a limited amount of compounds substantial changes. Nevertheless the base and transparency of all these data is largely improved. The evaluation of the selected site and exposure parameters in CSOIL lead to limited modifications, based on more extensive and more recent data. Besides, more information about the ranges (distribution) of the values is retrieved. The evaluated exposure parameters in SEDISOIL lead to changes of the fraction fat in fish and the exposed skin surface.

4 Human-toxicological Maximum Permissible Risk levels

4.1 Introduction

One of the bases of the Intervention Values is the human-toxicological Maximum Permissible Risk (MPR_{human}) value for each of these compounds: the present study comprises the revision of these MPRs of the first series of compounds, which was reported by Vermeire et al. (1991) and Vermeire (1993). The full derivation of the MPR_{human} values is given in the report of Baars et al. (2001).

4.2 General procedure

4.2.1 Definitions

The MPR_{human} is defined as the amount of a substance (usually a chemical substance) that any human individual can be exposed to daily during full lifetime without significant health risk. It covers both oral and inhalation exposure (and if necessary also dermal exposure), and classical toxic risks as well as carcinogenic risks. The MPR_{human} is generally expressed as either a tolerable daily intake (TDI) or an excess carcinogenic risk via intake (CR_{oral}), both covering exposure by oral ingestion, or a tolerable concentration in air (TCA) or an excess carcinogenic risk via air (CR_{inhal}), both covering exposure by inhalation.

The procedure to derive MPR_{human} is outlined in detail by Janssen and Speijers (1997). The approach of the present re-evaluation is a pragmatic one in that use has been made of existing toxicological evaluations by national and international bodies, in an attempt to avoid unwanted duplication of work. Existing evaluations were used in a critical fashion: on a case-by-case basis their adequacy for use in the present scope was judged, and from that the need to search additional literature was determined.

In the following the abbreviation "MPR" is used throughout to indicate the MPR_{human}.

4.2.2 Threshold versus non-threshold approach

In evaluating the toxicity of chemical substances, distinction must be made between two fundamentally different approaches. Genotoxic carcinogens are assumed to exert their activity also at the smallest dose, i.e., by definition a threshold for genotoxic activity does not exist. Toxic effects other than genotoxic carcinogenicity, however, are assumed to occur via receptor interaction, which implies that a certain threshold needs to be exceeded for the toxic effect to become manifest.

4.2.3 Excess lifetime cancer risk

For genotoxic carcinogens a cancer risk estimate is made based on known tumour incidences for the compound in question. This procedure results in an *excess lifetime cancer risk*. Basically, the approach assumes a linear relationship (also at very low doses) between dose and cancer incidence, which implies that the cancer incidence due to exposure to a particular genotoxic chemical is zero only if the dose is zero too.

In the framework of the Intervention Values the acceptable excess lifetime cancer risk is set at 1 in 10,000 (10^{-4}).

4.2.4 Tolerable daily intake (oral and inhalation)

Applying the threshold approach for all other toxic chemicals, a *tolerable daily intake (TDI)* is derived, representing the estimated amount of the chemical that humans can ingest daily during their entire lifetime without resultant adverse health effects. Analogously, a *tolerable concentration in air (TCA)* is derived for the inhalation route of exposure, representing the air concentration of the chemical that humans can inhale during their entire lifetime without resultant adverse health effects.

4.2.5 Deriving a MPR

Basically, the derivation of the MPR for a particular compound starts with examining the existing toxicology reviews of this compound. These include reviews by (inter)national organisations such as RIVM, WHO, EU, US-EPA, IARC, ATSDR [5]), etc. These are evaluations that are carried out by (inter)national committees of experts, and generally they can be taken as critical and well-validated data sources. Ideally these reviews report studies on the effects of the compound in humans, a variety of toxicological endpoints examined in animal experiments, and include information regarding the dose-effect relationship as well as information regarding the mechanism(s) of the toxic effect(s) observed. This information is critically evaluated, the pivotal toxicological endpoint is defined, and from a key study the *no observed adverse effect level (NOAEL)* is defined. The NOAEL is the highest dose in the study at which no substance-related adverse health effects were observed, generally the first dose below the one at which such effects did occur (which is defined as the *lowest observed adverse effect level - LOAEL*). In case of a non-genotoxic compound uncertainty factors are applied to extrapolate from the NOAEL to the MPR (see section 4.2.6), while for a genotoxic compound a linear extrapolation is applied to arrive at the acceptable cancer risk.
Sometimes a MPR is characterised as *provisional* or *temporarily*. *Provisional* is used if data for a particular route of exposure are not available, and other data had to be used to arrive at the MPR. *Temporarily* is used if a particular substance is being evaluated internationally, but the evaluation process has not yet resulted in a final report.

4.2.6 Uncertainty factors

According to the general principles of toxicological risk assessment (Faustman and Omenn, 1996; Woodward, 1996), so-called *uncertainty factors* (UFs, formerly called *safety factors*) are used to derive the MPR from the NOAEL. These UFs allow for interspecies (animal to human) variation and for intraspecies variation (variations in susceptibility in the human population). By default, these two types of variation are covered by UFs of 10 (Faustman and Omenn, 1996; Woodward, 1996; Vermeire et al., 1999). However, when there are flaws or omissions in the data package from which the NOAEL is taken, additional UFs or *modifying factors* (MFs) have to be applied. Thus:

$$\mathrm{MPR} = \mathrm{NOAEL}/\mathrm{UF}_1 \times \mathrm{UF}_2 \times \ldots$$

It must be emphasised that the UF applied in any particular case does not indicate the reliability of the resulting MPR. It is the factor which by expert judgement is considered necessary to extrapolate from the available toxicological data to a MPR that defines the daily intake of a chemical which during entire lifetime appears to be without appreciable risk on the basis of all currently known facts.

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[5]) WHO: World Health Organization (e.g., the International Programme on Chemical Safety, and the Joint Expert Committee on Pesticide Residues); EU: various Scientific Committees of the European Union; US-EPA: US Environmental Protection Agency; IARC: International Agency for Research on Cancer; ATSDR: US Agency for Toxic Substances and Disease Registry.

4.2.7 Route-to-route extrapolation

In the human-toxicological evaluation aimed at deriving MPRs, toxicity data for all routes of interest for a particular compound (i.e., oral, inhalation, and if applicable also dermal) are considered. This full data set is needed to obtain a complete picture of the toxicological properties of the compound. In practice, however, the available datasets are often limited. Consequently, when oral data are insufficient for deriving a TDI; *route-to-route extrapolation* is performed based on inhalation data. Vice versa, if inhalation data are lacking, route-to-route extrapolation can be applied using oral data. It must be emphasised, however, that route-to-route extrapolation is a rather unreliable method to derive any limit value.

4.2.8 Reliability

Depending on the size and quality of the database from which a MPR is derived, the resulting limit value has a certain reliability. In the current re-evaluation the reliability of the resulting MPRs is scored as *high, medium* or *low*.

Basically this reliability is the result of expert judgement of the database from which the limit value is derived. This judgement involves:

- A MPR represents a limit value for lifetime exposure. Generally, toxicity studies from which a MPR is derived should thus preferably be chronic studies (exposure of experimental animals during their full or almost full lifetime). Consequently, if chronic studies and even semi-chronic studies are not available, the resulting MPR will be of low or at best medium reliability. It should be noted, however, that some pivotal effects are only observed in specific studies regarding, e.g., reproduction or teratogenicity. Moreover, chronic studies are not by definition of better quality than other studies.
- The extent of the database. Any specific toxicity of a particular substance is better characterised if observed in different studies, by different investigators, in different animals, with different study designs. Thus, if only studies in one experimental animal species are available, or if only a very small number of studies are available, the resulting MPR will at best be of medium reliability. In this framework it should be noted that more recent studies might be expected to have involved modern research methods and good laboratory practice, but that studies of older date are not by definition less reliable.
- The design of a particular study. It should allow establishing the significance of a particular toxic effect, and its dose-effect relationship. If possible a toxic effect should be supported by histopathological data, microscopic observations, research (*in vivo* or *in vitro*) regarding the molecular mechanism of the effect, etc. Thus, poorly designed studies will result in a MPR with low reliability (if the database does not contain other, better-designed and more extensive studies).
- In general a MPR is scored as highly reliable if resulting from the evaluation by an internationally renowned committee of experts, particularly because these committees only derive an MPR if a rather complete database is available (cf. section 4.2.5).
- In addition, the extent of international consensus regarding the nature and the severity of a specific toxic effect of a particular compound indicates the trust (or distrust) of the international expert community in the toxicological characterisation of this substance.

It should be noted that in the present re-evaluation of MPRs the reliability qualification is only a very general one, due to the rather pragmatic way by which the MPRs were derived (cf. section 4.2.1).

4.3 Results and discussion

Table 4.1 lists the MPRs of the first series of compounds as derived in 1991/1993, together with the evaluations of these MPRs which were done in 1999/2000.
The majority of the substances were just re-evaluated on the basis of new and additional information. For some substances or groups of substances, however, full new evaluations were carried out. These involved:

- The so-called "dioxins". These now include polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and the co-planar polychlorinated biphenyls (the "dioxin-like" PCBs). The MPR is based on the recent WHO recommendation for this group of compounds.
- The polychlorinated biphenyls (PCBs), or better, the non-planar (non "dioxin-like") PCBs. Since there are a large number of congeners in this group, the MPR is based on the 7 indicator PCBs (IUPAC numbers # 28, 52, 101, 118, 138, 153, and 180) and also expressed in the (summed) amount of these indicator PCBs.
- The polycyclic aromatic hydrocarbons (PAHs). In the previous evaluation the MPR was based on the so-called "10 PAHs of VROM". In the present evaluation the number of PAHs has been extended from 10 to 17: the so-called "16 PAHs of US-EPA" plus naphthalene (which originally was not part of the 16 EPA-PAHs - currently it is), which in the past decade has become the internationally used standard. In the present evaluation the MPR is based on the carcinogenicity equivalence principle with the carcinogenicity of benzo(a)pyrene (BaP) as the standard, and expressing the carcinogenicity of other PAHs as fractions of BaPs carcinogenicity using "BaPEFs" (BaP equivalency factors; since BaP has the strongest carcinogenic potency of all PAHs, these factors are by definition between 0 and 1). Both new approaches are in full agreement with recent international developments regarding characterising and evaluating PAH mixtures.
- The group of total petroleum hydrocarbons (TPH; in Dutch *"minerale olie"*). The evaluation of these substances is now based on a tiered approach. Firstly it is investigated if the mixture can be evaluated on the basis of the "whole product" approach (namely, if the origin and source of the contamination is known to be one well known product, e.g., a particular jet fuel). Secondly it is considered if there are any carcinogenic substances present, which then must be evaluated as such. Finally, the components of the TPH mixture are evaluated for their (classical) toxicity by a fractional approach, distinguishing four fractions covering the aliphatic compounds, and three fractions covering the aromatic compounds. This new approach is in full agreement with recent international developments regarding characterising and evaluating TPH mixtures (Franken et al., 1999).

Some of the more volatile compounds have a rather strong and/or characteristic smell. Although the presence of such a compound can be detected by its smell, this gives no indication whatsoever about its toxicity, and is thus of no value for decision processes. Moreover, there are large individual differences in the capacity of humans to perceive certain odours. Finally, there is no uniform way in estimating odour thresholds, which results in quite large ranges as reported in the literature. Table 4.2 lists odour thresholds for a selected number of compounds. For some of these also the range is presented, indicating the variability in sense of smell and methods of estimating odour thresholds.
In comparing the odour thresholds with the TCAs/CRs$_{inhal}$ (Table 4.1) it is evident that of the sixteen odour thresholds listed in Table 4.2, only two (i.e., pyridine and styrene) have odour thresholds well below their TCAs. This demonstrates that the smell of a particular compound has no relation at all with its toxic and/or carcinogenic potential.

Table 4.1 Revised human-toxicological Maximum Permissible Risk levels of Evaluations 1999/2000, with reliability score (see section 4.2.8)(Baars et al., 2001)

Compound	**MPR 1991/1993**		**MPR revised (1999/2000)**			
	type	**value**	**type**	**value**	**remark**	**reliability**
I. Metals						
Arsenic	TDI	2.1	TDI	1.0		high
			TCA	1.0		high
Barium, soluble	TDI	20	TDI	20	1	high
Barium, insoluble	TDI	-	TDI	-	1	high
			TCA	1.0		high
Cadmium	TDI	1.0	TDI	0.5	2	high
Chromium III	TDI	5.0	-	-		-
Chromium III, soluble	-	-	TDI	5.0		medium
Chromium III, insoluble & metallic	-	-	TDI	5000		medium
			TCA	60		medium
Chromium VI	pCR_{oral}	0.7×10^{-3}	pTDI	5.0	3, 4	low
	CR_{inhal}	2.5×10^{-3}	CR_{inhal}	2.5×10^{-3}	4	high
Cobalt	TDI	1.4	TDI	1.4		medium
			TCA	0.5		medium
Copper	TDI	140	TDI	140		medium
			TCA	1.0		medium
Lead	TDI	3.6	TDI	3.6	5	high
Mercury, metallic	-	-	TCA	0.2		high
Mercury, inorganic	TDI	0.6	TDI	2.0		high
Mercury, organic	TDI	0.6	TDI	0.1		high
Molybdenum	TDI	10	TDI	10		high
			TCA	12		high
Nickel	TDI	50	TDI	50		high
			TCA	0.05		high
Zinc	TDI	1000	TDI	500		high
II. Other inorganic compounds						
Cyanides, free	TDI	50	TDI	50		high
	pTCA	200	TCA	25		high
Cyanides, complex	TDI	13	TDI	800	6	high
Thiocyanates	TDI	11	TDI	11		high
III. Aromatic compounds						
Benzene	PCR_{oral}1991	170	pCR_{oral}	3.3	7	medium
	CR_{inhal} 1991	1200	CR_{inhal}	20		high
	TDI 1993	4.3				-
	pTCA 1993	30				-
Ethylbenzene	TDI	136	TDI	100		high
	TCA	77	TCA	770		high
Toluene	pTDI	430	TDI	223		high
	TCA	3000	TCA	400		high
Xylenes	PTDI	10	TDI	150		high
	TCA	54	TCA	870		high
Styrene	TDI	77	TDI	120		high
	TCA	800	TCA	900		high
Phenol	TDI	60	TDI	40		high
	pTCA	100	pTCA	20	26	low
Dihydroxybenzenes (total)	TDI	25	TDI	25	25	medium
1,2-dihydroxybenzene (catechol)	TDI	40	TDI	40	25	medium
1,3-dihydroxybenzene (resorcinol)	TDI	20	TDI	20	25	medium
1,4-dihydroxybenzene (hydroquinone)	TDI	25	TDI	25	25	medium
Cresoles	TDI	50	TDI	50	25	medium
	TCA	170	TCA	170	25	medium
IV. Polycyclic aromatic hydrocarbons (PAHs)						
PAHs, total	CR_{oral}	6.3	-	-		-
acenaphtene	-	-	CR_{oral}	500		high
acenaphtylene	-	-	CR_{oral}	50		high

Compound	**MPR 1991/1993**		**MPR revised (1999/2000)**			
	type	**value**	**type**	**value**	**remark**	**reliability**
anthracene	TDI	50	TDI	40		high
benz[a]anthracene	CR_{oral}	20	CR_{oral}	5.0		high
benzo[b]fluoranthene	-	-	CR_{oral}	5.0		high
benzo[j]fluoranthene	-	-	CR_{oral}	5.0		high
benzo[k]fluoranthene	CR_{oral}	20	CR_{oral}	5.0		high
benzo[g,h,i]perylene	CR_{oral}	20	TDI	30		high
benzo[a]pyrene	CR_{oral}	2	CR_{oral}	0.5		high
chrysene	CR_{oral}	2	CR_{oral}	50		high
dibenz[a,h]anthracene	-	-	CR_{oral}	0.5		high
fluoranthene	CR_{oral}	20	CR_{oral}	50		high
9H-fluorene	-	-	TDI	40		high
indeno[1,2,3-c,d]pyrene	CR_{oral}	20	CR_{oral}	5.0		high
naphthalene	TDI	50	TDI	40		high
phenanthrene	CR_{oral}	20	TDI	40		high
pyrene	CR_{oral}	20	CR_{oral}	500		high
V. Chlorinated hydrocarbons						
1,2-Dichloroethane	CR_{oral}	14	CR_{oral}	14		high
	pCR_{inhal}	48	pCR_{inhal}	48	18	low
1,2-cis-Dichloroethene	TDI	6	TDI	6.0		medium
	pTCA	30	pTCA	30	8	low
1,2-trans-Dichloroethene	TDI	17	TDI	17		medium
	pTCA	80	pTCA	60	9	low
Trichloroethene	pTDI	540	pTDI	50	10	low
	TCA	1900	pTCA	200	10	low
Tetrachloroethene	TDI	16	TDI	16		high
	TCA	2500	TCA	250		medium
Dichloromethane	TDI	60	TDI	60		medium
	TCA	1700	TCA	3000		high
Trichloromethane (chloroform)	TDI	30	TDI	30		high
	TCA	100	TCA	100		high
Tetrachloromethane	TDI	4	TDI	4.0		high
	TCA	60	TCA	60		high
Vinylchloride	CR_{oral}	3.5	CR_{oral}	0.6		high
	CR_{inhal}	100	CR_{inhal}	3.6		high
monochlorobenzene	TDI	300	TDI	200		medium
			pTCA	500	11	medium
1,2-dichlorobenzene	TDI	600	TDI	430		high
	TCA	600	pTCA	600		low
1,3-dichlorobenzene	-	-	-	-	12	-
1,4-dichlorobenzene	TDI	190	TDI	100		high
	TCA	1200	TCA	670		high
1,2,3-trichlorobenzene	-	-	TDI	8.0		medium
			pTCA	50		low
1,2,4-trichlorobenzene	-	-	TDI	8.0		medium
			pTCA	50		low
1,3,5-trichlorobenzene	-	-	TDI	8.0		medium
			pTCA	50		low
tetrachlorobenzenes (total)	TDI	0.5	TDI	0.5	25	low
pentachlorobenzene	TDI	0.5	TDI	0.5	25	low
hexachlorobenzene	TDI	0.5	CR_{oral}	0.16		medium
			pCR_{inhal}	0.75	18	low
Monochlorophenols (total)	TDI	3	TDI	3	25	low
Dichlorophenols (total)	TDI	3	TDI	3	25	low
Trichlorophenols (total)	TDI	3	TDI	3	20	medium
Tetrachlorophenols (total)	TDI	3	TDI	3	20	medium
Pentachlorophenol	TDI	30	TDI	3		medium
Chloronaphthalenes	TDI	0.5	TDI	80	13	low
	TCA	600	pTCA	1	14	low
Dioxins (PCDDs, PCDFs, planar PCBs)	TDI	10×10^{-6}	TDI	$1\text{-}4\times10^{-6}$	15	high

Compound	**MPR 1991/1993**		**MPR revised (1999/2000)**			
	type	**value**	**type**	**value**	**remark**	**reliability**
Polychlorinated biphenyls, non-planar	TDI	0.09	TDI	0.01	16	high
			TCA	0.5	16	medium
VI. Pesticides						
DDT, DDD, DDE (total)	TDI	20	TDI	0.5	19	high
Aldrin	TDI	0.1	TDI	0.1	17	high
			pTCA	0.35	8, 17	low
Dieldrin	TDI	0.1	TDI	0.1	17	high
			pTCA	0.35	8, 17	low
Endrin	TDI	0.2	TDI	0.2		high
			pTCA	0.7	8	low
α-Hexachlorocyclohexane	TDI	1	TDI	1.0		high
	TCA	0.25	TCA	0.25		high
β- Hexachlorocyclohexane	TDI	0.02	TDI	0.02		high
γ- Hexachlorocyclohexane	TDI	1	TDI	0.04		high
	TCA	0.25	pTCA	0.14	8	medium
δ- Hexachlorocyclohexane	-	-	-	-	12	-
Carbamates (carbaryl)	TDI	10	TDI	3.0		high
			TCA	10		high
Carbamates (carbofuran)	TDI	10	TDI	2.0		high
Dithiocarbamates (maneb)	TDI	50	TDI	50		high
			TCA	18		high
Triazines (atrazine)	TDI	2	TDI	5.0		high
VII Total petroleum hydrocarbons	TDI	25,000	-	-	22	-
aliphatic >EC5-EC8	-	-	TDI	2000	23, 24	medium
			TCA	18,400	23, 24	medium
aliphatic >EC8-EC16	-	-	TDI	100	23	medium
			TCA	1000	23	medium
aliphatic >EC16-EC35	-	-	TDI	2000	23	medium
aliphatic >EC35	-	-	TDI	20,000	23	medium
aromatic >EC5-EC8	-	-	TDI	200	23	medium
			TCA	400	23	medium
aromatic >EC8-EC16	-	-	TDI	40	23	medium
			TCA	200	23	medium
aromatic >EC16-EC35	-	-	TDI	30	23	medium
VIII. Other compounds						
Cyclohexanone	TDI	4600	TDI	4600	25	high
	TCA	136	TCA	136	25	high
Phthalates (total)	TDI	25	TDI	4.0		medium
bis(2-ethylhexyl)phthalate	-	-	TDI	4.0		high
dibutyl phthalate	-	-	TDI	52		high
diethyl phthalate	-	-	pTDI	200	27	low
butylbenzyl phthalate	-	-	TDI	500		
Pyridine	TDI	1	TDI	1	25	medium
	TCA	120	TCA	120	25	low
Tetrahydrofuran	pTDI	10	pTDI	10	21,25	low
	TCA	35	TCA	35	25	high
Tetrahydrothiophene	pTDI	180	pTDI	180	21,25	low
	TCA	650	TCA	650	25	medium
Petrol/gasoline	TDI	3100	TDI	3100	25	high
	TCA	71	TCA	71	25	high

MPR: maximum permissible risk
TDI: tolerable daily intake (μg/kg bw/day)
TCA: tolerable concentration in air (μg/m^3)
CR$_{oral}$: 1:10^{-4} lifetime excess cancer risk oral (μg/kg bw/day)
CR$_{inhal}$: 1:10^{-4} lifetime excess cancer risk inhalation (μg/m^3)
p: provisional

Remarks

1. Only soluble barium-salts are orally biologically available and demonstrate toxic effects. Insoluble salts are orally not bioavailable and thus have no toxicological significance.
2. The TDI is based on a tolerable weekly intake of 3.5 µg/kg bw/week.
3. The TDI is provisional because the cancer risk following oral exposure cannot be estimated due to lack of data (thus this pTDI holds only for non-carcinogenic risks).
4. Chromium VI induces allergic contact dermatitis (ACD); the 10% threshold value (a level to which no more than 10% of the human sub-population sensitised to chromium would respond, and that would protect at least 99.84% of the general population) amounts 0.001% Cr(VI) (equalling 10 mg/L) or 0.089 µg/cm^2.
5. The TDI is based on a tolerable weekly intake of 25 µg/kg bw/week; the TCB (1999b) advised to additionally research the relation of the Pb-blood content and occurrence of effects.
6. The TDI (expressed as CN^-) holds for ferriferrocyanide (both solid and dissolved), and is derived from the TDI for free cyanide, based on the low bioavailability of complex cyanides in general and ferriferrocyanide in particular.
7. The CR_{oral} is provisional because it was estimated by route-to-route extrapolation from the CR_{inhal}.
8. The TCA is provisional because it was estimated by route-to-route extrapolation from the TDI. The reliability is low due to indications for route-specific metabolism.
9. The TCA is provisional because it was derived from a limited semichronic study. The reliability is low due to indications for route-specific metabolism.
10. The TDI and TCA are provisional due to lack of reliable (semi)chronic studies.
11. The TCA is provisional because it was directly taken from WHO-IPCS without further evaluation.
12. Adequate toxicity studies are not available, and thus an MPR cannot be derived.
13. The TDI is derived for 1- and 2-chloronaphthalene. Literature indicates that higher chlorinated naphthalenes are more severely toxic, but adequate data are lacking. Hence the TDI is not to be used for others than the monochloronaphthalenes.
14. The TCA is derived for tri- and tetrachloronaphthalenes. Literature indicates that higher chlorinated naphthalenes are more severely toxic, but adequate data are lacking. Hence the TCA is not to be used for others than the mono-, di-, tri- and tetrachloronaphthalenes.
15. WHO emphasised that the limit value of 4 pg/kg bw/day should be considered a maximum tolerable daily intake on a provisional basis, and that the ultimate goal is to reduce human intake levels below 1 pg/kg bw/day.
16. The TDI and TCA are based on, and expressed as the amount of the 7 indicator PCBs (IUPAC numbers # 28, 52, 101, 118, 138, 153, and 180).
17. The MPRs also hold for the sum of aldrin and dieldrin.
18. The CR_{inhal} is provisional because it was estimated by route-to-route extrapolation from the CR_{oral}.
19. The TDI also holds for the sum of DDT, DDD and DDE.
20. For these compounds limited new information is available. Due to time constraints, however, this could not be evaluated in time to be included in the present report. Consequently, and for the time being, the limit values as derived in 1991 are to be maintained.
21. The TDI is provisional because it was estimated by route-to-route extrapolation from the TCA.
22. In Dutch: *"minerale olie"*.
23. These MPRs exclude carcinogenic risks, and are to be applied only <u>after</u> carcinogenic risks have been ruled out; EC: Equivalent carbon number index - the EC is based on equivalent retention times on a boiling point gaschromatographic column (non-polar capillary column), in order to normalise different hydrocarbons to n-alkanes.
24. These MPRs are only valid if the amount of n-hexane present in the mixture is < 10%. If 10% or more n-hexane is present, a more detailed estimation has to be made involving the TDI for n-hexane (which is 60 µg/kg bw/day).
25. These MPRs were not re-evaluated due to the lack of new significant information. Consequently the previous MPRs are maintained (Vermeire et al., 1991).
26. The TCA is provisional because of the limited database.
27. The TDI is provisional because of the limited database.

Table 4.2 Odour thresholds of selected compounds

Compound	**Odour threshold (mg/m^3)**		**Reference**
	threshold value	**range**	
Cyanide (CN^-)	0.2	-	Baars et al., (2001)
Dichloromethane	1000	500 - 2100	Baars et al., (2001)
Trichloromethane (chloroform)	480	-	NorthEastern Univ., 2000
Tetrachloromethane	60	10 - 60	Baars et al., (2001)
1,2-Dichloroethane	350	50 - 600	Baars et al., (2001)
1,2-trans-Dichloroethene	68	-	Janssen et al., 1995
Trichloroethene	800	550 - 1100	Baars et al., (2001)
Tetrachloroethene	7	-	Baars et al., (2001)
Benzene	100	-	NorthEastern Univ., 2000
Toluene	0.75	-	NorthEastern Univ., 2000
Xylenes	4	-	Baars et al., (2001)
Phenol	0.2	0.1 - 0.4	Baars et al., (2001)
Vinylchloride	7800	-	Baars et al., (2001)
Styrene	0.1*	-	Baars et al., (2001)
Monochlorobenzene	10	1 - 10	Vermeire et al., 1991
1,2-Dichlorobenzene	305	-	Vermeire et al., 1991
1,4-Dichlorobenzene	10	1 - 10	Vermeire et al., 1991
Pyridine	0.03*		NorthEastern Univ., 2000
Tetrahydrofuran	100	60 - 150	Vermeire et al., 1991
Tetrahydrothiophene	3	-	Vermeire et al., 1991

* threshold is well below TCA/CR_{inhal}

5 Derivation of the human-toxicological serious risk concentration (SRC_{human})

5.1 Introduction

In this chapter the human-toxicological serious risk concentration (SRC_{human}) is derived for all compounds of the 1st series of Intervention Values. The general method for deriving the SRC_{human} for soil, groundwater and aquatic sediment is described in chapter 2. The calculation of the SRC_{human} is based on:

- the revised compound specific (physicochemical) data and exposure parameters (chapter 3);
- the revised human toxicological data (chapter 4);
- the modified exposure model CSOIL for soil and groundwater (see section 5.2);
- the revised use of the human-toxicological MPR in relation to the exposure to soil and groundwater (section 5.3);
- the evaluated exposure model SEDISOIL for sediment (see section 5.4).

First the modifications of the exposure model CSOIL, based on the evaluation of this model is discussed in section 5.2, followed by a description of the modified use of the human toxicological risk MPR (section 5.3). In section 5.4 the evaluation of the exposure model SEDISOIL is described and in section 5.5 the qualification of the reliability of the derived values is described.
In section 5.6 the calculated values of the SRC_{human} for soil, groundwater and sediment are presented. Besides the values information is given on the importance of the exposure routes. The values are also compared with the current human risk limits and the origin of the differences will be indicated if possible.
In section 5.6.3 the risk assessment for cyanides is described, which is based on the separate study of Köster (2001). In section 5.6.8 the SRC_{human} for mineral oil (Total Petroleum Hydrocarbons, TPH) is given based on Franken et al. (1999).
Section 5.7 describes the soil type correction that should be used for human risk assessment.

5.2 Evaluation of model concepts for human exposure to soil

5.2.1 Introduction

Since 1991 the CSOIL human exposure model has been used in the Netherlands for deriving the Intervention Values soil. All direct and indirect exposure routes present in CSOIL are given in Figure 5.1. The Intervention Values are based on potential risks. In the evaluation of the model concepts of human exposure (Rikken et. al., 2000) other (international) models are reviewed that might be useful for improvement of CSOIL (e.g. CLEA, UMS, CalTOX, VOLASOIL, EUSES). Because of the limited amount of time, the research is limited to the model concepts of the most relevant exposure routes of CSOIL:

1. ingestion of soil or dust;
2. inhalation of indoor air;
3. consumption of contaminated crops.

5.2.2 Soil ingestion

The model concept for this route is not changed. In general the soil ingestion route of CSOIL is identical to the three international exposure models. For the differences in the amount of

soil ingestion and revised soil ingestion data see section 3.3.3. When in further research the persistence or duration of deliberate soil ingestion by children can be quantified in more detail, it is recommended to implement this in CSOIL. Further research on the comparison of the short-term exposure of deliberate soil eating to acute toxicity data is particularly recommended (Calabrese et al., 1997; Kempchen, 2000).
For the exposure calculation it is decided to distinguish between the oral absorption of soil, oral absorption of food and inhalative absorption, because these can be different. Currently for all compounds and routes a value of 1 (except for lead) is used for calculating the potential exposure, but for some contaminants this might change in the future (see section 3.2.10).

5.2.3 Inhalation of indoor air

Currently a diffusion flux and an evaporation flux contribute to the concentration in indoor air. The diffusion fluxes from soil air to crawl space air in CSOIL, VOLASOIL and CLEA are identical. UMS and CalTOX do not use a diffusive flux. CLEA and VOLASOIL use a convective (pressure driven) air flux besides the mentioned diffusive fluxes. CalTOX and UMS implicitly account for a convective flux. Both models are based on equilibrium between the soil, pore-water and air phase. Differences between model calculations and measurements partly can be caused by lack of equilibrium. Signalising these differences cannot be part of a generic risk assessment but needs more attention in the actual (site-specific) risk assessment. Based on Rikken et al. (2000) it is decided to include a convective flux in the volatilisation module of CSOIL, because there is substantial evidence that a convective flux as well as diffusion flux contribute to the indoor air concentrations. It is also decided to exclude the evaporation flux from the volatilisation module. It appeared that the contribution of this flux is low and was not correctly implemented in the model. Outdoors, the precipitation exceeds evaporation generally. The boundary flux, currently in CSOIL does not lead to limitations of the total flux and will be left out. More information about can be found in Rikken et al. (2000).

5.2.4 Consumption of contaminated crops

Metals. For the consumption of contaminated crops a distinction is made between metals and organic compounds for roots and aboveground plant parts. For accumulation of metals in plants there are no adjustments recommended. Generally for this route BCF correlation models are used to estimate the concentration of metals in roots and leaf. The CLEA model incorporates additionally the influence of the soil pH. In section 3.2.5 the used method for deriving a BCF from field measurements (Otte et al., 2001) and the revised BCF-values are given. This method is based on a selection of data per plant species, after which a weighted average BCF value is calculated.

Organic compounds. Currently the relation of Briggs et al. (1982,1983), related to the Kow of compounds, is used for the uptake of organic compounds in roots and aboveground plant parts. The estimated uptake in roots is much higher than the uptake in aboveground plant parts (especially for compounds with a high Kow).
Comparing the estimations for roots of Briggs et al. (1982, 1983) and of Trapp & Matthies (1995; with default parameter values) with BCF-root values based on literature data, there seems an overestimation of the concentration in the plant at high Kow values (Rikken et al., 2000). The main reason probably is that, in contrary to fine roots and pore-water, there is no equilibrium between root crops and pore-water. Therefore it was decided to implement the concept of Trapp & Matthies (1995) with modified parameter values, leading to lower uptake by roots. Nevertheless it was recommended to further investigate the uptake by root crops by a combination of experiments, model modifications and parameterisation (Rikken et al., 2000).

For the uptake of organic compounds in aboveground plant parts it is decided to use the more sophisticated model concept of Trapp & Matthies (1995) instead of the current relation of Briggs et al. (1983). Because the Trapp & Matthies approach better describes the relevant processes and parameters. Comparing the estimated BCF with BCF values based on literature data, there seems to be an underestimation of the calculated BCF values with Briggs as well as Trapp & Matthies. A possible explanation for this difference is that the concentration in air was higher in the experiments than used in the models. For these cases the high concentrations in the plant originate mainly from air. Another reason can be that soil resuspension is not included in the model. It is recommended to investigate the validity of the Trapp & Matthies approach compared to more experimental data and in relation to different plant species (Rikken et al., 2000).

Soil and dust particles can deposit on the different plant parts by soil resuspension (rain splash). The route is implicitly included in the BCF values for metals, because these BCF values are based on field data. Currently a deposition factor is used based on dust particles in air. It was decided to implement resuspension in CSOIL for organic compounds instead of this deposition factor. The soil resuspension is provisionally set at 1% dry weight soil per kg dry weight plant, according to Sheppard and Evenden (1992), as proposed by Trapp et al. (1998) and as applied in CLEA and CalTOX. This soil will not be removed by normal food preparation (Rikken et al., 2000).

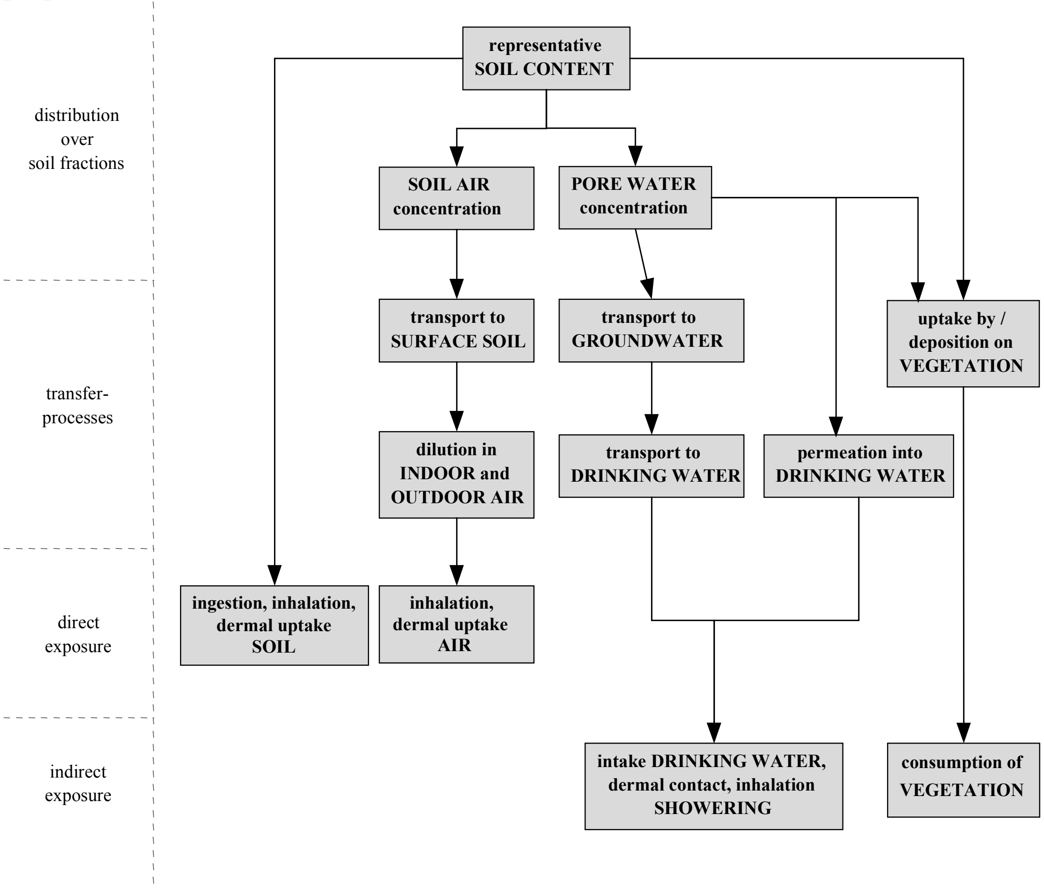

Figure 5.1 Diagram of the human exposure routes of CSOIL

5.3 Use of toxicological risk limits for derivation of SRC$_{\mathbf{human}}$

Until now the critical soil concentration (SCR$_{\text{human}}$) is calculated comparing the estimated exposure with the (oral) human MPR (Maximal Permissible Risk; TDI or 10^{-4} life long cancer risk for intake (CR$_{\text{oral}}$)). Besides, the estimated concentration in the air is compared with the

TCA (Tolerable Concentration Air). If the concentration exceeds the TCA, the Intervention Value for Soil/sediment is adjusted to the level at which the concentration in air equals the TCA.

This means that in fact exposure via the air is compared with an oral risk limit in the first step. In practice this means that the risk can be overestimated when the oral risk limit is more stringent. In the actual (site-specific) risk assessment of volatile compounds measured and predicted concentrations should also be compared with the TDI and TCA. In VOLASOIL the air concentration is only compared with the TCA, being inconsistent with the risk assessment in CSOIL. What is the most appropriate way of dealing with these toxicological risk limits? Both toxicological risk limits (oral and inhalative) have been evaluated and are in principle of equal standing. In some cases the oral value may be based on more and better data, but for other compounds the inhalative value will be based on more and better data (e.g. volatile compounds).
The main reason for using two toxicological values is that the absorption, distribution, metabolism, excretion and the toxicological effect all can depend on the exposure route. Therefore an equal standing in the risk assessment is recommended. Only when there is a lack of data route-to-route extrapolation is used.

Therefore it is decided to use the oral MTR (TDI or CR_{oral} in $\mu g.kg_{body\ weight}^{-1}day^{-1}$) for the risk assessment of the oral exposure and dermal exposure:

- ingestion of soil/dust;
- consumption of contaminated crops;
- intake of drinking-water due to permeation through drinking water pipe;
- uptake via dermal contact with soil;
- dermal uptake during bathing.

The TCA or CR_{inhal} (Cancer Risk Air)(in $\mu g/m^3$) are used for the risk assessment of exposure via air:

- inhalation of soil particles;
- inhalation of indoor air;
- inhalation of outdoor air;
- inhalation of vapours during showering.

To be able to use the TCA/CR_{inhal} in CSOIL both the TCA/CR_{inhal} and the exposure to contaminants in air are in CSOIL transformed to the unit $\mu g.kg_{body\ weight}^{-1}.d^{-1}$, just as the oral and dermal exposure and toxicological risk limits.
In this way it is possible to keep the sum of both risk-indexes equal maximally 1:

$$\frac{\sum \text{oral} + \text{dermal exposure}}{TDI\ or\ CRoral} + \frac{\sum \text{concentration in air}}{TCA\ or\ CRinhal} \leq 1$$

This principle is incorporated in the CSOIL model. In this way it is no longer necessary to compare the calculated concentration in air with the TCA/CR_{inhal} afterwards.

5.4 Evaluation of the exposure model SEDISOIL

In Figure 5.2 the exposure routes in SEDISOIL (Bockting et al., 1996) are shown, which are taken into account for the risk assessment of aquatic sediments. The SEDISOIL-exposure model has been evaluated and revised in 1999 (Otte et al. 2000a). The most important changes concern the update of partition coefficients (especially for metals) and the choice of the scenario to be used. Although uncertain, the BCF fish for metal uptake could not yet be improved. For the most important compounds found in sediment risk limits for different user scenarios were derived in Otte et al. (2000a). In section 5.6 the SRC_{human} for sediment is derived using the revised version of SEDISOIL, with the input-parameter set described in chapter 3 (section 3.2.6, 3.2.8 and 3.4) and with the revised human-toxicological Maximum Permissible Risk levels (MPR_{human}, see chapter 4).

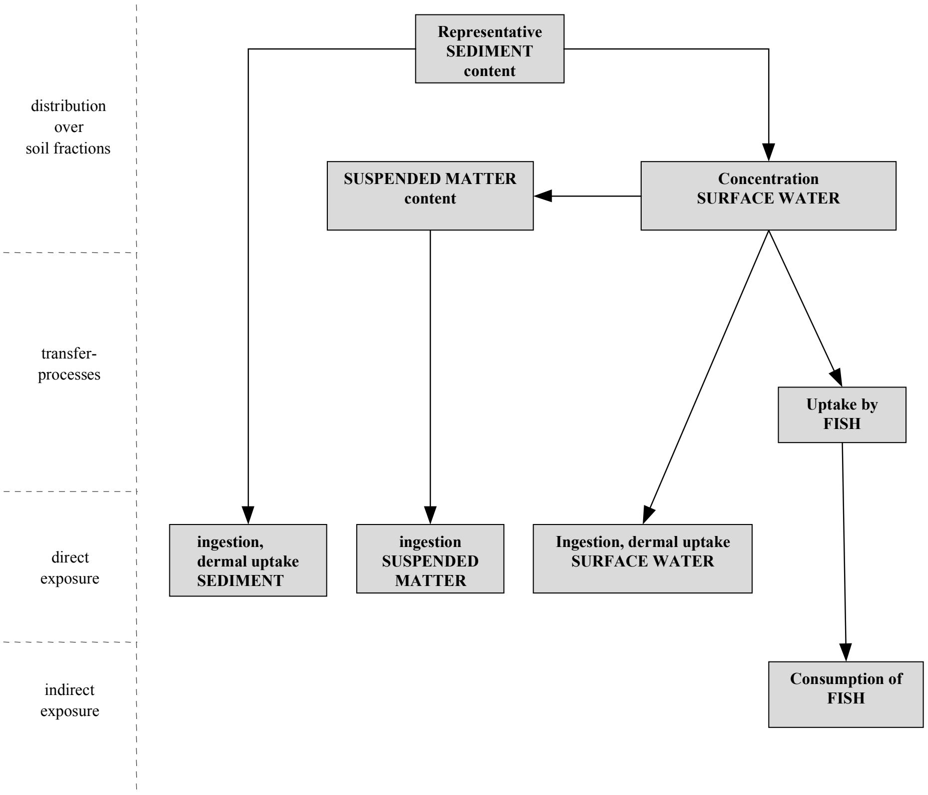

Figure 5.2 Diagram of the human exposure routes in SEDISOIL

5.5 Reliability of the SRC_{human}

The reliability of the SRC_{human} depends on the reliability of the human MPR (Maximal Permissible Risk; see chapter 4) and of the calculation of the exposure (see section 5.6) The reliability of the MPR as well as the estimated exposure are indicated with a label high, medium or low.

$MPR_{human.}$ Linking of the reliability to the so called “uncertainty factors” (or extrapolation factors), as was done before, gives no specific indication of the reliability of the human MPR. There are ideas for (statistical) improvement to deal with these uncertainty factors (Slob and Pieters, 1997), but these are not yet operational. As mentioned in section 4.2.8 the main criteria for the reliability concern the number, the quality and the date of the toxicity studies from which the MPR is derived. Besides the international differences in the interpretation of these data leads to more or less reliability of the MPR. Only when the “uncertainty factor” is very high (>1000), this could be an indication of a less reliable MPR.

Human exposure. The reliability of the calculated exposure to contaminants in soil depends on the reliability of the compound-specific input parameters and of the (dominant) model concept (in CSOIL) and is divided in three classes (1 to 3). The reliability of the model concepts cannot be quantified, but qualitatively can be stated that the exposure via soil ingestion is relatively reliable and the exposure via crop consumption and exposure via inhalation is relatively unreliable.

For the reliability of the exposure it is possible to score the sensitivity of the exposure to the variability of the input-parameters. The variability of the input-parameters (e.g. the solubility

(S), vapour pressure (Vp), log Kow and the logKoc) can be expressed as a “dispersion factor” (or uncertainty factor), k. This factor k can be defined as: 95% of the parameter values is within a factor k from the median (k= exp(1.96σ_{lnx})). In Jager et al. (1997) the differences in this factor are estimated for S, Vp and logKow for a selected group of chemicals. This can be used to discriminate between less uncertain and more uncertain values of input-parameters (if k>3 → uncertain).
The criteria for the assessment of the exposure are as follows (comparable to the 4th series of compounds for which Intervention Values have been proposed):

- low: exposure is sensitive to two or more uncertain input-parameters or very sensitive for one uncertain input-parameter;
- medium: exposure is sensitive to one uncertain input-parameter or moderately sensitive for several uncertain input-parameters;
- high: exposure is not sensitive to uncertain input parameters (or none of the input-parameters are uncertain).

When the dominant exposure routes are crop consumption or inhalation of indoor air the qualification high will not be given.

The reliability score of the human risk limit for groundwater is the same as for soil, but will additionally be sensitive to the Koc when the dominant exposure route is soil ingestion.

The reliability of the exposure to aquatic sediments is not scored, but is in general less reliable than the exposure to soil contamination. The reliability is relatively low for compounds for which the estimated dermal exposure, the bioconcentration factors for fish (for metals) and the partition coefficient (Kp) sediment/suspended matter to surface water (for metals) are important for the derived risk limit.

Integration. For the integration of the scores of the MPR and exposure, the scheme in Table 5.1 is used. This means that both factors have an equal weight; the method differs slightly from the integration method used for the 1st and 2nd and is equal to the 3rd and 4th series of compounds.

Table 5.1 Assessment of reliability scores of the SRC$_{human}$, based on scores of the calculated exposure and the MPR

human exposure				
		low	medium	high
human MPR	low	low	low	low
	medium	low	medium	medium
	high	low	medium	high

5.6 Results of SRC$_{human}$ for soil, aquatic sediment and groundwater

5.6.1 General

Revised human toxicological serious risk concentrations (SRC$_{human}$) are derived for all compounds of the 1st series of Intervention Values and for dioxins. These values are the concentrations in soil, sediment and groundwater (pore-water) at which the lifetime averaged daily exposure (as calculated with CSOIL and SEDISOIL) is equal to the Maximal Permissible Risk as described in chapter 4. The exposure of adults and children is calculated as a function of the concentration in soil (and pore-water), with the revised input-parameter set (chapter 3 and modified model concepts (section 5.2 and 5.3). For Total Petroleum Hydrocarbon (TPH) and cyanides the results of separate studies have been used (Franken et al, 1999; Köster, 2001). The results are presented in *Table 5.2* (and in Appendix 5A and 5B). The main human exposure routes per compound (for derivation of the human SRC for soil, groundwater and aquatic sediment) are given in Appendix 3.

The revised SRC_{human} are discussed in the following sections, giving special attention to:

- changes in the derived risk limits compared to the current level (see Appendix 6 for a general overview of the changes). A comparison only can be made for the SRC for soil. Besides the SRCs for aquatic sediment are compared with the revised SRCs for soil. The SRC for groundwater will be discussed in chapter 7 together with the other risk limits for groundwater;
- the possibility of sum values for groups of compounds, by using a geometric mean or a "toxic units approach" ("fraction approach") (as explained in section 2.6);
- the uncertainty of the derived risk limits.

When the derived SRC_{human} changes more than a factor of 2, this is indicated as a "substantial change". When possible the main reasons for these changes are described. In appendix 6 an overview is given of the changes in risk limits.

5.6.2 Metals

Changes. The SRC_{human} for soil of barium and lead are substantially higher and of cobalt and nickel substantially lower than the previous risk limit. The value of barium is higher because of a lower BCF. The value of lead is higher because the soil ingestion by children is set lower (section 3.3.3) and the relative oral absorption of lead in soil is adjusted to 0.6 instead of 1 (section 3.2.10). Compared to the earlier presented results in Lijzen et al. (1999) only the BCF for plants has been modified. The value of cobalt is lower, because the BCF is higher and the value of nickel is lower because a low TCA leads to relevant exposure to soil dust.

For chromium two values for soil are recommended, because the revised TDI is the same, but the CR_{inhal} is much lower for chromium VI than for chromium III. In groundwater one value for chromium VI is proposed, because there is no difference in the oral TDI of both compounds and, besides, there is no Kp available for chromium.

For mercury separate MPRs are derived for metallic mercury and organic mercury, because there is a large difference in the toxicity of both compounds. Because no physicochemical data on organic mercury are available, only a SRC_{human} for inorganic mercury could be derived. Volatilisation of (metallic) mercury is not included in the risk assessment and needs further attention in the future and in the actual risk assessment.

The SRC_{human} for sediment for all metals is much higher than the SRC_{human} for soil. For some metals no SRC_{human} for aquatic sediments is derived, because no partition coefficients for sediment to water are available. The SRC_{human} for groundwater is based on equilibrium partitioning with the SRC_{human} for soil, as described in section 2.4.5.

Reliability. The reliability of lead, arsenic and cadmium is scored high, because soil ingestion is an important exposure route and the MPR is scored high (chapter 4). For most other metals the reliability is scored medium, because crop consumption contributes to a large extent to the exposure.

5.6.3 Cyanides

To evaluate the current Dutch Intervention Values for cyanides a review is made of sources of CN soil contamination, behaviour of CN species and environmental concentrations related to soils contaminated twenty or more years ago. There is enough evidence for a major change in the risk assessment of free cyanides, complex cyanides and thiocyanates.

Available soil models are not suited to predict concentrations of free CN or CN species in pore water and soil air. In the current Intervention Value the risk was entirely based on the uptake into plants. Apart from a revised higher MPR for complex cyanides, there is evidence that cyanides are hardly taken up by plants and if they do so, probably transform these compounds to non-toxic compounds. Plant physiological studies indicate that soil contamination will not lead to critical CN concentrations in crops (Köster, 2001). It is shown in this report that critical exposure only could occur via inhalation of free CN in ambient air or via ingestion of ferrohexacyanide or thiocyanate dissolved in groundwater. These findings limit the foundation of the current Intervention Values.

A reliable relationship between CN species in the soil and HCN in air is not known. The maximum concentration measured in (soil) air in the field exceeds the TCA for free cyanide, but it is uncertain if the concentration in indoor air can exceed the TCA. Because of the mentioned reasons no traditionally risk-based SRC_{human} for soil (and aquatic sediment) on weight basis can be derived for free cyanides, complex cyanides and thiocyanates.

Three suggestions can be considered to deal with (potential) risks of cyanides in soil:

- direct measuring HCN concentrations in ambient and/or soil air, which can be checked with the TCA of 0.025 $mg.m^{-3}$ HCN in soil air or in ambient air;
- taking into account acute toxicity of incidental soil ingestion by children of 5g/day, a maximum concentration in soil for free cyanide, complex cyanide and thiocyanate can be derived of 150 mg CN/kg, 4800 mg CN/kg and 15 mg CN/kg, respectively. Only for complex cyanides this value is within the observed concentration range, the other observed concentrations are always lower;
- measuring the concentration in the pore-water of the contaminated soil the available concentration can measured, which could be compared with a risk limit for groundwater.

The human risk limit for groundwater can be set at 75 $\mu g.l^{-1}$ *total* (*EPA*) CN, being one value for all cyanides expressed as CN^-, based on toxicity of thiocyanates and the direct consumption of groundwater as drinking water by children. Based on the indications that after ingestion thiocyanates react as free CN and consumption of groundwater as drinking water (lifelong averaged), also the current Intervention Value could be maintained for *total (EPA)* CN (not per individual compound) (Köster, 2001)

5.6.4 Aromatic Compounds

Changes. The SRC_{human} for soil of ethylbenzene, phenol, cresoles, xylene, catechol and hydrochinon are substantially higher and the value of toluene is substantially lower than the previous SRC. The value of phenol, cresoles, catechol and hydrochinon is mainly higher because the uptake in plants is estimated lower. For ethylbenzene and xylene the TDI or TCA are substantially higher. The value of toluene is mainly lower because the TCA is reduced from 3000 to 400 $\mu g.m^{-3}$.

In general the SRC_{human} for aquatic sediment is in the same order of magnitude as the SRC_{human} for soil.

Sum value. For compounds with different isomers (cresoles and xylenes) the geometric mean is used (for soil, sediment and groundwater; see section 2.6). For the dihydroxybenzenes no sum value is derived, due to different MPRs and compound behaviour.

Reliability. The reliability of the aromatic compounds is scored as medium, being the result of MPRs scored as high and medium and the exposure mostly being scored as medium, due to the importance of the exposure via air and plants (Appendix 4).

5.6.5 PAH

Changes. Besides the 10 “standard PAH”, for 7 additional PAH risk limits are derived. The SRC_{human} for soil of phenantrene, fluoranthene and chrysene are substantially higher and the value of benzo(a)anthracene, benzo(a)pyrene, benzo(k)fluoranthene and indeno(123cd)pyrene are substantially lower than the former SRC. For most compounds the difference originates mainly from the revised MPR; for phenantrene, fluoranthene and chrysene also a lower estimated exposure contributes to the changes (see appendix 6). All PAH, except 4, are indicated as genotoxic carcinogens. The relatively high SRC_{human} for most PAH originates from the solubility that is exceeded in pore-water, leading to a cut-off exposure level to PAH via crop consumption.

The derived SRC_{human} for aquatic sediment is for all compounds substantially lower than the SRC_{human} for soil, for which the main exposure is via dermal contact with surface water.

Sum value. No sum value for PAH is derived. It is recommended to use the "toxic unit approach" (fraction approach), because of the same mode of action of most PAH (carcinogenic and some non-carcinogenic). Only, because for PAH human exposure is not linear with the soil concentration, the sum of the ratios of the *estimated dose* and the *human MPR* of each compound should not exceed 1 (see section 2.6). In the evaluation of the MPR (chapter 4) it is recommended to derive SRCs for 17 instead of 10 PAH. A SRC for the sum of 17 PAH can only be derived when the ratio of occurrence between the compounds is known. Because this ratio can be different for each site no sum value is derived.

Reliability. The reliability of the PAH is mainly scored as high because the high reliability of the derived MPR (chapter 4) and of the high contribution of soil ingestion to estimated exposure. Only for naphthalene and dibenzo(a,h)anthracene the reliability is lower, because the contribution of the inhalation of indoor air and crop consumption, respectively.

5.6.6 Chlorinated Hydrocarbons

Changes. The SRC_{human} for soil for dichloromethane, tetrachloroethene, trichlorobenzenes, mono-, di-, tri-and tetrachlorophenol and chloronaphthalene are substantially higher and of trichloroethene, vinylchloride, mono-, di-, tetra-, penta- and hexachlorobenzene, pentachlorophenol and dioxins are substantially lower, than the previous SRCs. For dichloromethane, trichlorobenzenes, tetrachlorophenol and chloronaphthalene the higher MPR (TDI/TCA) contributes to the higher SRCs and for dichloromethane, tetrachloroethene and the chlorophenols the lower estimated exposure contributes to the higher SRCs (see Appendix 6). The revised lower MPR leads to a substantial lower SRC for soil for trichloroethene, vinylchloride, hexachlorobenzene, pentachlorophenol and dioxins.

For trichloroethene, vinylchloride and chlorobenzenes also a higher estimated exposure (via indoor air) leads to lower SRCs.

The revised method for risk assessment is inline with the revision of the Intervention value for vinylchloride in 1997, but should be revised because of the lower revised MPR (TCA).

The SRC_{human} for aquatic sediment for the chlorinated aliphatic hydrocarbons are all slightly or substantially higher than the SRCs for soil. For chlorobenzenes, non-planar PCBs and (reported) dioxins the values are in the same order of magnitude, for chlorophenols they are substantially lower and for chloronaphthalene the values are higher than in soil.

Sum value. For the isomers of chlorobenzenes, chlorophenols and chloronaphthalene the geometric mean is used as a sum-value, because the MPR is the same and the compound behaviour is comparable.

For PCBs the "toxic unit approach" is recommended for the seven indicator compounds, because of the different contaminant behaviour. In this way the assessment can be carried out with the locally found PCB-profile. The "dioxin-like" or co-planar PCB are assessed together with dioxins, expressed as toxicity equivalent (TEQ) of the most toxic dioxin 2,3,7,8 TCDD.

For the PCDD (dioxins), the planar PCBs and PCDF (polychlorinated dibenzofurans) in principle the "toxic unit approach" (section 2.6) was recommended using the toxic equivalent factors (TEF; Van den Berg, 1998). Nevertheless a sum value (geometric mean) is proposed, because of the small differences in the derived $SRCs_{human}$.

Reliability. Although the reliability of the MPR of quite a lot compounds can be scored as high, most SRCs for soil are indicated as medium due to the large contribution of the exposure routes inhalation of indoor air and crop consumption. For some chlorobenzenes and chlorophenols and chloronaphthalene the reliability is low, because the reliability of the MPR is indicated as low (chapter 4).

5.6.7 Pesticides

Changes. The SRC_{human} for soil for endrin and b-HCH are substantially higher and for DDT, DDE, aldrin, g-HCH, carbaryl and carbofuran are substantially lower than the previous SRCs. (see Appendix 6). A lower estimated exposure for endrin and b-HCH lead to a higher SRC for soil. A lower MPR for DDT, DDE, g-HCH and carbofuran contributes to the lower revised SRC. For DDT, DDE, aldrin, carbaryl and carbofuran (also) a higher estimated exposure contributes to the lower SRC for soil. For d-HCH no toxicological information was found and no SRC could be derived. Mainly based on soil ingestion the risks of maneb are negligible. In fact it is not possible to derive a SRC_{human} with CSOIL, because it is a polymer with no Koc and Kow-value (Luttik and Linders, 1995).

For all pesticides, except carbofuran and atrazin, the calculated SRC_{human} for aquatic sediment is substantially lower than the SRC_{human} for soil.

Sum value. For the total of DDT, DDE and DDD the geometric mean for DDT and DDE is calculated, because DDD (or TDE) is hardly found in soil. No sum value is derived for total drins, because especially for dieldrin and aldrin the behaviour in soil is different; only for aldrin and dieldrin the toxic unit approach should be applied. For the HCH one value could be set for b-HCH and g-HCH, because the difference of the values is small.

Reliability. The reliability of the SRC for most pesticides is scored as medium due to the high reliability of the revised MPR and the large contribution of crop consumption to the exposure (medium reliable).

5.6.8 Mineral Oil

Changes. The current Intervention Value for Total Petroleum Hydrocarbons (TPH) is not based on risk assessment. For human toxicological risk assessment a fraction approach is recommended by Franken et al. (1999). In principle it was recommended to firstly evaluate a mixture on the basis of the "whole product" approach, but this is only possible when the origin and source of the contamination would be a well-known product (e.g. a particular jet fuel). It should be stressed that it is important to evaluate the carcinogenic substances (PAH and aromatic compounds), when present at a site. These evaluations are already accounted for with the existing risk assessment. The modification is to evaluate the components of the TPH mixture by a fractional approach, distinguishing six fractions of aliphatic compounds and five fractions of the aromatic compounds, based on differences in toxicity (see chapter 4) and differences in contaminant behaviour. Since benzene (EC= 6.5) and toluene (EC= 7.5) are the only representatives of the aromatic fractions EC 5-6 and EC 7-8) and both will be measured individually, these fractions have been skipped. Data of Franken et al. (1999) are presented in Table 5.1, only modified based on the adjustment of the exposure model CSOIL, as described in section 5.2 and 5.3. For the smaller fractions the SRC_{human} is much lower than the current Intervention Value for “mineral oil”. It strongly depends on the composition of the pollution whether the revised values will lead to a different risk assessment.

The SRC_{human} for aquatic sediment is substantially higher for most aliphatic compounds, for the aromatic compounds the values are in the same order of magnitude or lower.

Sum value. No sum value for all fractions will be derived, because there are large differences between the toxic risk level of the fractions and the behaviour in soil. A toxic unit approach (or fraction approach) is recommended for the different fractions, because additivity of effects is assumed (Franken et al., 1999)

Reliability. The reliability of the SRC for all fractions is medium, due to the medium reliability of the MPR (TDI) and the medium (and high) reliability of the exposure, which for the smaller fractions is mainly based on exposure via inhalation of indoor air.

5.6.9 Other pollutants

Changes. For two phthalates for which SRC$_{human}$ for soil were calculated before, the SRC$_{human}$ for butylbenzylphtalate was higher (higher MPR) and the SRC for di(2-ethylhexyl)phthalate was lower (lower MPR, higher estimated exposure). For pyridine, tetrahydrofuran and tetrahydrothiophene the derived SRC was substantially higher, because the estimated exposure was lower (see Appendix 6).

For most compounds the SRC$_{human}$ for aquatic sediment is lower than the SRC$_{human}$ derived for soil.

Sum values. Based on the differences in toxicology and environmental chemistry of the different phthalates it is not possible to set one value for phthalates. Also a toxic unit approach is not recommended because of the possible different mode of action of the compounds.

Reliability. The reliability of these compounds is medium or low; for some phthalates the reliability of the MPR is indicated low or the Kow/Koc is uncertain in combination with crop consumption as a major pathway. For the other compounds the low reliability is caused by the MPR.

Table 5.2 MPR$_{human}$ values and human-toxicological Serious Risk Concentration (SRC$_{human}$) for a standard soil (10% organic matter, 25% lutum), aquatic sediment and groundwater, with reliability scores (RS)

Compound	MPR$_{human}$ TDI/ CR$_{oral}$ [µg.kg$_{bw}$$^{-1}$.d^{-1}]	TCA/ CR$_{inhal}$ [µg.m^{-3}]	current SRC$_{human}$ soil [mg.kg^{-1} dry weight]	**New SRC$_{human}$ soil [mg.kg^{-1} dry weight]**	RS*^{1} Soil	**SRC$_{human}$ groundw. [µg.l^{-1}]**	**SRC$_{human}$ aquatic sediment [mg.kg^{-1} dry weight]**
I. Metals							
Arsenic	1	1	678	576	high	320*^{7}	3300
Barium	20	n.a.	4260	9340	medium	3740*^{7}	-
Cadmium	0.5	n.a.	34.9	28	high	11*^{7}	1800
Chromium	-	-	-	-		-	-
ChromiumIII	5	60	2250	2760	medium	574*^{7}	17600
CromiumVI	5	2.5E-3	-	78	low	-	-
Cobalt	1.4	0.5	452	43	low	361*^{7}	-
Copper	140	1	15700	8600	medium	4060*^{7}	>100000
Mercury				-		-	-
Mercury (inorganic)	2	0.2	197	210	medium	28*^{7}	6700
Mercury (organic)	0.1	n.a.	-	-		-	-
Lead*^{3}	3.6	n.a.	300*^{3}	622*^{3}	high	17*^{7}*^{8}	3210*^{3}
Molybdenum	10	12	911	1310	low	32500*^{7}	-
Nickel	50	0.05	6580	1470	medium	735*^{7}	>100000
Zinc	500	n.a.	56500	46100	medium	17700*^{7}	>100000
II. Other inorganic compounds							
Cyanides (free CN)	50	25	16.8	-*^{9}		*^{9}	-
Cyanides (complex CN)	800	n.a.	4.4	-*^{9}		12000*^{9}	-
Thiocyanates (as SCN)	11	n.a.	3.7	-*^{9}		170*^{9}	-
Total (as CN^{-})						75*^{9}	
III. Aromatic compounds							
Benzene	3.3	20	1.09	1.1	medium	251	5.5
Ethyl benzene	100	770	50	111	medium	5570	111
Phenol	40	20	74.1	390	medium	180000	174
Cresoles (sum)	50	170	117	365		128000	122
o-Cresol				324	medium	129000	108

Compound	MPR$_{human}$		current	**New**		**SRC$_{human}$**	**SRC$_{human}$**
	TDI/ CR$_{oral}$ [µg.kg$_{bw}$$^{-1}$.d^{-1}]	TCA/ CR$_{inhal}$ [µg.m^{-3}]	SRC$_{human}$ soil [mg.kg^{-1} dry weight]	**SRC$_{human}$ soil [mg.kg^{-1} dry weight]**	RS*^{1} Soil	**groundw. [µg.l^{-1}]**	**aquatic sediment [mg.kg^{-1} dry weight]**
m-Cresol				423	medium	128000	137
p-Cresol				354	medium	127000	122
Toluene	223	400	339	32	medium	4360	191
Xylenes (sum)	150	870	25.6	156		10100	127
o-Xylene				109	medium	12000	81
m-Xylene				248	medium	9210	114
p-Xylene				140	medium	9250	223
Dihydroxybenzenes (sum)	25	n.a.	-	no sum	-	-	-
Catechol	40	n.a.	22.9	457	medium	105000	1100
Resorcinol	20	n.a.	10.4	20	medium	18500	190
Hydrochinon	25	n.a.	10.8	96	medium	17800	1100
Styrene	120	900	249	472	medium	21200	224
IV. PAH							
Total PAHs (17)				*^{10}		*^{10}	*^{10}
Naphthalene	40	n.a.	603	870	medium	15600	120
Anthracene	40	n.a.	29000	25500*^{4}	high	71	4200
Phenantrene	40	n.a.	661	23000*^{4}	high	850	440
Fluoranthene	50	n.a.	1070	30300*^{4}	high	201	1600
Benzo(a)anthracene	5	n.a.	11200	3000*^{4}	high	12	290
Chrysene	50	n.a.	420	32000*^{4}	high	1.8	6000
Benzo(a)pyrene	0.5	n.a.	1110	280	high	0.84	17
Benzo(ghi)perylene	30	n.a.	12000	19200*^{4}	high	0.19	3600
Benzo(k)fluoranthene	5	n.a.	11600	3200*^{4}	high	0.48	560
Indeno(1,2,3-cd)pyrene	5	n.a.	11800	3200*^{4}	high	0.26	580
Pyrene *^{2}	500	n.a.	-	>100000*^{4}	high	106	60000
acenaphtene *^{2}	500	n.a.	-	>100000*^{4}	high	2570	47000
acenaphtylene *^{2}	50	n.a.	-	26000*^{4}	high	4010	170
Benzo(b)fluoranthene *^{2}	5	n.a.	-	2800*^{4}	high	17	100
Benzo(j)fluoranthene *^{2}	5	n.a.	-	2800*^{4}	high	8.8	90
Dibenz(a,h)anthracene *^{2}	0.5	n.a.	-	70	low	0.83	27
9H-Fluorene *^{2}	40	n.a.	-	23000*^{4}	high	1320	210
V Chlorinated hydrocarbons							
1,2-dichloroethane	14	48	3.86	6.4	low	3140	62
Dichloromethane	60	3000	18.9	68	medium	55800	210
Tetrachloromethane	4	60	0.92	0.70	medium	190	3.2
Tetrachloroethene	16	250	3.89	8.8	medium	560	19
Trichloromethane	30	100	8.86	5.6	medium	1910	84
Trichloroethene	50	200	303	10	low	1500	93
Vinylchloride	0.6	3.6	0.077	0.0022*^{6}	medium	0.40	1.6
Total chlorobenzenes	0.16	50	-	no sum		no sum	no sum
Monochlorobenzene	200	500	520	114	medium	8790	280
Dichlorobenzenes (sum)	-	-	1154	476		15800	336
1,2-Dichlorobenzene	430	600	1154	477	low	20400	550
1,3-Dichlorobenzene	-	-		-		-	-
1,4-Dichlorobenzene	100	670		475	medium	12300	205
Trichlorobenzenes (sum)	-	-	9.04	40		217	31
1,2,3-Trichlorobenzene	8	50		59	low	595	17
1,2,4-Trichlorobenzene	8	50		82	low	743	22
1,3,5-Trichlorobenzene	8	50		13	low	23	80
Tetrachlorobenzenes(sum)	0.5	n.a.	18	7.5		23	2.1
1,2,3,4-Tetrachlorobenz.				25	low	54	3
1,2,3,5-Tetrachlorobenz.				8.0	low	39	1.4
1,2,4,5-Tetrachlorobenz.				2.1	low	6.1	2.3
Pentachlorobenzene	0.5	n.a.	23.7	6.7	low	14	1.5
Hexachlorobenzene	0.16	0.75	26.8	2.7	medium	4.0	0.23

Compound	MPR$_{human}$		current	**New**		**SRC$_{human}$**	**SRC$_{human}$**
	TDI/ CR$_{oral}$ [µg.kg$_{bw}$$^{-1}$.d^{-1}]	TCA/ CR$_{inhal}$ [µg.m^{-3}]	SRC$_{human}$ soil [mg.kg^{-1} dry weight]	**SRC$_{human}$ soil [mg.kg^{-1} dry weight]**	RS*^{1} Soil	**groundw. [µg.l^{-1}]**	**aquatic sediment [mg.kg^{-1} dry weight]**
Total chlorophenols	-	-	-	*10		*10	*10
Monochlorophenols (sum)	3	n.a.	14	77		8980	11.7
o-Monochlorophenol				40	low	7100	12
m-Monochlorophenol				200	low	9360	20
p-Monochlorophenol				57	low	10900	6.7
Dichlorophenols (sum)	3	n.a.	32.5	105		4160	10.2
2,3-Dichlorophenol				117	low	5590	16
2,4-Dichlorophenol				114	low	5580	9.2
2,5-Dichlorophenol				155	low	3930	17
2,6-Dichlorophenol				148	low	5920	22
3,4-Dichlorophenol				161	low	3480	9.2
3,5-Dichlorophenol				27	low	2050	2.2
Trichlorophenols (sum)	3	n.a.	56.3	231		1922	8.8
2,3,4-Trichlorophenol				186	medium	2660	20
2,3,5-Trichlorophenol				199	medium	2370	19
2,3,6-Trichlorophenol				198	medium	1790	17
2,4,5-Trichlorophenol				254	medium	1900	22
2,4,6-Trichlorophenol				327	medium	1910	2
3,4,5-Trichlorophenol				247	medium	1230	2
Tetrachlorophenols (sum)	3	n.a.	18.3	172		1080	9
2,3,4,5-Tetrachlorophenol				343	medium	797	37
2,3,4,6-Tetrachlorophenol				80	medium	1090	1
2,3,5,6-Tetrachlorophenol				184	medium	1450	12
Pentachlorophenol	3	n.a.	79.8	20	medium	214	0.52
Chloronaphthalenes (sum)	80	1	9.12	29		190	207
1-Chloronaphthalene				19	low	122	215
2-Chloronaphthalene				45	low	295	200
Total of 7 PCBs (sum)	0.01	0.5	-	*^{10}		*^{10}	*^{10}
PCB28				0.69	low	0.291	0.06
PCB52				0.28	low	0.097	0.03
PCB101				0.61	low	0.031	0.20
PCB118				1.9	low	0.015	0.69
PCB138				0.32	low	0.011	0.28
PCB153				0.46	low	0.011	0.37
PCB180				0.17	low	0.003	0.45
Trichlorobiphenyl (18)	-	-	5.52	-			
Hexachlorobiphenyl	-	-	8.72	-			
Dioxins(+PCDF+PCB)*^{5}	$4*10^{-6}$	n.a.	0.001	*0.00036*		*3.1E-06*	*0.00021*
2,3,7,8-TeCDD *^{5}	$4*10^{-6}$	n.a.		0.00031	low	1.3E-05	0.00009
PeCDD *^{5}	$4*10^{-6}$	n.a.		0.00031	low	4.4E-06	0.00021
HxCDD *^{5}	$4*10^{-6}$	n.a.		0.00032	low	2.1E-06	0.00030
HpCDD *^{5}	$4*10^{-6}$	n.a.		0.00032	low	1.4E-06	0.00034
OCDD *^{5}	$4*10^{-6}$	n.a.		0.00032	low	1E-06	0.00037
PCB77 *^{5} *^{2}	$4*10^{-6}$	n.a.		0.00063	low	1.5E-07	0.00014
PCB105 *^{5} *^{2}	$4*10^{-6}$	n.a.		0.00063	low	8.1E-06	0.00021
PCB118 *^{5} *^{2}	$4*10^{-6}$	n.a.		0.00076	low	5.9E-06	-
PCB126 *^{5} *^{2}	$4*10^{-6}$	n.a.		0.00030	low	6.0E-06	0.00016
PCB156 *^{5} *^{2}	$4*10^{-6}$	n.a.		0.00032	low	2.5E-06	0.00027
PCB157 *^{5} *^{2}	$4*10^{-6}$	n.a.		0.00032	low	3.0E-06	0.00025
PCB169 *^{5} *^{2}	$4*10^{-6}$	n.a.		0.00026	low	4.4E-06	0.00018
TetraCDF *^{5} *^{2}	$4*10^{-6}$	n.a.		0.00031	low	2.2E-05	0.00006
PentaCDF *^{5} *^{2}	$4*10^{-6}$	n.a.		0.00031	low	1.2E-05	0.00010
HexaCDF *^{5} *^{2}	$4*10^{-6}$	n.a.		0.00031	low	2.0E-06	0.00030
HeptaCDF *^{5} *^{2}	$4*10^{-6}$	n.a.		0.00032	low	1.7E-06	0.00032
OctaCDF *^{5} *^{2}	$4*10^{-6}$	n.a.		0.00032	low	8.6E-07	0.00038

VI Pesticides							
Total DDT/DDD/DDE	0.5	n.a.	-	23			7.3
DDT			11300	31	medium	1.39	11
DDE			7830	17	medium	1.32	7
DDD				42	medium	4.73	5
Total drins	-	-	-	no sum		no sum	no sum
Aldrin and dieldrin			-	*10		*10	*10
Aldrin	0.1	0.35	13.8	0.32	medium	0.64	0.06
Dieldrin	0.1	0.35	5.45	9.1	medium	16	1.6
Endrin	0.2	0.7	4.36	16	medium	31	2.9
Total HCHs	-	-	-	no sum			no sum
a-HCH	1	0.25	21.1	20	medium	159	15
b-HCH	0.02	n.a.	0.42	1.6	medium	11	0.33
g-HCH	0.04	0.14	21.1	1.3	medium	23	0.3
d-HCH	-	-	-	-		-	-
Carbaryl (carbamate)	3	10	461	107	medium	9590	36
Carbofuran (carbamate)	2	n.a.	435	5.7	medium	2040	34
Maneb	50	18	29800	32100	high	no SRC	no SRC
Atrazin (triazines)	5	n.a.	21	18	medium	1930	37
VII Mineral Oil				*10		*10	*10
alifatics EC 5-6	2000	18400		35	medium	613	47000
alifatics EC >6-8	2000	18400		109	medium	444	>100000
alifatics EC >8-10	100	1000		28	medium	15*6	10600
alifatics EC >10-12	100	1000		152	medium	10*6	12100
alifatics EC >12-16	100	1000		55000*4	medium	0.59*6	12200
alifatics EC >16	2000	-		>100000*4	medium	0.001*6	>100000
aromatics EC >8-10	40	200		59	medium	640	100
aromatics EC >10-12	40	200		317	medium	2170	180
aromatics EC >12-16	40	200		5900*4	medium	5810	420
aromatics EC >16-21	30	-		17500*4	medium	543	2600
aromatics EC >21-35	30	-		19200*4	medium	6.6*6	3600
VIII Other compounds							
Cyclohexanone	4600	136	270	214	medium	262000	>100000
Total phthalates	4	-	-	no sum		no sum	no sum
Dimethyl phthalate	-	-	-	82	low	7750	169
Diethyl phthalate	200	-	-	17000	low	287000	4940
Di-isobutylphthalate	-	-	-	83	low	818	11
Dibutyl phthalate	52	-	-	22600	low	2350	50
Butyl benzylphthalate	500	-	776	>100000*4	medium	4220	21900
Dihexyl phthalate	-	-	-	381	low	12	12
Di(2-ethylhexyl)phthalate	4	-	4628	60	low	4.4	59
Pyridine	1	120	1.06	11	low	2130	32
Tetrahydrofuran	10	35	0.4	7	low	16000	48
Tetrahydrothiophene	180	650	94	234	medium	137000	426

\- not available.

*1. reliability scores (RS) have been determined as the product of separate sub-scores for the MPRhuman and the calculated potential exposure (high implies less uncertainty); the RS only accounts for SRC for soil.

*2. because these compounds were added at the end of the evaluation, not the complete data evaluation was performed.

*3. based on exposure and Maximal Permissible Risk for intake for a child (all values) and on relative bioavailability for lead in soil in the human body of 0.6 (revised values).

*4. solubility in pore-water is exceeded.

*5. value expressed as Toxicity equivalent (TEQ) of the most toxic dioxin 2,3,7,8 TCDD; the toxic equivalent factor (TEF) of is each compound (Appendix 5) is based on Van den Berg (1998).

*6. detection limit is exceeded, based on VROM (2000) or attention has to be given to detection limit ("mineral oil").

*7. based on equilibrium partitioning with the SRChuman for soil and the Kp for soil (section 3.2.7)

*8. value is below or near (< factor 2 higher) than (highest) Target Value (VROM, 2000).

*9. soil: no soil content could be derived, see text; groundwater: 170 µg SCN= 75 µg CN; based on direct consumption of groundwater as drinking water by children; the derived risk limit for free cyanide (750 µg/l) does not exceed the maximum observed field concentration (150 µg/l).

*10. PAH: the "toxic unit approach" (fraction approach) should be applied for carcinogenic compounds and non-carcinogenic compounds seperately (see section 2.6);
Chlorophenols: "toxic unit approach" should be applied for the mono-, di-, tri and tetrachlorophenols;
PCB: "toxic unit approach" should be applied for the 7 indicator PCBs;
Drins: "toxic unit approach" should be applied to aldrin and dieldrin;
Mineral oil: "toxic unit" approach should be applied to all TPH fractions.

5.7 Differentiation of SRC_{human} based on soil type

Soil

Human exposure and hence the SRC_{human} depends on the used exposure scenario. This means that in some cases the risks are underestimated. This could e.g. occur when the fraction contaminated crops is larger than 10% (in allotment gardens) or when the contamination with volatile organic compounds is less deep than 1.25 m minus land surface (or is in direct contact with the crawl space; see section 3.3.2).

When the soil contains less organic matter in general it is expected that the concentration of the contaminant in the porewater (and groundwater) is relatively higher. The partitioning between the solid phase and the pore-water phase depends of course also on the type of contamination. In case of, for example, granular PAH (tar) the concentration in the pore-water is much lower than in case of well mixed PAH from another source.
Whether human exposure to organic compounds is related to the organic matter (OM) content depends on the dominant exposure route. When the dominant exposure route is crop consumption or inhalation of (indoor) air (or some other exposure routes) the exposure is directly related to the OM-content of the soil. When the dominant exposure route is soil ingestion (or dermal uptake via soil contact) the exposure is independent of the OM-content. The exposure is also independent of the OM-content when the solubility of the compound in water is exceeded (although the dominant route is via pore-water).
It is recommended to correct for the OM-content only for the fraction of the exposure related to the pore-water content, f_{mob}. This leads to the following soil type correction for organic compounds in relation to human exposure (Lijzen et al., 1999a):

$$IVsoil_{act} = f_{mob} * IVsoil_{standard} * (K_{oc}*foc_{act})/K_{oc}*foc_{standard}) + (1- f_{mob}) * IVsoil_{standard}$$

$$= IVsoil_{standard} * (1 - f_{mob} + f_{mob} * foc_{act}/foc_{standard}) \quad (1)$$

with

f_{mob}= contribution (fraction between 0 and 1) to the total exposure of the exposure routes 1. crop consumption and 2. inhalation of air.

When the solubility of a compound is exceeded, f_{mob} is set at zero (no correction). In this relation it is neglected that the contribution of several exposure routes change when the OM-content changes. To account for that, the CSOIL model should be used with the site-specific parameters, which can be carried out in site specific risk assessment and out of the scope of this general approach.

Human exposure to metals only depends on the soil type, when crop consumption contributes to the exposure. For metals the following relation is can be derived:

$$IVsoil_{act} = IVsoil_{standard} * (1 + (y/x)*BCF_{standard})/ (1 + (y/x)*BCF_{actual}) \quad (2)$$

with

x= factor for exposure via soil ingestion, amount of soil (mg soil $_{dry\ weight}$.kg^{-1}$_{bw}$.day^{-1})
y= factor for exposure via crop consumption (mg crop $_{dry\ weight}$.kg^{-1}$_{bw}$.day^{-1})

Based on the relation derived between BCF metals, soil characteristics (pH, clay and OM-content) and the metal concentration (Versluijs and Otte, in prep.; Otte et al., 2001), a soil type correction could be derived for four metals (see Appendix 7). The ranges of %OM and %clay where the derived relations can be used are %OM= 1.5-22 and %clay = 2-33 (and pH= 5 - 7.5) (Versluijs and Otte, in prep). Applying these minimum and maximum values for OM and clay, lead to a soil-type correction for Pb of 0.94-1.02, for Cd of 0.93-1.03, for Cu of 0.74-1.19 and for Ni of 0.95-1.02 times the derived SRC$_{human}$. Including the effect of the pH, these differences would be much larger for Cd and Cu. The use of more data in the future also could lead to larger differences, because more statistical significant relations could be derived.

Based on the presented data it can be concluded that the SRC$_{human}$ of metals is relatively independent of the organic matter and clay content in the standard “residential with garden” scenario, with an exception for copper. Because for metals the SRC for soil is dominated by ecotoxicological risk, and no correction based on human exposure is necessary. Nevertheless in the actual (site-specific) risk assessment the given relations can be used. For that purpose also the pH-correction could be implemented.

Groundwater
For metals the SRC$_{human}$ is derived based on equilibrium partitioning between the risk based SRC$_{human}$ for soil and water (pore water or groundwater). Because for three metals a relation of the Kp with the soil characteristics is present (section 3.2.7 and Otte et al, 2001), this value could be corrected for the site specific soil characteristics. Nevertheless it is advised not to use such a correction, because of the uncertainty in relation and the heterogeneity of the soil (and its characteristics).

For organic compounds the risk based SRC$_{human}$ for groundwater is independent of the OM content of the soil, when the dominant exposure routes are crop consumption or inhalation of (indoor) air and when the solubility of the compound is exceeded (in the pore water). Then no correction for the SRC$_{human}$ for groundwater is necessary. When the dominant exposure route is soil ingestion or dermal contact (and the solubility is not exceeded), the SRC for groundwater could be corrected (a lower OM-content leads to a higher SRC for groundwater). However, because this does not occur for any compounds, no soil type correction is needed for the SRC$_{human}$ for groundwater.

Aquatic sediment
Human exposure to contaminants in sediments and surface water depends on the exposure scenario as well as the characteristics of the sediment and water (pH, OM, clay). The exposure calculations with SEDISOIL are carried out at pH=8, %OM =10 and %clay is 25. Because it is not possible to derive a simple relation between human exposure and the soil characteristics it is advised not to correct the derived SRC$_{human}$ for aquatic sediments for the characteristics of the sediment. When necessary a site-specific risk assessment can be carried out using these site-specific sediment characteristics and local measurements (according to: RWS-RIZA, in prep).

5.8 Major changes in the revised SRC$_{human}$

Differences between the revised SRC$_{human}$ and the previous human-toxicological values have four main sources. In the first place the human-toxicological MPRs have been revised, leading to 20 lower and 13 higher TDI/CR_{oral} and to 11 lower and 2 higher $TCA/CR_{inhal.}$ Secondly the use of the MPR is changed: the TDI/CR_{oral} is compared with the oral and dermal exposure and the TCA/CR_{inhal} is compared with the inhalative exposure, leading to higher as well as lower risk limits. Thirdly the model concept for human exposure is revised for the exposure routes crop consumption and inhalation of indoor air (both for organic compounds), in general leading to a lower exposure for crop consumption and a higher exposure to volatile compounds. Fourthly the physicochemical data (compound specific) and the exposure parameters have been revised. Especially the revision of the Kow, Koc and BCF can have a large impact on the calculated human exposure (to soil and aquatic sediment) and the K_p and K_{oc} on the derived SRC for groundwater.

6 Derivation of the ecotoxicological serious risk concentration (SRC_{eco})

6.1 Introduction

This chapter summarises the derivation of the SRC_{eco} for the compartments soil, sediment and surface water. The SRC_{eco} for groundwater is equal to that for surface water (see 2.4). In section 6.2 a short description of the used methodology is given. The new SRC_{eco} values for the 1st series of compounds and a comparison with the previous values, presented in VROM (1995) and mainly based on Denneman and van Gestel (1990, 1991), is presented in section 6.3.2. Details on both the methodology and the derivation of the new values for specific compounds are presented in the report by Verbruggen et al. (2001). The toxicity data used are as far as possible retrieved from the project “Setting Integrated Environmental Quality Standards” (De Bruijn et al., 1999). Also the methodology used is as far as possible in agreement with that of the derivation of the MPCs (maximum permissible concentrations) in this project. The data that were used for the partition coefficients for both organic compounds and metals were derived in the context of the evaluation of the Intervention Values (Otte et al., 2001).

The ecotoxicological risks of TPH (mineral oil) were not taken into account so far. A search in the open literature yielded too few data that could be used to underpin an HC50. Main problem was that in most studies the composition of the mineral oil in the test medium was unknown. A fraction approach, as was worked out by Franken et al. (1999) and recommended for the human risk assessment for TPH in this report, will be taken into account in a separate study in the project “Setting Integrated Environmental Quality Standards”.

6.2 Methodology for deriving revised SRC_{eco}

6.2.1 Literature search and data selection

For the derivation of the new SRC_{eco} the aquatic and terrestrial toxicity data collected in the framework of the project “Setting Integrated Environmental Quality Standards” have been used (De Bruijn et al., 1999). Some of the compounds of the 1st series were not yet dealt with and for those compounds new data have been searched for. For these new data quality criteria for the experimental studies and the derivation of the endpoints (NOEC or EC50) were also in accordance with the guidelines of the project “Setting Integrated Environmental Quality Standards”. All terrestrial data were recalculated to standard soil. The K_ps for metals and the K_{oc}s for organic compounds, used for equilibrium partitioning, and the K_{ow} values used as input for QSARs, were adopted from Otte et al. (2001). QSAR data were used in case no experimental toxicity data were available or in some cases as a check of the experimental toxicity data.

6.2.2 Procedure for determination of the HC50

The HC50 is used as toxicological endpoint that serves as basis for the SRC_{eco}. This value represents the concentration at which the NOEC is exceeded for 50% of the species or processes. However, in the methodology of Denneman and van Gestel (1990), processes were in principle not used to base the HC50 upon. The HC50 can be derived by both refined and preliminary risk assessments. For refined risk assessment a statistical extrapolation method is applied.

The method used in previous studies from the project “Setting Integrated Environmental Quality Standards” and for the derivation of the former SRC_{eco} values for the 1st series of

Intervention Values (Denneman & van Gestel, 1990) was based on a log-logistic distribution among the species. For the derivation of the new SRC_{eco} values a log-normal based method was chosen (Aldenberg & Jaworska, 2000). The HC50 is equal to the geometric mean of the data and therefore, no numerical differences in SRC_{eco} exist between the different methods. For other endpoints, such as the HC5, the numerical differences are small. However, this method has the advantages that it is easily applicable and provides confidence limits for different protection levels (e.g. HC5 and HC50). The most recent description of the method is given in the Guidance Document (Traas, in prep.)

To apply this method the available data have to meet two requirements. First, the data originate from at least 4 different taxonomic groups. This number was 5 in the methodology of Denneman and van Gestel (1990) who averaged species by taxonomic groups as starting point for their risk assessment. Further, the data must be log-normally distributed.

If one of these requirements was not met, a preliminary risk assessment was made. In this case the lowest value of the geometric mean of the NOECs and the geometric mean of the L(E)C50s divided by 10, is taken as HC50. In case of terrestrial toxicity data also a comparison with the HC50 derived by equilibrium partitioning is made.

Denneman and van Gestel did not use the minimum value for the derivation of the HC50 but the procedure with the highest priority. This priority was first determined by the number of terrestrial data and second by the kind of toxicity data: NOECs > EC50s > LC50s. The latter two were not combined. Equilibrium partitioning had the lowest priority. A geometric mean of procedures with highest and lower priority was taken, if the procedure with the lower priority resulted in a lower value.

6.2.3 Added risk approach.

In this report the added risk approach (Crommentuijn et al., 2000) was applied to derive SRC_{eco} for metals. The background concentration (C_b) contributed significantly to the SRC_{eco}; i.e. the C_b was substantial relative to the HC50. The data underlying the HC50 for metals are retrieved from laboratory studies expressed as the added amount added to the test, neglecting the background concentration already present in the test soil (Crommentuijn et al., 2000). The HC50 is thus not a measure for the serious risk concentration (SRC) but only for the added amount that causes the observed effects. This added amount is referred to as the serious risk addition (SRA).

For the purpose of Intervention Values the SRC is compared with a concentration in the field, which is not a measure of the added (anthropogenic) concentration but a total concentration. Therefore, the "real" SRC_{eco} consists of the SRA and the background concentration, and therefore, it is calculated as the sum of both ($SRC_{eco} = SRA_{eco} + C_b$). For a general applicable SRC_{eco}, a generic C_b is used, as reported in Crommentuijn et al. (1997). It is very well possible that the actual C_b at a location differs from the general C_b. The background concentrations can be estimated from the fraction of organic matter and lutum of the soil. In the determination of urgency such site-specific information can be taken into account.

6.2.4 Equilibrium partitioning

Equilibrium partitioning is applied to derive HC50 for soil and sediment from aquatic toxicity data. The assumption is that exposure of terrestrial organisms occurs via the pore water phase. The concentration in soil or sediment is calculated by means of a partition coefficient. Although the use of toxicity data for benthic and palegic organisms are preferred (as recommended by the TCB (1999a)), equilibrium partitioning is always used for sediment, because toxicity data for benthic organisms are absent. In Figure 6.1 a scheme is presented, in which the derivation of the HC50 for water, aquatic sediment and soil is outlined, with the conditions for refined and preliminary risk assessment and the use of equilibrium partitioning herein.

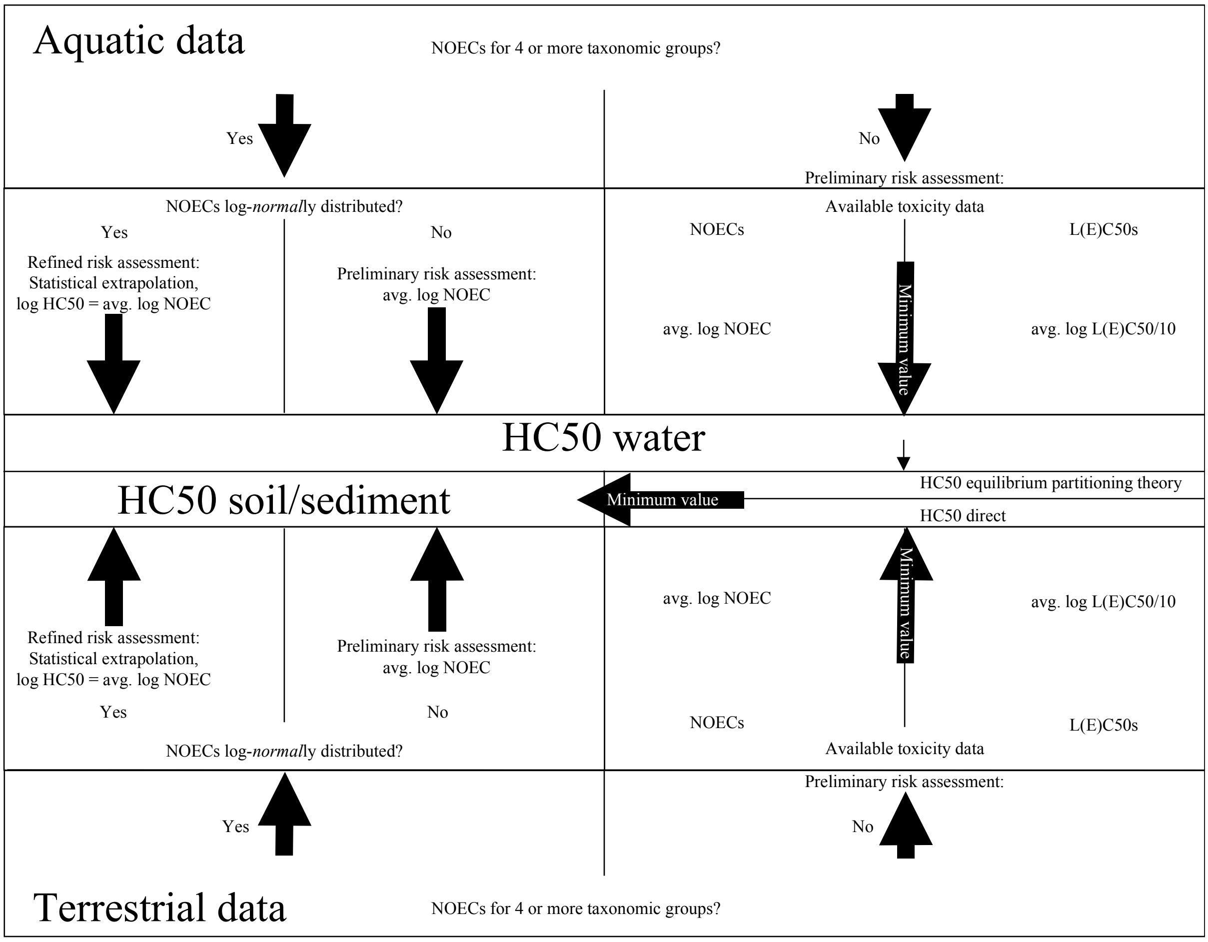

Figure 6.1: Schematic outline of the derivation of the SRC_{eco}; for explanation see section 6.2

6.2.5 Secondary poisoning

No secondary poisoning was included for the derivation of the SRC_{eco} and all values are based on direct aquatic and terrestrial toxicity data. At least for soil, secondary poisoning is considered to be of minor importance. The surface area is usually limited and it is assumed that top predators do not get their prey only from the contaminated sites. Nevertheless, it can be discussed if the surface area of contaminated sites, especially related to water systems, can be large enough for a substantial chance that predators only forage at the contaminated site (see section 8.2.5). In the derivation of (serious) risk limits for sediments by RIZA, secondary poisoning was included by a newly developed method (Van de Guchte et al., in prep.), but was not subscribed by the RIVM. No other method has yet been established by RIVM to estimate the HC50 from a combination of direct and indirect toxicity data.

6.2.6 Reliability of the SRC_{eco}

A classification of the reliability in three groups is found to be satisfactory. Further detail (as was done in the 1st and 2nd series) is not functional, based on the limited amount of data and especially because the quality of the data contributes also to the reliability of the derived ecotoxicological risk limits. The distribution of the available data also could be used, but is of limited value, because of the relatively small number of toxicological data. In Table 6.1 the criteria are summarised. These criteria are in line with the recommendations of the TCB on the 2nd and 3rd series of compounds (TCB, 1997).

Table 6.1 Criteria for assessment of the reliability of the ecotoxicological data

metals	
high	≥ 4 terrestrial taxonomic groups used
medium	< 4 terrestrial taxonomic groups used (value compared with equilibrium partitioning)
low	only aquatic toxicity data and equilibrium partitioning used
organic compounds	
high	≥ 4 terrestrial taxonomic groups used
medium	< 4 terrestrial taxonomic groups used (value compared with equilibrium partitioning) *or* ≥ 4 aquatic taxonomic groups and equilibrium partitioning used
low	only aquatic toxicity data (< 4 taxonomic groups) and equilibrium partitioning used

6.3 Results

1.1.1 A general value for the SRC$_{eco}$ of narcotic chemicals

The SRC$_{eco}$ determined for all compounds individually showed a rather narrow distribution, when only the chemicals were considered that are assumed to act mainly by narcosis (an non-specific mode of toxic action). This effect was observed for SRCs that were derived directly from terrestrial toxicity data, as well as those derived by equilibrium partitioning. Both sets of values were also mutually consistent. The variance among the data probably is caused by uncertainties in the derivation of the SRC$_{eco}$ for each chemical individually (Figure 6.2).
At this moment it was decided that a general value for all compounds acting by narcosis is in a preliminary stadium and therefore, no single value for SRC$_{eco}$ of these compounds is derived. This approach should be worked out in more detail in further studies to investigate whether or not it is sufficient to use one value for the SRC$_{eco}$ of narcotic chemicals and maybe even more accurate, because the uncertainty in individual SRC$_{eco}$ values is eliminated. Assuming the same mode of toxic action also facilitates the use of toxic units for combination toxicity of a large number of compounds.

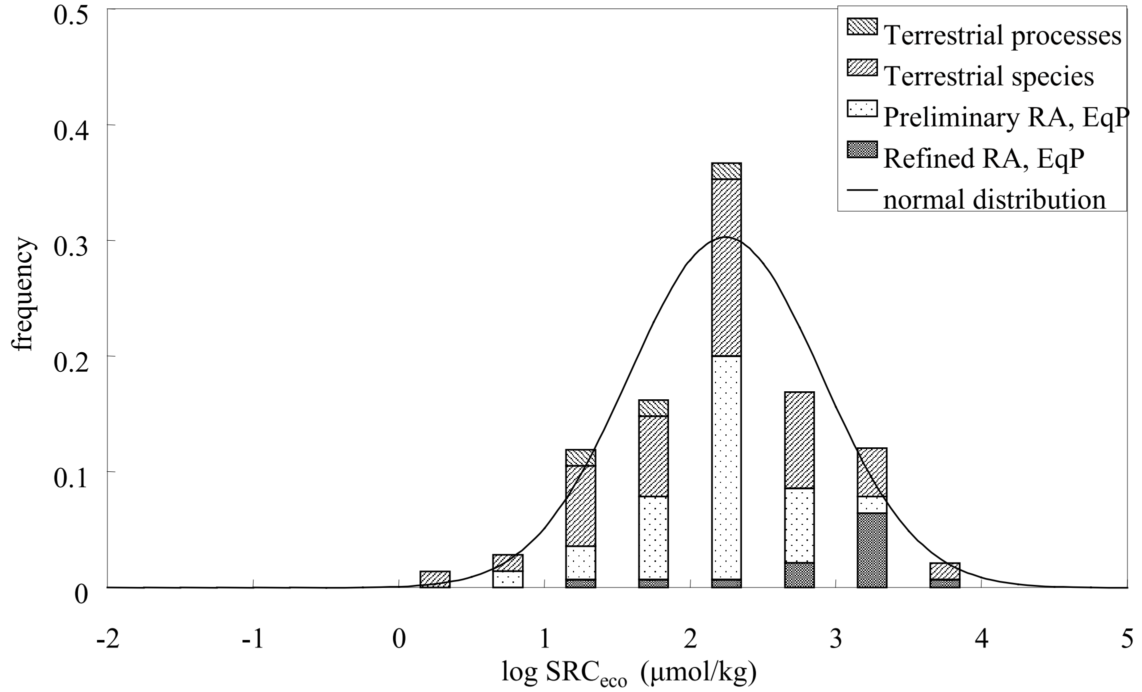

Figure 6.2: Distribution of SRC$_{eco}$ derived from terrestrial toxicity data or by equilibrium partitioning from aquatic toxicity data (Risk Assessment with EqP) for compounds that are assumed to act by narcosis.

6.3.2 Final proposals for SRC_{eco}

The results of the evaluation of the SRC_{eco} for each individual compound and compound groups are presented in Table 6.2. Some values could not be determined from experimental data because data were missing. In these cases QSAR estimates were used. In general it can be concluded that except for metals, most data for soil are based on a limited data set. The values for aquatic sediment were calculated by equilibrium partitioning in all cases.

Table 6.2 Ecotoxicological Serious Risk Concentration (SRC_{eco}) for soil, groundwater (surface water) and aquatic sediment, with reliability scores, background concentration of metals (C_b) of soil/sediment and current SRC_{eco} soil (VROM 1995, 2000); for sediment and groundwater currently no SRC_{eco} exists

Compound	Current SRC_{eco} soil [$mg.kg^{-1}_{d.w.}$]	C_b [$mg. kg^{-1}$]	**New SRC_{eco} for soil [$mg.kg^{-1}_{d.w.}$]**	RS[a)]	**New SRC_{eco} for aquatic sediment [$mg.kg^{-1}_{d.w.}$]**	RS[a)]	**New SRC_{eco} ground water [$\mu g.l^{-1}$]**	RS[a)]
I. Metals								
Arsenic	40	*29*	85	high	5900	low	890	high
Barium	650	*155*	890	high	7200	low	7100	medium
Cadmium	12	*0.8*	13	high	820	low	9.7	high
Chromium	230	*100*	220	high	43000	low	220	high
Cobalt	240 [b)]	*9.0*	180	high	3200	low	810	high
Copper	190	*36*	96	high	660	low	19	high
Mercury	10	*0.3*	36	high	1500	low	14	high
Methyl-mercury	-	*0.3*	4.0	medium			0.37	high
Lead	290	*85*	580	high	63000	low	150	high
Molybdenum	< 480	*0.5*	190	high	23000	low	27000	medium
Nickel	210	*35*	100	medium	2600	low	500	high
Zinc	720	*140*	350	high	6600	low	91	high
II. Other inorganic compounds								
Free cyanide (as CN^-)	-		n.a.		n.a.		31	high
Thiocyanate (as SCN^-)	-		620	low	n.a.		10000	medium
Complex cyanide (CN^-)	-		n.a.		n.a.		29	medium
III. Aromatic compounds								
Benzene	25		130	medium	130	medium	30000	high
Toluene	130 [b)]		47	medium	79	medium	11000	high
Ethylbenzene	-		110	medium	110	medium	5500	high
Sum xylenes	-		17		17		1100	
o-xylene			9.3	low	9.3	low	1000	medium
m-xylene			18	low	18	low	1200	medium
p-xylene			30	low	30	low	1100	medium
Styrene	-		86	low	86	low	3800	medium
Phenol	40		14	medium	14	medium	7000	high
Sum cresoles	50		13		27		10000	
o-cresol	- [b)]		50	medium	66	medium	29000	high
m-cresol	- [b)]		16	medium	110	medium	36000	high
p-cresol			2.6	low	2.6	low	1000	medium
Sum dihydroxybenzenes	-		8.0		8.0		3100	
Catechol	-		2.6	low	2.6	low	630	low
Resorcinol	-		4.6	low	4.6	low	5700	medium
Hydroquinone	-		43	medium	43	medium	8200	high
IV. PAH								
Sum PAHs	40		-		-		-	
Naphthalene	- [b)]		17	low	17	low	290	medium
Anthracene	-		1.6	medium	1.6	low	1.4	medium
Phenanthrene	- [b)]		31	low	31	low	30	medium
Fluoranthene	-		260	low	260	low	30	medium
Benzo[a]anthracene	-		2.5	medium	49	low	1.0	low
Chrysene	-		35	QSAR	35	QSAR	1.2	QSAR
Benzo[k]fluoranthene	-		38	low	38	low	0.36	low
Benzo[a]pyrene	-		7.0	medium	28	low	0.72	medium
Benzo[ghi]perylene	-		33	QSAR	33	QSAR	0.18	QSAR
Indeno[1,2,3-cd]pyrene	-		1.9	QSAR	1.9	QSAR	0.036	QSAR

Compound	Current SRC_{eco} soil [$mg.kg^{-1}_{d.w.}$]	C_b [$mg.kg^{-1}$]	**New SRC_{eco} for soil [$mg.kg^{-1}_{d.w.}$]**	RS[a]	**New SRC_{eco} for aquatic sediment [$mg.kg^{-1}_{d.w.}$]**	RS[a]	**New SRC_{eco} ground water [$\mu g.l^{-1}$]**	RS[a]
V Chlorinated hydrocarbons								
1,2-dichloroethane	60 [b]		240	medium	240	medium	130000	high
Dichloromethane	60 [b]		3.9	medium	40	low	40000	low
Tetrachloromethane	60 [b]		29	low	29	low	8700	low
Tetrachloroethene	60 [b]		16	medium	16	low	1000	medium
Trichloromethane	60 [b]		170	medium	170	medium	63000	high
Trichloroethene	60 [b]		2.5	medium	130	medium	20000	high
Vinylchloride	60 [b]		17	QSAR	17	QSAR	8000	QSAR
Sum chlorobenzenes	30 [b]		TU approach		TU approach		TU approach	
Monochlorobenzene	-		15	low	15	low	1100	medium
Dichlorobenzenes	-		19		19		650	
1,2-dichlorobenzene	-		17	low	17	low	740	medium
1,3-dichlorobenzene	-		24	low	24	low	820	medium
1,4-dichlorobenzene	- [b]		18	medium	18	low	460	medium
Trichlorobenzenes	- [b]		11		25		140	
1,2,3-trichlorobenzene	- [b]		5.0	medium	10	low	100	medium
1,2,4-trichlorobenzene	- [b]		5.1	medium	5.1	low	46	medium
1,3,5-trichlorobenzene	- [b]		50	medium	310	low	550	low
Tetrachlorobenzenes	- [b]		2.2		39		120	
1,2,3,4-tetrachlorobenzene	- [b]		16	medium	40	low	83	medium
1,2,3,5-tetrachlorobenzene	- [b]		0.65	medium	47	low	210	low
1,2,4,5-tetrachlorobenzene	-		1.0	medium	31	low	90	medium
Pentachlorobenzene	50		16	medium	16	low	32	medium
Hexachlorobenzene	500		2.0	medium	2.0	low	3.0	medium
Sum chlorophenols	10 [b]		-		-		-	
Monochlorophenols	10 [b]		5.4		8.5		1000	
2-chlorophenol			7.8	medium	7.8	low	1400	medium
3-chlorophenol			14	medium	54	low	2500	low
4-chlorophenol			1.4	low	1.4	low	290	medium
Dichlorophenols	10 [b]		22		22		870	
2,3-dichlorophenol			31	low	31	low	1400	low
2,4-dichlorophenol			8.4	medium	8.4	medium	410	high
2,5-dichlorophenol			53	low	53	low	1300	low
2,6-dichlorophenol			57	low	57	low	2300	medium
3,4-dichlorophenol			27	medium	27	low	590	low
3,5-dichlorophenol			5.4	medium	5.4	low	420	low
Trichlorophenols	10 [b]		22		41		340	
2,3,4-trichlorophenol			30	low	30	low	420	low
2,3,5-trichlorophenol			4.5	medium	22	low	260	low
2,3,6-trichlorophenol			110	low	110	low	990	low
2,4,5-trichlorophenol			22	medium	22	low	160	medium
2,4,6-trichlorophenol			8.1	medium	80	low	480	medium
3,4,5-trichlorophenol			39	low	39	low	190	low
Tetrachlorophenols	10 [b]		21		22		130	
2,3,4,5-tetrachlorophenol	- [b]		64	medium	67	low	150	low
2,3,4,6-tetrachlorophenol			13	low	13	low	160	medium
2,3,5,6-tetrachlorophenol			12	low	12	low	95	medium
Pentachlorophenol	5		12	high	8	medium	85	high
Sum chloronaphthalenes	-		23		23		150	
1-chloronaphthalene			18	low	18	low	120	medium
2-chloronaphthalene			30	low	30	low	190	low
Sum PCBs	1 [b]		3.4		3.4		-	
PCB 77			4.2	low	4.2	low	0.10	low
PCB105			10	low	10	low	0.13	low
PCB 126			0.92	low	0.92	low	0.018	low
VI. Pesticides								
Sum DDT/DDE/DDD	4 [b]		-		-		-	
DDT	- [b]		1.0	medium	9.5	low	0.43	medium
DDE	-		1.3	low	1.3	low	0.10	medium
DDD	-		34	low	34	low	3.8	low
Sum drins	4 [b]		0.14		1.2		1.8	
Aldrin / dieldrin			0.22	medium	-		3.4	high

Compound	Current SRC_{eco} soil $[mg.kg^{-1}_{d.w.}]$	C_b $[mg.kg^{-1}]$	**New SRC_{eco} for soil $[mg.kg^{-1}_{d.w.}]$**	RS[a)]	**New SRC_{eco} for aquatic sediment $[mg.kg^{-1}_{d.w.}]$**	RS[a)]	**New SRC_{eco} ground water $[\mu g.l^{-1}]$**	RS[a)]
Aldrin	- [b)]		-		1.7	medium	-	
Dieldrin	- [b)]		-		1.9	medium	-	
Endrin	- [b)]		0.095	medium	0.48	medium	0.92	high
Sum HCHs	2 [b)]		6.4		10		100	
α-HCH	-		17	medium	17	medium	140	high
β-HCH	-		13	medium	13	medium	93	high
γ-HCH	- [b)]		1.2	medium	5.0	medium	87	high
Carbaryl	5		0.45	medium	0.45	medium	41	high
Carbofuran	1.5		0.017 [c)]	medium	0.017 [c)]	low	6.5	medium
Maneb	35 [b)]		22	medium	n.a.		32	low
Atrazin	6 [b)]		0.71	medium	0.71	medium	76	high
VII. Mineral oil	-		-		-		-	
VIII. Other compounds								
Sum phthalates	60 [b)]		-		-		-	
Dimethylphthalate	- [b)]		84	medium	84	low	8100	medium
Diethylphthalate	- [b)]		53	medium	580	medium	23000	high
di-*iso*-butylphthalate	-		17	low	17	low	160	low
di-*n*-butylphthalate	- [b)]		36	medium	36	low	170	medium
Butylbenzylphthalate	-		48	low	48	low	100	medium
Dihexylphthalate	-		220	low	220	low	84	low
diethylhexylphthalate	-		69	low	10	medium	5.0	medium
cyclohexanone	-		150	medium	150	medium	260000	high
pyridine	150		50	medium	280	medium	57000	high
tetrahydrofuran	-		120	medium	120	medium	800000	high
tetrahydrothiophene	-		8.8	QSAR	8.8	QSAR	9400	QSAR

a) reliability (options: low-medium-high); QSAR= low

b) current SRC_{eco} for soil (VROM 1995, 2000) differs from ecotoxicological data reported by Denneman and Van Gestel (1990). See Verbruggen et al. (2001) for comparison with data of Denneman and van Gestel (1990)

c) the detection limit is exceeded, based on VROM (2000)

d) Toxic Unit approach: see 6.4 and Verbruggen et al. (2001) for explanation

n.a. insufficient data available

An update of the SRC_{eco} is advisable if the compound has been evaluated in a European framework (EU commission regulation 1488/94). The compounds of the first series of Intervention Values that are listed in the first priority list of the European Union are nickel, cadmium, several chromium salts, zinc, benzene, toluene, ethylbenzene, styrene, phenol, chloroform, trichloroethene, tetrachloroethene, naphthalene, anthracene, 1,4-dichlorobenzene, 1,2,4-trichlorobenzene, dibutyl phthalate, benzyl butyl phthalate, bis(2-ethylhexyl) phthalate and other phthalates. For these compounds a European evaluation will be available on a short term, probably leading to more toxicity data.

6.4 Mixture toxicity: sum values and toxic units

As explained in section 2.6 mixture toxicity can be captured by working with toxic units. This approach is proposed for chlorobenzenes (similar toxic mode of action, but different environmental behaviour). For the groups of PAHs, chlorinated aliphatic hydrocarbons, chlorophenols, and phthalates the mode of toxic action is not the same for all compounds. Some of the compounds in these groups exhibit only a non-specific mode of action, while others have besides this narcotic effect also a more specific mode of action to a part of the species. Therefore, no toxic unit approach or sum values for these groups of compounds are proposed (Verbruggen et al., 2001)

Because no information is on the BSAF values is collected, sum values (geometric mean) are only derived for isomers of compounds, for which it is assumed that they have similar physicochemical behaviour. These isomers are xylenes, cresols, dihydroxybenzenes, isomers of chlorophenols and chlorobenzenes, monochloronaphthalenes and hexachlorocyclohexanes

(HCHs). Sum values are also derived for the drins and polychlorinated biphenyls (PCBs). The use of one value for the sum of similar compounds has the advantage that the influences of uncertainties in the derivation of the risk limits for individual compounds are decreased. In section 6.3.1, the outlook of deriving a sum value in the future for compounds that act mainly by narcosis is discussed.

6.5 Major changes in the revised SRC_{eco}

Differences of the revised SRC_{eco} with the values derived by Denneman and van Gestel (1990) may have two sources. These are the use of a different methodology for the derivation of the SRC_{eco} as well as differences in the data that are the basis for this SRC_{eco}. The differences in the data used for derivation of the SRC_{eco} relate to both toxicity and partitioning. Changes in methodology can be recapitulated by entries per species instead of taxonomic group, the grouping of all acute toxicity data instead of separate values for LC50s and EC50s, the number and type of data to apply statistical extrapolation upon, the inclusion of data on processes to base the SRC_{eco} upon, and the way in which it is determined whether to use chronic, acute or equilibrium partitioning data to derive the SRC_{eco} in case of preliminary risk assessment. Mostly a combination of several of the above mentioned factors explains the differences with the formerly derived values.
For metals the high SRC_{eco} for sediment compared to the SRC for soil is mainly caused by the use of equilibrium partitioning in combination with the high values for the log K_p for sediments compared to soil, and not by differences in sensitivity between aquatic and terrestrial organisms.

7 Integration of risk limits

7.1 Introduction

In this chapter the integrated risk limits (integrated SRCs) for soil, groundwater and aquatic sediment are presented. These values will lead to proposals for new Intervention Values in the policy phase of the "Evaluation of Intervention Values for Soil". Policy has to decide on the procedure for deriving Intervention Values for Soil and/or sediment and on the procedure for deriving Intervention Values for Groundwater (section 2.4 and chapter 8). The presented risk limits in section 7.2 and 7.3 can be used in these discussions prior to policy decisions on the procedures to be followed. In chapter 5 and chapter 6 the derivation of the SRC_{human} and SRC_{eco} are discussed in more detail.

In Appendix 5A and 5B an overview of the derived risk limits is given. In Appendix 6 an indication is given of the origin of differences between the current Intervention Value for Soil and the revised integrated SRC for soil. For the SRC for aquatic sediments and groundwater such an analysis is not possible, because the values have been newly derived and another procedure has been followed, respectively.

7.2 Integrated SRC for soil and aquatic sediment

7.2.1 Introduction

Table 7.1 presents the SRCs for soil and for aquatic sediment based on ecotoxicological and human-toxicological risk assessment, together with the current Intervention Values for Soil/sediment.

The sub-sections below provide information for each group of compounds on the following issues:

- changes in the risk limits compared to the current Intervention Values for Soil/sediment and (when possible) the main reasons for these changes; when the derived SRC differs more than a factor of 2, this is indicated as "substantial";
- whether or not the risk limit is based on human toxicological or ecotoxicological risks (underlined);
- whether or not sum values are proposed;
- whether or not large differences in the reliability (uncertainty) of the SRC_{eco} and SRC_{human} exist.

Whether the derived risk limits will be used for a separate Intervention Value for aquatic sediments or will constitute part of an integrated Intervention Value for Soil/sediment comprises part of the policy phase of the "Evaluation of Intervention Values" (see section 1.2).

7.2.2 Metals

Changes The integrated SRC for soil for mercury is substantially higher and for methyl-mercury, nickel and zinc substantially lower than the current Intervention Value for Soil/sediment. All SRCs for soil are based on ecotoxicological risks, except the SRC for cobalt and chromiumVI. The SRC_{human} and SRC_{eco} for lead differ only slightly. All changes originate from the additional of ecotoxicological information that has become available. Only the lower value for chromiumVI originates from the potential high risk of chromiumVI in air (soil dust).

The SRCs for aquatic sediment are based on ecotoxicological as well as human risks and are all substantially higher than the derived values for the SRC for soil. These differences originate from the different partition coefficients (SRC_{eco}) and different exposure routes that have been taken into account (SRC_{human}).
Reliability Because of the high reliability of SRC_{eco} for soil for cobalt and the low reliability of the SRC_{human} for soil (because of an uncertain BCF for plants), it is proposed to use the higher ecotoxicological value of 180 mg/kg instead of the human value of 43 mg/kg. The reliability of the $SRCs_{eco}$ for sediments can be indicated as being low because of the uncertainty of equilibrium partitioning. The human-toxicologically based SRCs for sediment are mainly based on soil ingestion, and therefore more reliable.

7.2.3 Cyanides

There is enough evidence for a major change in the risk assessment for free cyanides, complex cyanides and thiocyanates (see section 5.6.3 and Köster [2001]). Köster (2001) has shown that critical exposure to soil contamination could only occur via inhalation of HCN in ambient air or via ingestion of ferrohexacyanide or thiocyanate dissolved in groundwater. When acute toxicity of incidental exposure of children is also taken into account, a maximum concentration in soil can be derived. Only for thiocyanate could a SRC_{eco} for soil be derived. As concluded from these findings, the foundation for the current Intervention Value is no longer valid, but neither can a SRC for soil and sediment be derived, on the basis of the generic procedure (a partition coefficient is lacking).
In the policy phase of the “Evaluation of Intervention Values for Soil” it has to be decided on how to deal with cyanides in soil (and sediment). Three suggestions with respect to the (potential) risks of cyanides can be considered:

- measurement of HCN concentrations directly in ambient and/or soil air, which can be assessed with the TCA of 0.025 $mg.m^{-3}$ HCN in soil air or in ambient air;
- derivation of a maximum concentration in soil for free cyanide, complex cyanide and thiocyanate of 150 mg/kg, 4800 mg/kg and 33 mg/kg, respectively, taking into account an acute toxicity of incidental soil ingestion by children of 5 g/day. Only for complex cyanides is this value within the concentration range observed in the field; the other observed concentrations are always lower;
- measuring the concentration in pore water of the contaminated soil; this could be compared with the risk limit for groundwater (human and/or ecotoxicological value; section 7.3).

7.2.4 Aromatic Compounds

Changes. The integrated SRC for soil for ethylbenzene and cresoles are substantially higher and the SRC for phenol and toluene are substantially lower than the current Intervention Value for Soil/sediment. All SRCs, except for benzene and toluene are ecotoxicologically based risk limits. The origin of the changes in the SRC_{eco} was described in general in chapter 6. The lower SRC for toluene is due to the lower revised TCA; for benzene the SRC is almost equal to the current Intervention Value for Soil.
In general, the SRCs for aquatic sediment are equal to or in the same order of magnitude of the SRCs for soil.
Sum values. For cresoles, xylene and dihydroxybenzenes a sum-value can be derived (geometric mean) for soil, sediment and groundwater (see section 2.6).
Reliability. The reliability of the SRC for the aromatic compounds is described as medium and low. There are no large differences in the reliability between the ecotoxicological and human risk limits.

7.2.5 Polycyclic Aromatic Hydrocarbons (PAH)

Changes. The integrated SRCs for PAH for soil (1.9 to 260 mg/kg) is for 9 PAH lower and for 1 higher than the current Intervention Value for PAH (sum value 40 mg/kg). All critical values are based on ecotoxicological risks. For 7 PAHs the revised value could be based on toxicity data (and for 3 PAH only on QSARs), whereas the former value was based on data for only three compounds. The geometric mean of these 7 data is 15 mg/kg, being much lower than the current Intervention Value for Soil/sediment. The seven additional SRCs$_{\text{human}}$ are only relevant in the actual risk assessment, because the SRC$_{\text{eco}}$ for PAHs are much lower. The derived SRCs for aquatic sediment for PAHs are the same as for soil, except from the higher values for benzo(a)pyreen and anthracene. The geometric mean of the 7 data for sediment of 27 mg/kg is only slightly lower than the current Intervention Value for Soil/sediment.

Sum value. The current value of 40 mg/kg is a sum value. Currently, there are indications that PAHs act via various modes of action (Kalf et al. 1995). Besides narcotic effects, some PAHs can have a strong photo-induced toxicity (see e.g. Mekenyan et al., 1994). Therefore no sum value or a toxic unit approach is proposed for PAHs. The differences between individual SRCs could also originate from different origins of toxicity data (e.g. different taxonomic groups, different experimental layout).

Reliability. The reliability of the individual SRC$_{\text{eco}}$ for soil and sediment is scored low and medium. Because the reliability of the SRC$_{\text{human}}$ for soil mainly is scored as high, use of the more reliable higher value should be considered. Nevertheless use of the SRC$_{\text{eco}}$ is recommended, because using the higher value will lead to unacceptable ecotoxicological risks.

7.2.6 Chlorinated Hydrocarbons

Changes. The integrated SRC for soil for tetrachloroethene, di- tri- and tetrachlorophenols and chloronaphthalenes are substantially higher than the the current Intervention Values for Soil/sediment; For dichloromethane, trichloroethene, vinylchloride, tri-, tetra-, penta- and hexachlorobenzene, some PCBs and dioxins (experessd in TEQ) are substantially lower. Human as well as ecotoxicological risks determine the risk limits for the different compounds (Table 7.1). The higher SRCs for soil for tetrachloroethene, chlorophenols and chloronaphthalenes originate from the revised ecotoxicological data. The lower SRCs for dichloromethane and tetrachlorobenzenes also originated from revised ecotoxicological data. A lower human MPR leads to lower integrated SRCs for soil for trichloroethene, vinylchloride, tri- and hexachlorobenzene, PCBs and dioxins; for some compounds this is also due to a higher estimated exposure (see Appendix 6). For dioxins ecotoxicological risk limits still has to be derived; based on the derived risk limits by the Health Council (Gezondheidsraad 1996) a risk limit in the same order of magnitude can be expected. The integrated SRCs for aquatic sediment for the chlorinated aliphatic hydrocarbons are all slightly or substantially higher than the SRC for soil. For most chlorobenzenes, chloronaphthalene, non-planar PCBs and (reported) dioxins the values (in TEQ) are equal to or in the same order of magnitude; for chlorophenols and hexachlorobenzene they are substantially lower than in soil.

Sum values. The geometric mean of the eco- or human-toxicological values for the isomers of chlorobenzenes, chlorophenols and chloronaphthalene is used since the toxicity is equal and the contaminant behaviour is to a large extent comparable. For PCBs the “toxic units approach” is recommended for the seven indicator compounds. In this way the assessment can be carried out with the locally found PCB profile. The dioxin-like PCBs (planar PCBs) are assessed together with dioxins. In principle, for the PCDD (dioxins), the planar PCBs and PCDF (expressed in TEQ) a “toxic units approach” was recommended, but a geometric mean is proposed because of the small differences in the derived SRCs (see section 5.6.6).

Reliability. The reliabilities of SRC_{human} and SRC_{eco} are all scored as medium or low due to the uncertainty in human exposure and the limited amount of soil toxicity data. Only for pentachlorophenol is the reliability of the SRC_{eco} scored as high.

7.2.7 Pesticides

Changes. The integrated SRC for soil for a-HCH and DDD is substantially higher and for DDT, DDE, total drins, carbaryl, carbofuran and atrazin substantially lower than the current Intervention Value for Soil/sediment (see Appendix 6). Although sometimes close together, all SRCs, except for b-HCH, are determined by ecotoxicological risks. Therefore all changes also relate to the revised ecotoxicological data. For d-HCH no SRCs could be derived.
For all pesticides, except for DDT, dieldrin and endrin, the integrated SRCs for aquatic sediment are equal to or lower than the integrated SRC for soil. No SRC for aquatic sediment can be derived for maneb, because there is no Kow/Koc for this compound (a polymer).
Sum value. There are indications that ecotoxicologically DDT and DDE have a different mode of action. Therefore scientifically no sum value is suggested. For pragmatic reasons for soil a sum value for DDT and DDE of 1.1 mg/kg (DDD is excluded, because of the different toxic level and since DDD is hardly found in soil) and for sediment a sum value for DDT, DDE and DDD of 3.5 (geometric mean) might be used. A SRC sum-value for soil for total drins is derived; no sum value is derived for sediment, because the SRC_{eco} as well as the SRC_{human} determine the integrated SRC. No sum-value is derived for soil and sediment for the HCH, because the SRC_{eco} as well as the SRC_{human} determine the integrated SRC and the human risks probably relate to a different mode of action.
Reliability. The reliability of the SRCs for most pesticides is scored as medium. When the reliability is low the SRC is based on only aquatic data and equilibrium partitioning between soil/sediment and water.

7.2.8 Mineral Oil

Changes. The SRC could only be based on human-toxicological risk assessment. For the smaller “Equivalent Carbon (EC) fractions” the SRC_{human} is much lower and for the larger fractions (EC >12) the SRC_{human} is (much) higher than the current Intervention Value for “mineral oil”. Whether the revised values lead to more stringent risk assessment will strongly depend on the composition of the contamination. It is recommended to apply this method to several cases to ascertain the consequences of this method.
Besides, it should be considered if ecotoxicological risk limits should be derived first, before using general (integrated) SRCs for soil and aquatic sediment.
The derived SRC_{human} for aquatic sediment is substantially higher for most aliphatic compounds, while the values for the aromatic compounds are in the same order of magnitude or lower.
Sum value. No sum value for all fractions is derived because of large differences in the toxic risk level of the fractions and the soil behaviour. A toxic unit approach (or fraction approach) is recommended for these different fractions, because additivity of effects is assumed (Franken et al., 1999)
Reliability. The reliability of the SRC for soil for most fractions is scored as medium due to the medium reliability of the MPR (TDI) and the medium (and high) reliability of the exposure, which for the smaller fractions is mainly based on exposure via inhalation of indoor air.

7.2.9 Other compounds

Changes. The integrated SRC for soil for cyclohexanone, pyridine, tetrahydrofuran and dihexylphthalate are higher and the SRC for soil for tetrahydrothiophene and di-

isobutylphthalate lower than the current Intervention Value for Soil/sediment. The values for cyclohexanone, pyridine and tetrahydrofuran are higher, mainly because of a lower estimated human exposure. The derivation of a SRC_{eco} leads for cyclohexanone to a higher and for tetrahydrothiophene to a lower integrated SRC (compared to the current Intervention Value). The SRCs for the mentioned phthalates are based on newly derived ecotoxicological values. For most compounds the integrated SRC for aquatic sediment is equal to the integrated SRC derived for soil. For pyridine, tetrahydrofuran and diethyl-phthalate the integrated SRC for aquatic sediment is higher and the SRC for dihexyl-phthalate is lower than the value for soil. *Sum values.* No sum-value was derived for phthalates for soil and sediment, because there probably are differences in the mode of action and toxicity of different phthalates (for humans as well as ecosystems (Van Wezel et al., 2000; Baars et al., 2001). Besides, the SRC_{human} for some phthalates is lower than the SRC_{eco}.
Reliability. The reliability of the SRC for all these compounds is medium or low, depending on the amount of available ecotoxicological data and the reliability of the human MPR and the uncertainty of the Kow/Koc.

Table 7.1 Ecotoxicological Serious Risk Concentration (SRC_{eco}), Human-toxicological Serious Risk Concentration (SRC_{human}) for soil and aquatic sediment, with reliability scores (RS), integrated SRCs for soil and aquatic sediment and the current Intervention Value (IV) for Soil/sediment in $mg.kg^{-1}{}_{dry\ weight}$ (VROM, 2000; standard soil: 10% organic matter, 25% lutum, pH=6); the lowest values are underlined.

Compound	*Current IV for soil [mg.kg^{-1}]*	**Integr. SRC for soil [mg.kg^{-1}]**	SRC_{eco} soil [mg.kg^{-1}]	RS*^{1}	SRC_{human} soil [mg.kg^{-1}]	RS*^{1}	**Integr. SRC for aquatic sediment [mg.kg^{-1}]**	SRC_{eco} sediment [mg.kg^{-1}]	RS*^{1}	SRC_{human} sediment [mg.kg^{-1}]
I. Metals										
Arsenic	*55*	**85**	85	high	576	high	**3300**	5900	low	3300
Barium	*625*	**890**	890	high	9340	med	**7200**	7200	low	-
Cadmium	*12*	**13**	13	high	28	high	**820**	820	low	1800
Chromium	*380*	**-**	220	high	-		**-**	43000	low	-
ChromiumIII		**220**	-	high	2760	med	**17600**	-	low	17600
CromiumVI		**78**	-	med.	78	low	**-**	-	low	-
Cobalt	*240*	**180**	180	*high*	43	*low*	**3200**	3200	low	-
Copper	*190*	**96**	96	high	8600	med	**660**	660	low	>100000
Mercury (inorganic)	*10*	**36**	36	high	210	med	**1500**	1500	low	6700
Mercury (organic)		**4.0**	4.0	med.	-		**-**	-		-
Lead*3	*530*	**580**	580	high	622	high	**3210**	63000	low	3210
Molybdenum	*200*	**190**	190	high	1310	low	**23000**	23000	low	-
Nickel	*210*	**100**	100	med.	1470	med	**2600**	2600	low	>100000
Zinc	*720*	**350**	350	high	46100	med	**6600**	6600	low	>100000
II. Other inorganic compounds										
Cyanides (free; as CN)	*20*	**-*^{7}**	-		-*^{7}		**-**	-		-
Cyanides (complex; as CN)	*650/50*	**-*^{7}**	-		-*^{7}		**-**	-		-
Thiocyanates (as SCN)	*20*	**-*^{7}**	620	low	-*^{7}		**-**	-		-
Total as (CN^-)	-	**-**	-		-		**-**	-		-
III. Aromatic compounds										
Benzene	*1*	**1.1**	130	med.	1.1	med	**5.5**	130	med.	5.5
Ethyl benzene	*50*	**110**	110	med.	111	med	**110**	110	med.	111
Phenol	*40*	**14**	14	med.	390	med	**14**	14	med.	174
Cresoles (sum)	*5*	**13**	13	med.	365	med	**27**	27	med.	122
Toluene	*130*	**32**	47	med.	32	med	**79**	79	med.	191
Xylenes (sum)	*25*	**17**	17	low	156	med	**17**	17	low	127
Dihydroxybenzenes (sum)		**8**	8		no sum		**8**	8		no sum
Catechol	*20*		2.6	low	457	med		2.6	low	1100
Resorcinol	*10*		4.6	low	20	med		4.6	low	190
Hydrochinon	*10*		43	med.	96	med		43	med.	1100
Styrene	*100*	**86**	86	low	472	med	**86**	86	low	224
IV. PAH										
Total PAHs (10)	*40*	**no sum**	no sum		*^{10}		**no sum**	no sum		*^{10}

Compound	*Current IV for soil [mg.kg^{-1}]*	**Integr. SRC for soil [mg.kg^{-1}]**	SRC$_{eco}$ soil [mg.kg^{-1}]	RS^{*1}	SRC$_{human}$ soil [mg.kg^{-1}]	RS^{*1}	**Integr. SRC for aquatic sediment [mg.kg^{-1}]**	SRC$_{eco}$ sediment [mg.kg^{-1}]	RS^{*1}	SRC$_{human}$ sediment [mg.kg^{-1}]
Naphthalene	-	**17**	17	low	870	med	**17**	17	low	120
Anthracene	-	**1.6**	1.6	med.	25500	high	**1.6**	1.6	low	4200
Phenantrene	-	**31**	31	*low*	23000	*high*	**31**	31	low	440
Fluoranthene	-	**260**	260	*low*	30300	*high*	**260**	260	low	1600
Benzo(a)anthracene	-	**2.5**	2.5	med	3000	high	**49**	49	low	290
Chrysene	-	**35**	35	*Qsar*	32000	*high*	**35**	35	Qsar	6000
Benzo(a)pyrene	-	**7.0**	7.0	med.	280	high	**17**	28	low	17
Benzo(ghi)perylene	-	**33**	33	*Qsar*	19200	*high*	**33**	33	Qsar	3600
Benzo(k)fluoranthene	-	**38**	38	*low*	3200	*high*	**38**	38	low	560
Indeno(1,2,3cd)pyrene	-	**1.9**	1.9	*Qsar*	3200	*high*	**1.9**	1.9	Qsar	580
Pyrene *^{2}	-		-		>100000	high		-		60000
Acenaphtene *^{2}	-		-		>100000	high		-		47000
acenaphtylene *^{2}	-		-		26000	high		-		170
Benzo(b)fluoranthene *^{2}	-		-		2800	high		-		100
Benzo(j)fluoranthene *^{2}	-		-		2800	high		-		90
Dibenz(a,h)anthracene *^{2}	-		-		70	low		-		27
9H-Fluorene *^{2}	-		-		23000	high		-		210
V Chlorinated hydrocarbons										
1,2-dichloroethane	*4*	**6.4**	240	med.	6.4	low	**62**	240	med.	62
Dichloromethane	*10*	**3.9**	3.9	med.	68	med	**40**	40	low	210
Tetrachloromethane	*1*	**0.70**	29	low	0.70	med	**3.2**	29	low	3.2
Tetrachloroethene	*4*	**8.8**	16	med.	8.8	med	**16**	16	low	19
Trichloromethane	*10*	**5.6**	170	med.	5.6	med	**84**	170	med.	84
Trichloroethene	*60*	**2.5**	2.5	med.	10	low	**93**	130	med.	93
Vinylchloride	*0.1*	**0.0022*^{6}**	17	Qsar	0.0022	med	**1.6**	17	Qsar	1.6
Total chlorobenzenes	*30*	**no sum**	*^{10}		no sum		**no sum**	*^{10}		no sum
Monochlorobenzene	-	**15**	15	low	114	med	**15**	15	low	280
Dichlorobenzenes (sum)	-	**19**	19		476		**19**	19		336
1,2-Dichlorobenzene	-		17	low	477	low		17	low	550
1,3-Dichlorobenzene			24	low	-			24	low	-
1,4-Dichlorobenzene			18	med.	475	med		18	low	205
Trichlorobenzenes (sum)	-	**11**	11	med.	40	low	**25**	25	low	31
Tetrachlorobenzenes (sum	-	**2.2**	2.2	med.	7.5	low	**2.1**	39	low	2.1
Pentachlorobenzene	-	**6.7**	16	med.	6.7	low	**1.5**	16	low	1.5
Hexachlorobenzene	-	**2.0**	2.0	med.	2.7	med	**0.23**	2.0	low	0.23
Total chlorophenols	*10*	**no sum**	no sum		no sum		**no sum**	no sum		no sum
Monochlorophenols (sum)	-	**5.4**	5.4	med.	77	low	**8.5**	8.5	low	12
Dichlorophenols (sum)	-	**22**	22	med.	105	low	**10**	22	low	10
Trichlorophenols (sum)	-	**22**	22	med.	231	med	**8.8**	41	low	8.8
Tetrachlorophenols (sum)	-	**21**	21	med.	172	med	**9.3**	22	low	9.3
Pentachlorophenol	-	**12**	12	high	20	med	**0.52**	8	med	0.52
Chloronaphthalenes (sum)	*10*	**23**	23	low	29	low	**23**	23	low	207
Total of 7 PCBs	*1*	*^{10}	3.4	low	*^{10}		*^{10}	3.4	low	*^{10}
PCB28		**0.69**			0.69	low	**0.06**			0.06
PCB52		**0.28**			0.28	low	**0.03**			0.03
PCB101		**0.61**			0.61	low	**0.20**			0.20
PCB118		**1.9**			1.9	low	**0.69**			0.69
PCB138		**0.32**			0.32	low	**0.28**			0.28
PCB153		**0.46**			0.46	low	**0.37**			0.37
PCB180		**0.17**			0.17	low	**0.45**			0.45
Dioxins(+PCDF+PCB)	*(0.001)^{*4}*	**0.00036*^{5}**	-*^{9}		*0.00036*^{5}*		**0.00021*^{5}**	-*^{9}		*0.00021*^{5}*
2,3,7,8-TeCDD					0.00031*^{5}	low				0.00009*^{5}
PeCDD					0.00031*^{5}	low				0.00021*^{5}
HxCDD					0.00032*^{5}	low				0.00030*^{5}
HpCDD					0.00032*^{5}	low				0.00034*^{5}
OCDD					0.00032*^{5}	low				0.00037*^{5}
PCB77 *^{2}			4.2	low	0.00063*^{5}	low		4.2	low	0.00014*^{5}
PCB105 *^{2}			10	low	0.00063*^{5}	low		10	low	0.00021*^{5}
PCB118 *^{2}					0.00076*^{5}	low				-
PCB126 *^{2}			0.92	low	0.00030*^{5}	low		0.92	low	0.00016*^{5}
PCB156 *^{2}					0.00032*^{5}	low				0.00027*^{5}
PCB157 *^{2}					0.00032*^{5}	low				0.00025*^{5}

Compound	*Current IV for soil [mg.kg^{-1}]*	**Integr. SRC for soil [mg.kg^{-1}]**	SRC$_{eco}$ soil [mg.kg^{-1}]	RS[*1]	SRC$_{human}$ soil [mg.kg^{-1}]	RS[*1]	**Integr. SRC for aquatic sediment [mg.kg^{-1}]**	SRC$_{eco}$ sediment [mg.kg^{-1}]	RS[*1]	SRC$_{human}$ sediment [mg.kg^{-1}]
PCB169 *2					0.00026*5	low				0.00018*5
TeCDF *2					0.00031*5	low				0.00006*5
PeCDF *2					0.00031*5	low				0.00010*5
HxCDF *2					0.00031*5	low				0.00030*5
HpCDF *2					0.00032*5	low				0.00032*5
OCDF *2					0.00032*5	low				0.00038*5
VI Pesticides										
Total DDT/DDE/DDD	*4*	**-*8**	no sum		23		**-*8**	no sum		7.3
DDT	-	**1**	1	med.	31	med	**9.5**	9.5	low	11
DDE	-	**1.3**	1.3	low	17	med	**1.3**	1.3	low	7
DDD		**34**	34	low	42	med	**5**	34	low	5
Total drins	*4*	**0.14**	0.14		no sum		**no sum**	1.2		no sum
Aldrin and dieldrin		**0.22**	0.22	med.	no sum					
Aldrin	-	**-**	-		0.32	med	**0.06**	1.7	med	0.06
Dieldrin	-	**-**	-		9.1	med	**1.6**	1.9	med	1.6
Endrin	-	**0.1**	0.095	med.	16	med	**0.48**	0.48	med	2.9
Total HCHs	*2*	**no sum**	6.4		no sum		**no sum**	10		no sum
a-HCH	-	**17**	17	med.	20	med	**15**	17	med	15
b-HCH	-	**1.6**	13	med.	1.6	med	**0.33**	13	med	0.33
g-HCH	-	**1.2**	1.2	med.	1.3	med	**0.3**	5	med	0.3
d-HCH	-	**-**	-		-		**-**	-		-
Carbaryl	*5*	**0.45**	0.45	med.	107	med	**0.45**	0.45	med	36
Carbofuran	*2*	**0.017*6**	0.017	med.	5.7	med	**0.017*6**	0.017	low	34
Maneb	*35*	**22**	22	med.	32100	high	**no SRC**	no SRC		no SRC
Atrazin	*6*	**0.71**	0.71	med.	18	med	**0.71**	0.71	med	37
VII Mineral Oil	*5000*		-		*10			-		*10
alifatics EC 5-6	-		-		35	med		-		47000
alifatics EC >6-8	-		-		109	med		-		>100000
alifatics EC >8-10	-		-		28	med		-		10600
alifatics EC >10-12	-		-		152	med		-		12100
alifatics EC >12-16	-		-		55000	med		-		12200
alifatics EC >16	-		-		>100000	med		-		>100000
aromatics EC >8-10	-		-		59	med		-		100
aromatics EC >10-12	-		-		317	med		-		180
aromatics EC >12-16	-		-		5900	med		-		420
aromatics EC >16-21	-		-		17500	med		-		2600
aromatics EC >21-35	-		-		19200	med		-		3600
VIII Other compounds										
Cyclohexanone	*45*	**150**	150	med.	214	med	**150**	150	med.	>100000
Total phthalates	*60*	**no sum**	no sum		*10		**no sum**	no sum		*10
Dimethyl phthalate	-	**82**	84	med.	82	low	**84**	84	low	169
Diethyl phthalate	-	**53**	53	med.	17000	low	**580**	580	med.	4940
Di-isobutylphthalate	-	**17**	17	low	83	low	**11**	17	low	11
Dibutyl phthalate	-	**36**	36	med.	22600	low	**36**	36	low	50
Butyl benzylphthalate	-	**48**	48	low	>100000	med	**48**	48	low	21900
Dihexyl phthalate	-	**220**	220	low	381	low	**12**	220	low	12
Di(2-ethylhexyl)phthalate	-	**60**	69	low	60	low	**10**	10	med.	59
Pyridine	*0.5*	**11**	50	med.	11	low	**32**	280	med.	32
Tetrahydrofuran	*2*	**7**	120	med.	7	low	**48**	120	med.	48
Tetrahydrothiophene	*90*	**8.8**	8.8	Qsar	234	med	**8.8**	8.8	Qsar	426

- not available.

*1. The reliability scores (RS); see chapters 5 and 6 for explanation (high implies less uncertainty);

*2. These compounds were added at the end of the evaluation process; therefore the complete data evaluation was not performed.

*3. Based on exposure and Maximal Permissible Risk for intake for a child, and a relative bioavailability for lead in soil in the body of 0.6.

*4. Indicative Value for Soil; no reliable value could be derived

*5. Human-toxicological value expressed as Toxicity equivalent (TEQ) of the most toxic dioxin 2,3,7,8 TCDD

*6. The detection limit is exceeded (based on VROM (2000)) or attention still has to be given to detection limit (for “mineral oil”)

*7. SRCs for cyanides in soil could not be derived; (see text and Köster (2001)); ecotoxicological data are poor.

*8. For soil a sum value could be based on the risk limits of DDT and DDE and for sediment on DDT, DDE and DDD see text;

*9. The ecotoxicological data are not evaluated, because they belong to the second series of Intervention Values. Taking into account biomagnification, the advisory values of the Health Council (Gezondheidsraad, 1996) for 2,3,7,8 TeCDD are for soil 2 ng.kg$_{dm}^{-1}$ and for sediment 13 ng.kg$_{dm}^{-1}$. Not taking into account biomagnification and a higher risk-level (HC50), comparable to the other SRC$_{eco}$, the derived concentration will be in the same order of magnitude or higher than the SRC$_{human}$.

*10. the "toxic unit approach" (fraction approach) can be applied for this group of compounds (see section 2.6), because compounds probably have the same mode of action.

7.3 Integrated SRCs for groundwater

7.3.1 Introduction

Table 7.2 presents the integrated SRCs for groundwater. The three elements used to derive these values are summarised, as are the current Intervention Value for Groundwater. The procedure for deriving Intervention Values for Groundwater still has to be discussed in the policy phase of the project "Evaluation of Intervention Values for Soil", including the use of the elements given in Table 7.2 and information given in Appendix 5B.

Each group of compounds is described in the sections below, focussing on the following subjects:

- changes in the integrated risk limit, compared to the current Intervention Values for Groundwater and (where possible) the main reasons for these changes;
- whether or not the risk limit is based on ecotoxicological risks, human-toxicological risks or on the risk of using groundwater as drinking water (underlined);
- whether or not values are proposed;
- whether or not large differences exist in the reliability (uncertainty) of the SRC$_{eco}$ and SRC$_{human}$.

It is also indicated if the integrated SRCs are lower (or less than a factor of 2 higher) than the Target Values for Groundwater or the detection limits as given in VROM (2000).

7.3.2 Metals

Changes. The integrated SRC for groundwater for chromium and nickel are substantially higher and for cobalt, copper, lead and zinc are substantially lower than the current Intervention Value for Groundwater. The SRCs for groundwater are based mainly on the SRC$_{eco}$ and the maximum concentration in drinking water. For copper, lead and zinc the integrated SRC is close to the Target Value for Groundwater.
The value for chromium can be expressed as total chromium. For mercury a distinction is made between inorganic and organic mercury.
Reliability. The reliability of the SRC$_{eco}$ for groundwater is in general high. The reliability of the concentration in drinking water is related to the reliability of the oral MPR (see chapter 4) and is high or medium for all metals.

7.3.3 Cyanides

There is enough evidence for a major change in the human risk assessment for free cyanides, complex cyanides and thiocyanates (see section 5.6.3 and Köster [2001]). Köster (2001) has shown that critical exposure to soil contamination could only occur via inhalation of HCN in ambient air or via ingestion of ferrohexacyanide or thiocyanate dissolved in groundwater. The human risk limit for cyanides can be set at 75 µg *total* (*EPA*) CN.l^{-1}, being one value for all cyanides, based on toxicity of thiocyanates and direct consumption of groundwater as drinking water by children. Because the SRC$_{eco}$ for free and complex cyanides in groundwater

is lower, an integrated SRC of 30 µg.l^{-1} is derived for these individual compounds. For thiocyanates the integrated SRC is 75 µg CN.l^{-1} (= 170 µg SCN.l^{-1}). High concentrations of thiocyanates and complex cyanides can be found in groundwater at contaminated sites; the observed maximum concentration of free cyanides in groundwater (150 µg /l) is close to the derived risk limits (Köster, 2001). Based on the indications that after ingestion thiocyanates react as free CN and consumption of groundwater as drinking water (lifelong averaged) also the current Intervention Value could be maintained for *total (EPA)* CN (not per individual compound) (Köster, 2001).
Reliability. The reliability of the SRC_{eco} for groundwater and the derived maximum concentration in drinking water are scored high.

7.3.4 Aromatic Compounds

Changes. The integrated SRC for groundwater for benzene, ethylbenzene, cresoles, toluene, xylene and styrene are substantially higher than the current Intervention Value for Groundwater. Most values are based on the maximum concentration in drinking water and the SRC_{eco}, only for toluene it is based on the SRC_{human} (see Table 7.2). The main reason for the higher values is the fact that the dilution factor of 0.1 is not used in these values. Besides the TDI for xylene and the TCA for ethylbenzene and xylene are substantially higher.
Sum values. For isomers of cresoles and xylene a sum-value is derived (geometric mean; see section 2.6).
Reliability. There are no large differences in the reliability. The reliability of the SRC_{eco} for groundwater and the maximum concentration in drinking water are scored as high and medium; only for catechol is the SRC_{eco} scored as low.

7.3.5 Polycyclic Aromatic Hydrocarbons (PAH)

Changes. The integrated SRC for groundwater for most PAHs is substantially higher than the current Intervention Values for Groundwater, except for a lower value for anthracene. All integrated SRCs of the standard 10 PAH are based on the SRC_{eco}. For the additional seven PAH, ecotoxicological data are not yet available; integrated SRCs for these compounds have not been derived because this would lead to relatively high concentrations.
Sum value. Because of the large differences in the values and indications for different ecotoxicological modes of action, it is not possible to present a sum–value for PAH in groundwater. This is in line with the current Intervention Values for Groundwater.
Reliability. The reliability of the SRC_{eco} for groundwater is medium and low. It is not advised to use the maximum concentration in drinking water, although the MPRs for PAH are scored as high.

7.3.6 Chlorinated Hydrocarbons

Changes. The integrated SRC for groundwater for all chlorinated aliphatic hydrocarbons are substantially higher or about the same; only for vinylchloride is this value lower than the current Intervention Value for Groundwater. All these SRCs are based on the maximum concentration in drinking water (although some are close to the SRC_{human}), except for vinylchloride which is based on the SRC_{human}. The main reason for the higher values is the fact that the dilution factor of 0.1 is not used in these values. The reason for the lower value for vinylchloride is the revised MPR (CR_{inhal} from 100 to 3.6 µg.m^{-3}) and the revised exposure modelling for volatile compounds.
For all chlorobenzenes, all chlorophenols (except monochlorophenol), chloronaphthalene and dioxins (including planar PCB) the integrated SRC for groundwater is substantially higher than the current Intervention Value for Groundwater. For PCBs the value is in the same order

of magnitude. Human-toxicological as well as ecotoxicological risks determine the integrated SRCs (Table 7.1).

Sum values. The geometric means are used for the isomers of chlorobenzenes, chlorophenols and chloronaphthalene because the toxicity is equal and the contaminant behaviour is comparable.

For PCBs the “toxic unit approach” is recommended for the seven indicator compounds. In this way the assessment can be carried out with the locally found PCB profile. The dioxin-like PCBs (planar PCB) are assessed together with dioxins. Because of the small differences between the derived $SRCs_{human}$, the geometric mean is proposed as a sum value.

Reliability. The reliability of the SRC_{human}, the SRC_{eco} and the maximum concentration in drinking water vary from low to high for the different compounds. However, per compound, there are no large differences in the reliability.

7.3.7 Pesticides

Changes. The integrated SRC for groundwater for DDT, DDE, DDD, drins, a-HCH and maneb are substantially higher and for carbofuran is substantially lower than the current Intervention Value for Groundwater (see Appendix 6). Most values are based on the SRC_{eco}, except for aldrin, dieldrin and HCHs (maximum concentration in drinking water). For d-HCH no data were available. Because for maneb no Kow/Koc exists the SRC_{eco} determines the value for groundwater.

Sum value. No sum value is proposed for the total of DDT, DDE and DDD. For aldrin and dieldrin a sum value is derived; this is due to the derived risk limits being equal (human toxicological as well as ecotoxicological). No sum value is proposed for HCHs, because of the different toxicity levels and the different mode of action for humans.

Reliability. For aldrin, because the reliability of the maximum concentration in drinking water (and for SRC_{eco}) is high, and for SRC_{human} low, the higher value of 3.3 μgl^{-1} was chosen. In general, the reliability of the SRC_{eco} is high and medium, and the MPRs (on which the maximum concentrations in drinking water are based) are scored as high.

7.3.8 Mineral Oil

Changes. The derived Integrated SRCs are only human-toxicologically based. Compared to the current Intervention Value for Groundwater of 600 μg/l, the Integrated SRCs for the larger aliphatic fractions (EC>8) and aromatic fractions (EC>21) are substantially lower. Most integrated SRCs are based on the derived SRC_{human} and some on the maximum concentration in drinking water. It should be noted that some SRCs are near the Target Value.

Sum value. No sum value for all fractions is derived because of large differences in the toxic risk level of the fractions and the soil behaviour. A toxic unit approach (or fraction approach) is recommended for these different fractions, because additivity of effects is assumed (Franken et al., 1999)

Reliability. The reliability of the SRC_{human} for groundwater is scored as medium, due to the medium reliability of the MPR (TDI) and the medium reliability of the exposure. The exposure is, for the smaller fractions, based mainly on exposure via inhalation of indoor air and for the larger fractions on soil ingestion (combined with equilibrium partitioning).

7.3.9 Other pollutants

Changes. The integrated SRC for groundwater for cyclohexanone and for most phthalates are substantially higher than the current Intervention Value for Groundwater. The values for pyridine, tetrahydrofuran and tetrahydrothiophene are comparable to the current Intervention Value. All the integrated SRCs are based on the maximum concentration in drinking water.

Sum values. No sum-value was derived for phthalates for soil and sediment, because there probably are differences in the mode of action and toxicity of different phthalates (for humans as well as ecosystems (Van Wezel et al., 2000; Baars et al., 2001). Besides, the SRC$_{human}$ for some phthalates is lower than the SRC$_{eco}$.

Reliability. No large differences are present in the reliability per compound. The reliability of all the relevant SRC$_{eco}$ is scored as medium and low, while the relevant SRC$_{human}$ medium and of the relevant MPR (for deriving the maximum concentrations in drinking water) is high, medium and low (see chapter 4).

Table 7.2 Ecotoxicological Serious Risk Concentration (SRCeco), Human-toxicological Serious Risk Concentration (SRChuman) for groundwater, with reliability scores, Integrated SRC for groundwater and current Intervention Value (IV) for Groundwater (for standard soil: 10% organic matter, 25% lutum); the lowest values are underlined.

Compound	*Current IV for ground-water [µg.l^{-1}]*	**Integr. value for ground-water [µg.l^{-1}]**	SRC$_{eco}$ ground-water [µg.l^{-1}]	RS*[1]	SRC$_{human}$ ground-water [µg.l^{-1}]	RS*[1]	EqP with SRC$_{human}$ [µg.l^{-1}]	max. in drinking water [µg.l^{-1}]
I. Metals								
Arsenic	*60*	**33**	890	high	-		320	33
Barium	*625*	**666**	7100	med.	-		3740	666
Cadmium	*6*	**10**	9.7	high	-		11	17
Chromium	*30*	**166**	220	high	-		574	166
ChromiumIII	*30*	**166**	220	high	-		574	166
CromiumVI			260	high	-		-	166
Cobalt	*100*	**47**	810	high	-		361	47
Copper	*75*	**19*[6]**	19	high	-		4060	4660
Mercury	*0.3*			high	-			
Mercury (inorganic)		**14**	14	high	-		28	67
Mercury (organic)		**0.37**	0.37	high	-		-	3
Lead*[3]	*75*	**17*[6]**	150	high	-		17	54
Molybdenum	*300*	**333**	27000	med.	-		32500	333
Nickel	*75*	**500**	500	high	-		735	1664
Zinc	*800*	**91*[6]**	91	high	-		17700	16643
II. Other inorganic compounds								
Cyanides, free (as CN$^-$)	*1500*	**31**	31	high	-		-	750*[9]
Cyanides, complex (asCN$^-$)	*1500*	**29**	29	med.	-		-	12000
Thiocyanates (as SCN$^-$)	*1500*	**170**	10000	med.	-		-	170
Total (as CN$^-$)	-	**75**	-		-			75
III. Aromatic compounds								
Benzene	*30*	**110**	30000	high	251	med		110
Ethyl benzene	*150*	**3330**	5500	high	5570	med		3330
Phenol	*2000*	**1330**	7000	high	180000	med		1330
Cresoles (sum)	*200*	**1660**	10000	high	128000	med		1660
Toluene	*1000*	**4360**	11000	high	4360	med		7420
Xylenes (sum)	*70*	**1100**	1100	med.	10100	med		4990
Dihydroxybenzenes (sum)		**-**	3100	high	-			-
Catechol	*1250*	**630**	630	low	105000	med		1330
Resorcinol	*600*	**666**	5700	med.	18500	med		666
Hydrochinon	*800*	**832**	8200	high	17800	med		832
Styrene	*300*	**3800**	3800	med.	21200	med		3990
IV. PAH								
Total PAHs (10)	*40*	**no sum**	-		-			
Naphthalene	*70*	**290**	290	med.	15600	med		1330
Anthracene	*5*	**1.4**	1.4	med.	71	med.		1330
Phenantrene	*5*	**30**	30	med.	850	med.		1330
Fluoranthene	*1*	**30**	30	med.	201	med.		1660
Benzo(a)anthracene	*0.5*	**1**	1	low	12	med.		166

Compound	*Current IV for groundwater [µg.l^{-1}]*	**Integr. value for groundwater [µg.l^{-1}]**	SRC$_{eco}$ groundwater [µg.l^{-1}]	RS^{*1}	SRC$_{human}$ groundwater [µg.l^{-1}]	RS^{*1}	EqP with SRC$_{human}$ [µg.l^{-1}]	max. in drinking water [µg.l^{-1}]
Chrysene	*0.2*	**1.2**	1.2	Qsar	1.8	med.		1660
Benzo(a)pyrene	*0.05*	**0.72**	0.72	med.	0.84	med.		17
Benzo(ghi)perylene	*0.05*	**0.18**	0.18	Qsar	0.19	med.		999
Benzo(k)fluoranthene	*0.05*	**0.36**	0.36	low	0.48	med.		166
Indeno(1,2,3-cd)pyrene	*0.05*	**0.036**	0.036	Qsar	0.26	med.		166
Pyrene *^{2}	-	**-**	-		106	med.		16600
Acenaphtene *^{2}	-	**-**	-		2570	med.		16600
acenaphtylene *^{2}	-	**-**	-		4010	med.		1660
Benzo(b)fluoranthene *^{2}	-	**-**	-		17	med.		166
Benzo(j)fluoranthene *^{2}	-	**-**	-		8.8	med.		166
Dibenz(a,h)anthracene *^{2}	-	**-**	-		0.83	low		17
9H-Fluorene *^{2}	-	**-**	-		1320	med.		1330
V Chlorinated hydrocarbons								
1,2-dichloroethane	*400*	**466**	130000	high	3140	med		466
Dichloromethane	*1000*	**2000**	40000	low	55800	med		2000
Tetrachloromethane	*10*	**133**	8700	low	190	med		133
Tetrachloroethene	*40*	**533**	1000	med.	560	med		533
Trichloromethane	*400*	**999**	63000	high	1910	med		999
Trichloroethene	*500*	**1660**	20000	high	1500	med		1660
Vinylchloride	*5*	**0.40**	8000	Qsar	0.40	med		20
Total chlorobenzenes	-	**no sum**	-		-			-
Monochlorobenzene	*180*	**1100**	1100	med.	8970	med		6660
Dichlorobenzenes (sum)	*50*	**650**	650	med.	15800			-
1,2-Dichlorobenzene		**740**	740	med.	20400	med		14300
1,3-Dichlorobenzene		**820**	820	med.	-			-
1,4-Dichlorobenzene		**460**	460	med.	12300	med		4990
Trichlorobenzenes (sum)	*10*	**140**	140	med.	217	med		266
Tetrachlorobenzenes(sum)	*2.5*	**17**	120	med.	23	low		17
Pentachlorobenzene	*1*	**15**	32	med.	14	low		17
Hexachlorobenzene	*0.5*	**3**	3	med.	4.0	low		5
Total chlorophenols	-	**no sum**	-		-			-
Monochlorophenols (sum)	*100*	**100**	1000	med.	8980	low		100
Dichlorophenols (sum)	*30*	**100**	870	med.	4160	low		100
Trichlorophenols (sum)	*10*	**100**	340	low	1922	med		100
Tetrachlorophenols (sum)	*10*	**130**	130	med.	1080	med		832
Pentachlorophenol	*3*	**85**	85	high	214	med		100
Chloronaphthalenes (sum)	*6*	**150**	150	med.	190	low		2660
Total of 7 PCBs	*0.01*	*^{10}	-		*^{10}			0.33
PCB28		**0.291**	-		0.291	low		0.33
PCB52		**0.097**	-		0.097	low		0.33
PCB101		**0.031**	-		0.031	low		0.33
PCB118		**0.015**	-		0.015	low		0.33
PCB138		**0.011**	-		0.011	low		0.33
PCB153		**0.011**	-		0.011	low		0.33
PCB180		**0.003**	-		0.003	low		0.33
Dioxins (+PCDF+PCB)	*0.000001*	**0.000003*^{5}**	-*^{8}		3.1E-6*^{5}			0.0001*^{5}
2,3,7,8-TeCDD	**^{4}	**(geomean)**	-		1.3E-5*^{5}	low		0.0001*^{5}
PCDD			-		4.4E-6*^{5}	low		0.0001*^{5}
HxCDD			-		2.1E-6*^{5}	low		0.0001*^{5}
HpCDD			-		1.4E-6*^{5}	low		0.0001*^{5}
OCDD			-		1.0E-6*^{5}	low		0.0001*^{5}
PCB77 *^{2}			0.1	low	1.5E-7*^{5}	low		0.0001*^{5}
PCB105 *^{2}			0.13	low	8.1E-6*^{5}	low		0.0001*^{5}
PCB118 *^{2}			-		5.9E-6*^{5}	low		0.0001*^{5}
PCB126 *^{2}			0.018	low	6.0E-6*^{5}	low		0.0001*^{5}

Compound	*Current IV for ground-water [µg.l^{-1}]*	**Integr. value for ground-water [µg.l^{-1}]**	SRC$_{eco}$ ground-water [µg.l^{-1}]	RS^{*1}	SRC$_{human}$ ground-water [µg.l^{-1}]	RS^{*1}	EqP with SRC$_{human}$ [µg.l^{-1}]	max. in drinking water [µg.l^{-1}]
PCB156 *^{2}			-		2.5E-6*^{5}	low		0.0001*^{5}
PCB157 *^{2}			-		3.0E-6*^{5}	low		0.0001*^{5}
PCB169 *^{2}			-		4.4E-6*^{5}	low		0.0001*^{5}
TeCDF			-		2.2E-5*^{5}	low		0.0001*^{5}
PCDF			-		1.2E-5*^{5}	low		0.0001*^{5}
HxCDF			-		2.0E-6*^{5}	low		0.0001*^{5}
HpCDF			-		1.7E-6*^{5}	low		0.0001*^{5}
OCDF			-		8.6E-7*^{5}	low		0.0001*^{5}
VI Pesticides								
Total DDT/DDD/DDE	*0.01*				*^{10}			
DDT	-	**0.43**	0.43	med.	1.39	low		17
DDE	-	**0.1**	0.1	med.	1.32	low		17
DDD		**3.8**	3.8	low	4.73	low		17
Total drins	*0.1*	**-**	1.8		-			
Aldrin and dieldrin		**3.3**	3.4	*high*	-			
Aldrin	-	**3.3**	-		0.64	*low*		3.3
Dieldrin	-	**3.3**	-		16	med		3.3
Endrin	-	**0.92**	0.92	high	31	med		6.7
Total HCHs	*1*	**no sum**	100		-			-
a-HCH	-	**33**	140	high	159	med		33
b-HCH	-	**0.7**	93	high	11	med		0.7
g-HCH	-	**1.3**	87	high	23	med		1.3
d-HCH		**-**	-		-			-
Carbaryl (carbamate)	*50*	**41**	41	high	9590	med		100
Carbofuran (carbamate)	*100*	**6.5**	6.5	med.	2040	med		67
Maneb	*0.1*	**32**	32	low	-*^{7}			1660
Atrazin (triazines)	*150*	**76**	76	high	1930	med		166
VII Mineral Oil	*600*	***10**						
alifatics EC 5-6		**613**	-		613	med		66600
alifatics EC >6-8		**444**	-		444	med		66600
alifatics EC >8-10		**15**	-		15*^{6}	med		3330
alifatics EC >10-12		**10**	-		10*^{6}	med		3330
alifatics EC >12-16		**0.59**	-		0.59*^{6}	med		3330
alifatics EC >16-21		**0.001**	-		0.001*^{6}	med		66600
aromatics EC >8-10		**640**	-		640	med		1330
aromatics EC >10-12		**1330**	-		2170	med		1330
aromatics EC >12-16		**1330**	-		5810	med		1330
aromatics EC >16-21		**543**	-		543	med		999
aromatics EC >21-35		**6.6**	-		6.6*^{6}	med		999
VIII Other compounds								
Cyclohexanone	*15000*	**153000**	260000	high	262000	med		153000
Total phthalates	*5*	**no sum**	-		-			832
Dimethyl phthalate	-	**832**	8100	med.	7750	med		832
Diethyl phthalate	-	**3330**	23000	high	287000	med		3330
Di-isobutylphthalate	-	**160**	160	low	818	low		832
Dibutyl phthalate	-	**170**	170	med.	2350	low		2660
Butyl benzylphthalate	-	**100**	100	med.	4220	med		13300
Dihexyl phthalate	-	**12**	84	low	12	med		832
Di(2-ethylhexyl)phthalate	-	**4.4**	5	med.	4.4	low		832
Pyridine	*30*	**33**	57000	high	2130	med		33
Tetrahydrofuran	*300*	**333**	800000	high	16000	med		333
Tetrahydrothiophene	*5000*	**5990**	9400	Qsar	137000	med		5990

- = not available.

*1. The reliability scores (RS); see chapters 5 and 6 for explanation (high implies less uncertainty);

*2. These compounds were added at the end of the evaluation process; therefore not the complete data evaluation was performed.

*3. Based on exposure and Maximal Permissible Risk for intake for a child, and a relative bioavailability for lead in soil in the body of 0.6.
*4. Indicative Value for Soil, no reliable value could be derived
*5. Value expressed as Toxicity equivalent of the most toxic dioxin 2,3,7,8 TCDD
*6. Value is below or near (< factor 2 higher than) the (highest) Target Value (VROM, 2000)
*7. No value could be derived because no Koc is available
*8. The ecotoxicological data are not evaluated, as they belong to the second series of Intervention Values. Taking into account biomagnification, the advisory values of the Health Council (Gezondheidsraad, 1996) for 2,3,7,8 TeCDD is 0.0001 $ng.l^{-1}$. Not taking into account biomagnification and a higher risk-level (HC50), comparable to the other SRC_{eco}, the derived concentration will be in the same order of magnitude as the SRC_{human}.
*9. Critical concentration (based on intake by children) of free CN is higher than the maximal observed concentration (Köster, 2001)
*10. the “toxic unit approach” (fraction approach) can be applied for this group of compounds (see section 2.6), because compounds probably have the same mode of action.

7.4 Differentiation of Intervention Values based on soil type

Human exposure and the ecotoxicological risk depend to some extent on the soil type. The ecotoxicological risk is related to the influence of the soil type on the bioavailability of the compounds. For organic compounds it is widely accepted that there is a relationship between the bioavailability and the organic matter content of the soil. As stated in section 2.5 and discussed in chapter 6, a correction based on the organic matter content was applied and is recommended. For metals the bioavailability based on soil characteristics is still under discussion (see also section 8.9). Therefore no new methods are proposed. Provisionally the current soil type correction as applied to the Target Values can be used, although this is only a correction for the occurrence of background concentrations in relation to soil type.

For the compounds for which the integrated SRC is based on human risks the proposals worked out in section 5.7 could be applied. This means that for most organic substances the correction is (almost) linearly related to the organic matter content of the soil. For substances for which the solubility is exceeded no soil type correction is necessary. The proposal for soil-type correction for metals is not relevant for the integrated SRC since ecotoxicological risks dominate these values.

If the proposals for integrated SRCs for soil were to be derived for the proposed alternative standard soil (section 3.3.1), the values for all organic compounds would be about half of the SRCs presented.

The integrated SRCs for groundwater are (almost) independent of the soil type.

The risk limits for organic compounds derived for aquatic sediments depend only on the organic matter content of the sediment for the ecotoxicologically based values. The human-toxicological risk of a compound is related to the organic matter content, depending on the dominant exposure route. This is similar to the description for the human risk assessment of dry soil (section 5.7). These characteristics are taken into account in the assessment of actual (site-specific) risks with the SEDISOIL model (Otte et al., 2000a).

7.5 Conclusion

Tables 7.3 a-c present the differences (amount of compounds) between the derived SRCs for soil, sediment and groundwater and the current Intervention values for Soil/sediment and Groundwater. When a sum value is derived for some compounds, this is treated as one SRC.

First, from table 7.3a it becomes clear that the SRCs for soil are more often adjusted down than up, when compared to the Intervention Value for Soil. The SRCs for sediment are found to be for the same amount of compounds higher as lower, when compared to the Intervention Value for Soil.
The main reasons for higher and lower ecotoxicologically based SRCs, are the use of a different methodology for the derivation of the SRC_{eco} as well as differences in the data that are the basis for this SRC_{eco} (both toxicity and partitioning data).
The main reasons for the higher human-toxicologically based SRCs for soil are the revised higher MPR (oral and inhalative), the adjusted use of the oral and inhalative MPR and the lower estimated exposure (due to the revised model concept for uptake of organic compounds in plants and revised Koc and Kow values). The main reasons for the lower values are the revised lower MPR and the higher estimated exposure (due to the revised model concept of exposure to indoor air and revised Koc and Kow values).

Second, it can be seen (Table 7.3b) that the derived SRCs for sediment are, in general, higher than the derived SRCs for soil, which is largely caused by the higher ecotoxicological values for metals. Differences also originate from human exposure modelling with SEDISOIL compared to exposure modelling with CSOIL.

From Table 7.3c it becomes clear that the Integrated SRCs for groundwater are more often adjusted upward than downward compared to the Intervention Value for Groundwater. The main reason for the higher values is that the dilution factor of 0.1 is not used in these values, whereas it was used for deriving the current Intervention Value. The main reasons for the lower Integrated SRCs are the revised lower MPR and the higher estimated exposure (due to the revised model concept of exposure to indoor air and the revised Koc and Kow values of compounds).

Figure 7.3a Differences (> factor 2) between revised SRCs for soil and for sediment and current Intervention Value for Soil (number of compounds)

	> current Intervention Value for Soil	< current Intervention Value for Soil	~ current Intervention Value for Soil
Integrated SRC for soil	15	32	36
Integrated SRC for sediment	27	30	23

Figure 7.3b Differences (> factor 2) between SRCs for sediment and SRCs for soil (number of compounds)

	> SRC for soil	< SRC for soil	~ SRC for soil
Integrated SRC for sediment	30	16	32

Figure 7.3c Differences (> factor 2) between revised SRCs for groundwater and the current Intervention Value for Groundwater (number of compounds)

	> current Intervention Value for Groundwater	< current Intervention Value for Groundwater	~ current Intervention Value for Groundwater
Integrated SRC for groundwater	53	15	26

8 Discussion and recommendations

8.1 Introduction

In this chapter different aspects within the procedure for deriving risk limits on which Intervention Values can be based will be discussed and commented on, starting with the influence of several starting points on the derived risk limits (section 8.2). Next, some considerations will be given to the differences in the risk assessment for soil and aquatic sediment (section 8.3). Section 8.4 discusses the proposed procedure for deriving Intervention Values for Groundwater and section 8.5 and 8.6 some issues concerning the human toxicological and the ecotoxicological risk assessment, respectively. Some considerations on the partition coefficient for soil and sediment are given in section 8.7, followed by some remarks on the use of sum values (section 8.8), soil type correction (section 8.9) and uncertainty of the derived risk limits (section 8.10). Finally, recommendations for further research and for policy are summarised in section 8.11.

8.2 Influence of starting points on the derived SRCs

8.2.1 Introduction

As described in section 1.3, several starting points are used for the derivation of SRCs. These starting points are often a consequence of the policy framework in which Intervention Values are used or related to the daily practise of soil and groundwater quality assessment. Some starting points are widely accepted and others are more subjective and can be discussed. Some of the starting points are discussed in the following sections, focussing on their influence on the level of the SRCs. A summary can be found in Figure 8.1.

8.2.2 Realistic case

The choice for parameters used for underpinning the SRC_{eco} or SRC_{human} is based on a realistic, “average” situation if possible. A -political- reason for this choice is that a consistent use of “worst case” parameters will lead to low values and an accompanying early qualification as “seriously contaminated” soil, sediment or groundwater. In the subsequent determination of site-specific actual risks, often the predicate “not urgent” would be given as a consequence. A substantial discrepancy between generic and site-specific risk assessment is not considered desirable.

The parameters used in the derivation of SRCs all have uncertainty margins, the choice for an average situation or the more conservative choice for a worst case situation influencing the level of SRCs. In order to obtain insight into the consequences of worst case vs. realistic case, a Monte Carlo analysis should be performed. Therefore the uncertainty distributions of all underlying parameters must be known. For the most important parameters these distributions can be derived from the parameters given by Otte et al. (2001).

Deviations from realistic case

The amount of homegrown vegetables (fraction of 0.1) and the material LDPE as drinking water pipeline in CSOIL, as well as consumption of fish by anglers in SEDISOIL, do not reflect an average Dutch situation. The selected scenario of the consumption of 2 litre groundwater per day for deriving a risk limit for groundwater also does not reflect an average Dutch situation. These parameters are estimated as being more conservative because it is found important to protect also the situations in which a limited group has a higher exposure, due to a different behaviour, and in this way these potential risks can be recognised. Besides, it can be stated that the quality of soil/groundwater should be such that these uses are possible.

8.2.3 Background exposure

General

It was decided not to include background exposure of humans via other compartments than (in)directly via the soil in the SRC_{human} (see section 1.4.6). As a consequence, the real human exposure will be higher than the modelled exposure resulting in higher risks. The difference between the total and modelled exposure varies per specific situation and per compound. This information could be taken into account in the actual site-specific risk assessment, although currently it is not considered in the procedure for remediation urgency. In the risk assessment in several other countries, an average background exposure is taken into account (e.g. Ferguson et al., 2000), and this principle was also applied for the derivation of the Dutch soil-use specific remediation objectives (Lijzen et al., 1999b).

Compounds for which background exposure forms a significant part of the Maximal Permissible Risk (MPR)

Along with the evaluation of the MPR (chapter 4, Baars et al., 2001), more data on the background exposure have come available (see Appendix 9). For metals, the contribution of background exposure is substantial, especially for barium, cadmium, lead, molybdenum and zinc. For thiocyanate, the estimated background exposure exceeds the TDI almost 7-fold. However, the kinetics and availability during uptake in the gastro-intestinal tract of naturally occurring thiocyanate in plants -contributing a large amount to the background exposure- might not be comparable to the uptake of the thiocyanate added during the toxicity experiments on which the TDI was based. For dioxins and dioxin-like compounds, including the non-planar PCBs, background exposure via food almost equals the -ultimate- TDI (of 4 $pg.kg^{-1}{}_{bw}.d^{-1}$). For β- and γ-hexachlorocyclohexane, there are also indications that a major part of the TDI is filled by background exposure. For one fraction of aliphatic hydrocarbons (C7-C12) background exposure leads to a 5-fold exceedance of the TDI. For these C7-C12 compounds an exposure during painting was assumed, which will need further study.
For all mentioned compounds, including the background exposure, the result will be an SRC_{human} which is significantly lower than proposed in this report.

8.2.4 Human exposure scenario

The Intervention Value is a generic value and applies to soils having various uses. The SRC_{human} for soil is based upon the standard scenario “residential with garden” which includes several exposure routes (see section 1.4.4). Situations will occur where exposure is higher or lower than in the standard scenario. If the actual exposure is lower than modelled for the standard scenario via CSOIL, this will result in the qualification “seriously contaminated but no urgency for remediation”. If, on the contrary, the actual exposure is higher than in the standard scenario (and risks are higher), this situation might not be recognised after the qualification “lightly contaminated” is given. The eventual risk in these situations should be recognised, and should be judged accordingly. Examples of these situations are allotment gardens where vegetables can cover more than the standard 10% of the total crops consumed or where the soil-user consumes meat, dairy products or eggs from animals living on the contaminated site. Another example is a situation where the depth of volatile contaminants (or groundwater table) is less than 1.25 m below the soil surface.
The choice to base the SRC_{human} on a lifetime exposure of 70 years, of which 6 are in childhood (with a higher exposure to soil), has not been revised. The fact that Dutch life expectancy is currently higher than 70 years for men and women would only influence the relative importance of exposure of adults versus children. The choice for assessment of lifetime exposure leads to relatively higher exposure during childhood (and temporary exceedance of the MPR). Only in the case of lead, is the risk assessment based on children as the most vulnerable group for lead exposure. It was recommended to consider focusing on

children or the foetus when critical for other contaminants as well (TCB, 1999b), but there were no direct indications that children or foetuses are more sensitive for other contaminants. Standard, a factor of 10 is included for intra-species variation (see chapter 4), by which also the more vulnerable humans should be considered protected.
Besides, the 6 years of "childhood" is important for the duration of higher amount of soil ingestion during childhood. Available studies deal mostly with children up to 5 years old (Calabrese et al., 1989; Van Wijnen et al., 1990) or up to 7 years old (Davis et al., 1990). The information for setting the period for the higher soil ingestion at 6 years is therefore limited; this period can be longer.

8.2.5 Exposure routes considered for ecosystems

Only direct exposure and no bio-magnification in the food chain is included in the SRC_{eco}. Reason for this choice is the limited surface area of individual seriously contaminated locations. Most organisms at the top of the food chain will forage in a broader area than just the contaminated site.
There are several reasons to discuss the choice to exclude biomagnification. Predators with only a small home range -e.g. mice or meadow birds- might get a large part of their prey from a seriously contaminated location. If several small contaminated sites exist in a same region, bio-magnification can be of importance. Especially in riverbeds, including river forelands, areas of serious contamination can be large, and certain predators are attached to this habitat. Including biomagnification in deriving a SRC_{eco} is technically possible and several methods can be followed. Inclusion of the risks for predators after biomagnification will lower the SRC_{eco} for the more hydrophobic compounds (roughly K_{ow}>5). For example for PCBs and dioxin-like compounds, SRC_{eco} would be seriously lowered if biomagnification were included in the derivation. The current SRC_{eco} is not protective for the situations in which biomagnification plays a significant role or where cattle or food products are at risk.
As for certain human exposure routes, serious risks can also occur in slightly contaminated sites, and should be considered separately.

● ➡ : Influence on SRC

Starting points

Starting point	***Influence on SRC***	***Remarks***
Realistic case	Unquantified rise of SRC compared to worst case	Monte Carlo analysis is recommended
More conservative estimations for exposure parameters	Lowers SRC_{human} compared to average situation	For compounds where crop consumption or direct exposure via groundwater is important
Background exposure not included	Raises SRC_{human} compared to including background exposure	Especially relevant for metals, thiocyanate, dioxin-like compounds, HCH, TPH-fraction C7-C12
Standard exposure scenario	Higher or lower, depending on actual exposure or risks	Actual (site-specific) exposure can be lower (seriously contaminated but not urgent) or higher (potentially serious risks are not recognised)
No biomagnification	Raises SRC_{eco} compared to including biomagnification	For compounds that biomagnify (strongly hydrophobic compounds)

Figure 8.1 Influence of starting points on the level of SRC.

8.3 Risk assessment for aquatic sediment compared to soil

Current Intervention Values are based on terrestrial ecosystems and human exposure to a contaminated terrestrial soil, but are also applied to sediments. In this report, separate SRCs are for soil and aquatic sediment have been presented. Human risk limits based on exposure to contaminated sediments have been derived by Otte et al. (2000a), based on the SEDISOIL exposure model. This model is based on exposure routes to sediment (not being dry sediment in river foreland). The choice of the incorporated routes is based on a scenario where recreation is important (fishing and swimming). The SRC_{human} derived for soil or aquatic sediment differs because of the different exposure routes. Important routes for soil are soil ingestion, crop consumption and inhalation of indoor air and for sediment fish consumption, dermal exposure to sediment and sediment ingestion. Because of the exposure route by consumption of fish, the bioconcentration factor (BCF) from water to fish is an important parameter. For those compounds where fish consumption significantly adds to the total exposure - i.e. the more hydrophobic compounds -, the BCF is more difficult to determine experimentally and therefore more uncertain.

For SRC_{eco} too, values are derived for soil and aquatic sediment separately. Major differences between SRC_{eco} for soil or sediment are the value assigned to K_p, and the fact that the SRC_{eco} for sediment could not be based on sediment toxicity data directly, meaning that equilibrium partitioning always had to be applied.

Whether separate Intervention Values are established for sediment will be up to policy-makers. Separate SRCs for soil and aquatic sediment are presented here because of the differences in exposure routes for humans and the ecosystem between soil and sediments, which results in different risks-limits.

8.4 SRCs for groundwater

The procedures to derive SRCs for groundwater have been revised, as described in section 2.4. The focus has been changed from the signalling of serious contamination of soil to protecting directly the risks of humans and (ground) water organisms by exposure to groundwater. The integrated SRC for groundwater is no longer harmonised with the integrated SRC for soil using equilibrium partitioning. Equilibrium partitioning is only used to derive the SRC_{human} for groundwater. Another change in the derivation of integrated SRC for groundwater, is that the factor of 10 used in addition to equilibrium partitioning, to extrapolate from pore-water to groundwater, is no longer applied. When from a policy point of view a more conservative approach is found applicable, for example as a trigger for soil contamination, a safety or correction factor could be applied.

Human risks due to exposure to groundwater are modelled via CSOIL. For volatile compounds the contaminant concentration at the top of the saturated zone is assumed to equal the concentration in the groundwater, for the other exposure route it is assumed that the concentration in the groundwater equals the concentration in the pore water of the surface soil. More in-depth research on the relationship between the concentration in groundwater and the aforementioned compartments, and the variation therein, is recommended to obtain insight in the value of these assumptions.

Aquatic toxicity data are used to derive SRC_{eco}, as toxicity data for groundwater organisms specifically are nearly always absent (see 2.4.3. for further discussion). Processes occurring in the (ground)water have not been taken into account so far as data are lacking.

Exposure of plants or livestock directly to the groundwater (by pumping or seepage) is not taken into account in the SRC_{eco} for groundwater, because it is found more appropriate to be part of site-specific (actual) risk assessment. It is up to policy-makers to decide if these risks are taken into account in the potential risk assessment. Currently, risks (phytotoxicity) for

plants are only taken into account in deriving SRC_{eco} for soil and, if toxicity data are available, plants are protected by toxicity data for surface water (e.g. algae).
The K_p, derived for the surface soil and attached (pore)water, is used for the derivation of the SRC_{human} for metals in groundwater from the SRC_{human} for soil (section 3.2.7). The relevance of this K_p for describing the relationship between surface soil and related groundwater can be discussed (see 8.7.1).

8.5 Human-toxicological serious risk concentrations (SRC_{human})

Revision and use of MPR

The revision of the MPR_{human} is an important factor in the current evaluation. The revised TDI/CR_{oral} became higher as well as lower, where the TCA/CR_{inhal} in most cases were set lower. Because of the methods used and harmonisation with evaluations of national and international bodies, it is believed that the derived MPRs are also protective for relatively susceptible humans. The politically set acceptable excess lifetime risk of 1 in 10^{-4} for carcinogenic compounds is not discussed. As proposed by the TCB (1999b) and advised by the Expert group on human-toxicological risk assessment it could be considered for some revised MPRs to carry out a peer review by another organisation to enlarge the support of these values. For lead in particular it was advised by the TCB (1999b) to additionally investigate the relation between recent lead-blood content and the occurrence of effects.
The modified use of the oral and inhalative MPR (section 5.3), has a substantial effect on the derived risk limits for compounds for which the use of the oral MPR for exposure via inhalation would lead to lower risk limits. The inhalative MPR (TCA/CR_{inhal}) can also be of importance for non-volatile compounds, via exposure to soil particles in the air (e.g. chromium VI).

Oral bioavailability

Correction for the differences in oral uptake between toxicants in food or water, and toxicants in soil (the relative absorption factor: RAF) is not applied, except for lead (see section 3.2.10). The TCB advised for lead also to hold on to the conservative estimate (TCB, 1999b) For several compounds there are indications that the RAF is smaller than 1 (Ruby et al., 1999; Oomen et al., 2000; Sips et al., in prep.). However, indications from *in vivo* studies are scarce and highly variable depending on the soil type and species tested. For example for arsenic RAFs are found between <1% and 98%. *In vitro* studies give varying RAFs depending on the test system and on the soil type (BioAvailability Research Group Europe or BARGE, preliminary results). Because of the variability in RAFs encountered on this moment the conservative estimate of a RAF of 100% is continued. For lead the (preliminary) data justified to adjust this factor already (Lijzen et al., 1999a; Sips et al., in prep.).

Amount of soil ingestion

Although the average daily soil ingestion by adults, currently and revised 50 $mg.d^{-1}$, is most important for the lifelong exposure, most discussion concentrated on the average daily soil ingestion of children, currently 150 $mg.d^{-1}$. When the risk assessment is based on the vulnerable group “children”, in case of lead, this is a very relevant parameter for the derived SRC_{human}. As described in paragraph 3.3.3, the average daily soil ingestion of children was estimated to be 100 $mg.d^{-1}$ with an upper limit of the 90%-confidence interval of 125 $mg.d^{-1}$. In fact both values could be used depending on the required safety. The 90- and 95-percentile, 150 and 200 $mg.d^{-1}$ respectively, can be used when more than the average behaviour should be protected. However, because it is decided to use a realistic case approach, and in general no conservative estimates in case of uncertain parameters are used, it was decided to implement the amount of 100 mg.d^{-1}. Besides 100 mg.d^{-1} links up with values used in Germany, the UK and the USA. The Technical Soil Protection advised to maintain the value of 150 mg.d^{-1}, because of the high uncertainty of this parameter (TCB, 1999b). It was not found necessary to adjust the value of 50 mg.d^{-1} for adults.

Modelling exposure via inhalation of indoor air
The module to calculate the indoor air concentration is improved by the incorporation of a convective airflow (section 5.2.3). Still, the flux of volatile contaminants from soil to indoor air is difficult to estimate due to the large variability of site-specific circumstances and the lack of equilibrium between soil, pore water and air. The uncertainty in the modelled indoor air concentration is especially important for the volatile compounds where this exposure route contributes largely to the total exposure (see appendix 3), and where the SRC_{human} is lower than the SRC_{eco} and thus determines the integrated SRC (see chapter 7). Site-specific risk assessment, including time-integrated concentration measurements in air, is important for the mentioned compounds and can be a first step for determining the remediation urgency.

Modelling exposure via crop consumption
Organic compounds. In absolute sense accumulation in root crops is more important for human exposure than in leafy crops (Rikken et al., 2000). The highest uncertainty in modelling the accumulation in crops is the prediction of concentration in the aboveground plant parts. For the accumulation of organic compounds in root crops there was sufficient evidence for lowering the estimated concentration in roots, although large variations exist. The model used for calculating the concentration in leafy crops is changed according to Trapp & Matthies (1995). In this model, the volatility of a compound is important, next to the K_{ow}. For leafy crops resuspension (or rainsplash) can be an important additional process and is included in the model. Still, variation between modelled and observed concentration of organic compounds can be high (up to 2 orders of magnitude). The model gives the most certain predictions for compounds with a low K_{oa} and low K_{ow}. For compounds for which the predictions vary highly with the observed values (compounds with a high K_{oa} and high K_{ow}), the exposure via crops is a major exposure route, and the SRC_{human} determines the final SRC, it is recommended to determine the concentrations in leafy crops also on site measurements, in order to judge if there is a serious contamination.
For some compounds (some PAH, TPH-fractions and phthalates) the solubility (S) is exceeded. Because in these cases the solubility limits the exposure via crop consumption (and other pore-water routes) this parameter can be an important factor for the derivation of the SRC_{human}.

Metals. The exposure to metals via the Dutch average consumption package of crops is based on empirical field data on consumption crops. Per crop, multiple linear regressions were made with soil properties (pH, clay, OC%) and metal concentrations as variable. These regressions were interpolated to the standard soil properties if statistically appropriate. Otherwise, geometric means were used. Subsequently, the BCFs per plant species were combined to a generic BCF per metal based on the average Dutch consumption package of crops.
As the variability of BCF values for metals is quite high for different crops and soil characteristics (i.e. up to 2 orders of magnitude), for the purpose of site-specific risk assessment measurements can be carried out. However, for metals SRC_{eco} always determines the final SRC, so the BCF plant will not determine the classification of serious contaminated.

8.6 Ecotoxicological serious risk concentration (SRC_{eco})

As described in Verbruggen et al. (2001) and chapter 6, lognormal distributions are used instead of log-logistic distributions for refined ecotoxicological risk assessment (Aldenberg & Jaworska, 2000). For preliminary risk assessment also modifications are applied; the SRC_{eco} is determined by the minimum value of 1) the geometric mean of NOECs and 2) L(E)C50s/10, when no NOECs are available. The added-risk approach was applied to derive the SRC_{eco} (Crommentuijn et al., 2000), because the background concentration is not included in the nominal concentrations from the underlying toxicity tests (section 6.2.3). This argument for using the added-risk approach was not yet taken into account in the advice of the TCB (1999a) not to apply this method. For this purpose a general background concentration is used (Van den Hoop, 1995; Crommentuijn et al., 1997).

For all metals and 24 organic compounds SRC_{eco} for soil is derived without applying equilibrium partitioning, so directly based on terrestrial data. For all metals except for nickel statistical extrapolation could be applied. For all organic compounds except pentachlorophenol preliminary assessment was used.

When based on aquatic toxicity, for 24 organic compounds statistical extrapolation could be used and for 61 organics preliminary assessment was applied. For 20 compounds, only acute toxicity data were available.

For ecosystems the protection goal is set at the HC50. The HC50 can be considered a robust figure. Especially if equilibrium partitioning is not used, it is not sensitive to the variation in the data set. The HC50 can be based on a limited number of data, or upon a statistical extrapolation if there are more than 4 data on species or processes available. The implication is that the more sensitive species or processes are not protected at the level of SRC_{eco}.

8.7 Partition coefficients for metals

8.7.1 Kp for soil/water

The Kp values for metals for soil (section 3.2.7) are based on linear regression on data sets with field data for soils in the Netherlands and on geometric means of these data sets for metals with less data available. Variability in Kp can be several orders of magnitude for the soils in the Netherlands (Janssen et al., 1997a; Otte et al. 2000b). Therefore, it is recommended to measure site-specific soil/water partitioning for actual site-specific risk assessment. The main purpose of the Kp is the derivation of SRCs in groundwater; the Kp does not describe human exposure to soil in CSOIL and the SRC_{eco} can for all metals (except zinc) be based directly upon terrestrial data. It can be questioned if the Kp measured in surface soil and attached (pore)water is a good predictor of the concentration ratio between surface soil and (deep) groundwater. A (literature) study for better quantification of the relationship between surface soil and related groundwater is recommended.

8.7.2 Kp for sediment/water

For sediments the Kp is a more critical parameter than for soil, as the SRC_{eco} for aquatic sediments is derived by applying the equilibrium partitioning theory. The sediment/water Kps used (3.2.8) are based on suspended matter/surface water partitioning in the field (Stortelder et al., 1989), and generally are comparable to recent sediment/water data reported by Vink (1999) for aerobic and anaerobic sediment from river foreland. The Stortelder data are in general comparable to data from anaerobic sediment (Vink, 1999), except of Pb and Cr where Stortelder data are higher, and Ni where Stortelder data are lower. In this report we choose the Stortelder data to work with, used before to derive Dutch environmental risk limits (Crommentuijn et al., 2000).

In Dutch policy related to risks of soil contamination, “sediment” can also apply to soil in river foreland, besides to aquatic sediment. Aquatic sediment is mostly anoxic and has high concentrations of acid volatile sulfides (AVS), where “dry” sediment is oxidated. Because of the high concentration of sulfides in the aquatic sediment, which can bind metals reversibly, sediment/water partitioning will be higher (Ankley et al., 1996; Van den Hoop et al., 2000). We used in the calculations of SRC_{eco} for sediment partition coefficients derived in aquatic situations. The SRC_{eco} for soil applies also to “dry” sediments.
The general application of a higher K_p for sediments is discussed, because in the direct neighbourhood of organisms, the state of anoxia can be lowered as a result of bioturbation (Peterson et al., 1996). The magnitude at which it occurs and how it affects the fate of metals depends on the type of species studied (Rasmussen et al., 2000). Therefore sediment/water K_ps which are derived in anoxic sediment might be considered less applicable. On the other hand, bioturbation also can create nonoxic and AVS rich sediment patches at the oxic surface layer of sediments as observed by Williamson et al. (1999). More attention should be given to this issue in the near future.

8.8 Sum values

Sum values are presented for groups of compounds, when found scientifically defensible. This means that compounds having one value should have the same toxicological mechanism and, for humans, the exposure routes are comparable. The sum values are defined as a geometric mean of the SRCs of the individual compounds. When measured, the sum of the concentrations of the individual compounds on one site should not exceed the sum SRC.
For the SRC_{eco} sum values are proposed if the toxicological mechanism of the individual compounds is comparable as well as the results of the toxicity tests (taking into account uncertainty). An additional assumption for soil is that the biota-to-soil/sediment accumulation factor (BSAF; concentration ratio of organism and soil/sediment) of the individual compounds is comparable. For groundwater only sum values are derived for SRC_{eco} if the hydrophobicity of the individual compounds is comparable.
For SRC_{human} deriving sum values is often found appropriate for isomers of the same compound, as the toxicity and the physicochemical properties of the compounds that determine the importance of the various exposure routes are more or less comparable for isomers. For dioxins (as TEQ) a sum-value is proposed because the derived SRC_{human} for the different compounds is almost the same.
When the toxicological mechanism is the same, but the SRCs are different, the “toxic unit approach” (“fraction approach”) can be applied (section 2.6). This is recommended for the integrated SRC for soil and sediment for PCBs and TPH (“minerale olie”) and the SRC_{human} for PAHs.
No sum values are given for integrated SRCs, when the individual SRCs are based on both ecotoxicological and human-toxicoogical risks. In addition to the proposed sum values in the chapters 5 to 7, sum values can be determined because of practical and policy reasons, but this is not within the scope of this report. In practice at a location mostly individual compounds are measured, so for each compound the exceedance of the SRC or Intervention Value can be determined separately.
When no sum value is derived or toxic unit approach is recommended (because there are indications for different modes of actions), it should be considered that, in case *part* of the compounds have the same mode of action, effects can be present below the individual risk limit of each compound. Using a sum value or TU approach for the whole group of compounds could solve this problem, but would be too protective (conservative).

Nevertheless, it may be desirable to take into account mixture toxicity for certain groups. The topic of mixture toxicity will be addressed in a separate project within the framework of "Setting Integrated Environmental Quality Standards".

8.9 Bio-availability and soil type correction for metals (for pH, OM and clay)

It is often supposed that organic matter content and clay content influence bioavailability and toxicity of metals to organisms. Several studies confirm that these soil properties influence the concentration of metals in the pore water, and also the accumulation in soft-bodied organisms. Other studies indicate that accumulation in semi- or hard-bodied organisms is not related to soil properties in the same way. Differences between organisms can be large, because the bioavailability depends on the exposure pathways of organisms (direct contact with soil and pore-water or indirect exposure via food and soil particles). In addition the uptake of metals is sometimes regulated, and time-dependent. For literature on this subject it is referred to Janssen et al. (1997ab) and Peijnenburg et al. (1999ab). A lower pH also can lead to higher bioavailability of metals to organisms. A discussion was started whether the soil type correction formula, as presently used, still can be applied. Because this discussion is not completed (due to the lack of consensus), changes in soil correction formula are not proposed in the present report.

For human exposure it is recommended to differentiate, based on the fraction exposure via the mobile and immobile (soil) phase (section 5.7). It is recommended to modify the soil type correction for both human and ecotoxicological risk limits, together with the used "standard soil". Until experts and policy have decided on this subject, the current method should be used.

8.10 Reliability and uncertainty of risk limits

Many steps are involved in the procedure for derivation of risk limits for Intervention Values. In each step choices have been made on procedures, models and input parameters, where each of these aspects contribute to uncertainty. As a consequence the proposed risk limits for soil, groundwater and sediment are characterised by a rather large uncertainty (Vissenberg and Swartjes, 1996). Uncertainty in the derived risk limit is the result of:

- gaps in knowledge, which can be categorised in procedures, model concepts and input-parameters;
- focussing on potential risk assessment for humans and ecosystems compared to site-specific risk assessment;
- policy decisions on starting points for deriving risk limits.

To account for the first kind of uncertainty every individual SRC_{eco} and SRC_{human} was scored according to its reliability, high, medium or low. These scores are given in Tables 7.1. and 7.2 and Appendix 4 (see also section 5.5 and 6.2.6). Rarely, for a compound one SRC was classified as highly reliable and the other as having a low reliability (only PAHs and cobalt for soil). In only one case, these scores influenced the choice for the integrated SRC. This was for example the case for the SRC_{soil} for cobalt. For PAHs in soil the absolute differences between SRC_{eco} and SRC_{human} are very high (orders of magnitude); the low but highly uncertain value was preferred over the high and certain value. For sediment, reliability for SRC_{human} was not scored.

The second source of uncertainty is not part of this study, but originates from e.g. different soil use, human behaviour or the composition of ecosystems. The choice of starting points and the impact on the derived risk limits is already discussed in section 8.2.

8.11 Recommendations

8.11.1 Human-toxicological risk assessment

Uptake by plants. It is recommended to further investigate uptake by root crops by a combination of experiments, model adjustments and parameterisation to improve human exposure modelling. It is also recommended to investigate the validity of the Trapp & Matthies model for aboveground plant parts compared to more experimental data and different plant species (section 5.2.4).
Volatilisation to indoor air. It is recommended to investigate the behaviour of volatile compounds under field circumstances to be able to evaluate the revised model concept in CSOIL and to get more insight in the parameters and processes that determine the transport to the soil surface.
Mercury. Although exposure through volatile mercury species might take place, this has not been taken into account. It is recommended to investigate implementation of the exposure to volatile mercury in the human risk assessment. Nevertheless attention should be given to this exposure route in the site specific risk assessment of mercury (measurements).
Acute toxicity. It is recommended to further investigate the acute toxicity of contaminants in soil via soil ingestion. It should be prevented that occasionally high intake of contaminant could lead to acute toxic effects (section 5.2.2).
Uncertainty analysis. It is recommended to carry out an uncertainty analysis with the revised CSOIL model and the revised data set. For this purpose distributions for all relevant parameters have to be determined (section 8.2.2).
Derivation of MPR. It is recommended to stimulate and follow the developments in differentiating uncertainty factors (UF), used for extrapolating from NOAELs to human-toxicological MPR-levels (section 4.2.6 and 5.5).
Uncertainties in derived risk limits. It is recommended to stimulate the use of measurements of concentrations in air and plants for substances with SRCs based on human-toxicological risks with a reliability scored as low.
Human exposure to aquatic sediments (with SEDISOIL). It is recommended to improve the quantification of the accumulation of metals in fish from surface water and to compare calculated with measured concentration for all compounds. Secondly the research on partition coefficients of metals and slow desorption of organic compounds should be followed and implemented when possible. Also validation and uncertainty analysis needs further attention (Otte et al., 2001)

8.11.2 Ecotoxicological risk assessment

Compounds with a narcotic mode of action. In chapter 6 it is stated that a general value for all compounds acting by narcosis is in a preliminary stadium, but can be favourable in the future. Therefore this approach should be worked out in more detail in further studies to investigate whether or not it is sufficient to use one value for the SRC_{eco} of narcotic chemicals and maybe even more accurate, because the uncertainty in individual SRC_{eco} values is eliminated.
Metals in aquatic sediment. Because the derived risk limits for sediment for metals (based on the EqP method from aquatic data) are relatively high, it is recommended to carry out more ecotoxicological research on organisms living in or near sediments in order to evaluate or even replace the results of the EqP method for metals.

Assessment factors. Future developments concern the development of assessment factors (between acute and chronic toxicity, or for the so-called initial assessment-extrapolation from few data towards a SRC_{eco}) which are based upon knowledge from toxicity databases and the mode-of action.

8.11.3 Integration of risk limits

Total Petroleum hydrocarbon (TPH or "mineral oil")
Before the proposed method is implemented it is recommended to give attention to the practical implication of this method on the assessment of specific sites and the general applicability of the analytical protocols. Besides, more attention should be given to the ecotoxicological risk assessment of TPH.
Cyanides. Because no risk limits could be derived for soil and sediment (the partitioning of cyanides in soil cannot be estimated sufficiently), it is recommended to further investigate the release of HCN to soil or ambient air and the accumulation of cyanides in plants.
Equilibrium partitioning between soil and groundwater. It is recommended to investigate the quantitative relationship between surface soil and the underlying groundwater at contaminated sites and to investigate what Kp could be used best for the describing the behaviour of metals in groundwater (the saturated zone).

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List of abbreviations

ATSDR	US Agency for Toxic Substances and Disease Registry
BCF	Bioconcentration factor: the ratio of the substance concentration in (part of) an organism (e.g. plant, fish) to the concentration in a medium (e.g. soil, water) at steady state
BEVER	The Dutch government has been working to create a new policy on contaminated land, the "BEVER" project. New elements of this policy include the harnessing of market forces for soil clean-up purposes and the decentralisation of some central government functions
CalTOX	California Environmental Protection Agency, Department of Toxic Substances Control (US-EPA)
CLEA	Contaminated Land Exposure Assessment model from (UK)
CR_{inhal}	$1{:}10^{-4}$ lifetime excess cancer risk for inhalation
CR_{oral}	$1{:}10^{-4}$ lifetime excess cancer risk for oral intake
CSOIL	Exposure model used to derive human-toxicological risk limits for soil and groundwater
CTB	capillary transition boundary
EC	Equivalent Carbon
ECOTOX SCC	Ecotoxicological Serious Contamination Concentration
EqP	Equilibrium Partitioning
EU	European Union
EUSES	European Union System for the Evaluation of Substances
Fag	Relative oral absorption factor for soil intake
HC50	Hazardous Concentration for which for half of the species and processes are not protected
human MPR	Maximum Permissible Risk level for humans. For substances without a threshold below which there are no effects (e.g. carcinogens), the MPR is defined as the concentration at which there is annually 1 death per million (risk 10^{-6}/year or 10-4 at life long exposure). For substances with a threshold level the MPR for humans is set to the exposure level without any effect (NOAEL).
HUMTOX SCC	Human-toxicological Serious Contamination Concentration (currently SRC_{human})
IARC	International Agency for Research on Cancer
integrated SRC	Integrated Serious Risk Concentration: The lowest value of both SRC_{eco} and SRC_{human}.
IV	Intervention Value: generic soil quality standard based on potential human and ecotoxicological risks.
K_{oa}	Octanol-air partition coefficient
K_{oc}	Organic carbon-water partition coefficient
K_{ow}	Octanol-water partition coefficient
K_p	Solid-water partition coefficient (for soil or sediment)
L(E)C50	Lethal (Effect) Concentration at which the concentration of a compound causes 50% response
LDPE	Low Density PolyEthylene
LMG	National Groundwater Monitoring Network
M	Molecular weight
MPC	Maximal Permissible Concentration
MPR	Maximum Permissible Risk level (for humans); see human MPR
NC	Negligible Concentration
NOAEL	No Observed Adverse Effect Level
NOEC	No Observed Effect Concentration
OC	Organic Carbon
OM	Organic Matter
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorobiphenyls

PCDD	Polychlorinated dibenzo-p-dioxin
PCDF	Polychlorinated dibenzofurans
Pe	Permeation coefficient, a measure of the affinity for transport of a compound through a membrane
pKa	Acid Dissociation Constant
QSAR	Quantitative Structure Activity Relationship
RA	Risk Assessment
RIVM	National Institute of Public Health and the Environment
RIVO	Netherlands Institute for Fisheries Research
RIZA	National Institute for Inland Water Management and Waste Water Treatment
RS	Reliability Scores
S	Solubility
SEDISOIL	Exposure model used to derive human-toxicological risk limits for sediments
SRC_{eco}	Ecotoxicological Serious Risk Concentration (formerly called ECOTOX SCC)
SRC_{human}	Human-toxicological Serious Risk Concentration (formerly called HUMTOX SCC)
TCA	Tolerable Concentration in Air
TCB	Technical Soil Protection Committee
TDI	Tolerable Daily Intake
TEF	Toxic Equivalency Factor (compared to 2,3,7,8 TCDD)
TEQ	Toxic Equivalent
TPH	Total Petroleum Hydrocarbon
UF	Uncertainty factors, formerly called safety factors, used to derive the MPR from the NOAEL
UI	Procedure on remediation urgency and Intervention Values (Working group UI)
UMS	Umweltmedizinische Beurteilung der Exposition des Menschen durch altlastbedingte Schadstoffe (Germany)
US-EPA	US Environmental Protection Agency
VOLASOIL	Model calculating indoor air concentrations for the Dutch situation in buildings situated on soils contaminated with volatile compounds
Vp	Vapour Pressure
VROM	Ministry of Housing Spatial Planning and the Environment
WHO	World Health Organisation

Appendix 1 Mailing list

1- 6	DGM/BWL-directeur, Drs. J.A. Suurland
7	Plv. Directeur-Generaal Milieubeheer, VROM, Dr.ir. B.C.J. Zoeteman
8	Directoraat-Generaal Milieubeheer, Directie Bodem, Water en Landelijk gebied, Afdeling Landelijk gebied en Bodembeheer: Dr. J.M. Roels
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61-70	Leden Werkgroep UI, via mw. dr.T. Crommentuijn (DGM/BWL)
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72	IPO/ABO, via dhr. F. Kok (Prov. Zuid-Holland, Den Haag)
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166-200 Reserve-exemplaren

Appendix 2 Data set of physicochemical parameters and human-toxicological risk limits

	M [g.mol-1]	Kp metal [dm3/kg]	BCF-metal [kg/kg]	TCA/CRinhal [mg/m3]	TDI/CRoral [mg/kg.d]
Metals and trace elements					
arsenic	74,9	1800	0,009	1,00E-03	1,00E-03
barium	137,3	2500	0,017	-	2,00E-02
cadmium	112,4	2560	0,310	-	5,00E-04
chromium (III)	52,0	4800	0,011	6,00E-02	5,00E-03
chromium (VI)	52,0	4800	0,011	2,50E-06	5,00E-03
cobalt	58,9	120	0,580	5,00E-04	1,40E-03
copper	63,5	2120	0,200	1,00E-03	1,40E-01
mercury (inorganic)	200,6	7500	0,150	2,00E-04	2,00E-03
lead	207,2	36000	0,017	-	3,60E-03
molybdenum	95,9	40	0,120	1,20E-02	1,00E-02
nickel	58,7	2000	0,028	5,00E-05	5,00E-02
zinc	65,4	2600	0,180	-	5,00E-01

	M [g.mol-1]	S [mg/dm3]	Vp [Pa]	log Kow [-]	log Koc [dm3/kg]	Dpe [m2/d]	pKa [-]	TCA/CRinhal [mg/m3]	TDI/CRoral [mg/kg.d]
Aromatic compounds									
Benzene	7,81E+01	1,99E+03	9,51E+03	2,13	1,87	1,40E-06	-	2,00E-02	3,30E-03
Ethylbenzene	1,06E+02	1,59E+02	9,53E+02	3,15	2,53	2,10E-06	-	7,70E-01	1,00E-01
Phenol	9,41E+01	6,56E+04	3,29E+01	1,47	1,52	8,40E-09	10,00	2,00E-02	4,00E-02
o-Cresol	1,08E+02	1,49E+04	2,35E+01	1,95	1,59	1,00E-06	10,20	1,70E-01	5,00E-02
m-Cresol	1,08E+02	6,32E+03	1,14E+01	1,96	1,72	1,00E-06	10,00	1,70E-01	5,00E-02
p-Cresol	1,08E+02	2,86E+04	1,88E+01	1,94	1,64	1,00E-06	10,10	1,70E-01	5,00E-02
Toluene	9,21E+01	6,11E+02	2,96E+03	2,73	2,09	1,20E-06	-	4,00E-01	2,23E-01
o-Xylene	1,06E+02	2,19E+02	6,76E+02	3,12	2,18	1,60E-06	-	8,70E-01	1,50E-01
p-Xylene	1,06E+02	2,11E+02	8,60E+02	3,15	2,66	1,60E-06	-	8,70E-01	1,50E-01
m-Xylene	1,06E+02	1,97E+02	8,05E+02	3,20	2,41	1,60E-06	-	8,70E-01	1,50E-01
Catechol	1,10E+02	1,24E+05	3,39E+00	0,88	1,85	1,00E-07	10,60	-	4,00E-02
Resorcinol	1,10E+02	2,42E+05	8,03E-01	0,80	1,14	1,00E-07	9,70	-	2,00E-02
Hydroquinone	1,10E+02	3,92E+04	3,86E-02	0,59	1,95	1,00E-07	10,60	-	2,50E-02
Styrene	1,04E+02	3,20E+02	5,25E+02	2,95	2,58	2,00E-06	-	9,00E-01	1,20E-01
Polyciclic aromatic hydrocarbons									
Naphthalene	1,28E+02	3,18E+01	6,83E+00	3,30	2,98	5,00E-07	-	-	4,00E-02
Anthracene	1,78E+02	7,13E-02	9,31E-04	4,45	4,30	5,00E-07	-	-	4,00E-02
Phenanthrene	1,78E+02	8,50E-01	1,51E-02	4,47	4,23	5,00E-07	-	-	4,00E-02
Fluoranthene	2,02E+02	2,01E-01	3,80E-03	5,16	5,18	2,00E-07	-	-	5,00E-02
Benzo(a)anthracene	2,28E+02	1,16E-02	2,07E-07	5,54	5,79	2,00E-07	-	-	5,00E-03
Chrysene	2,28E+02	1,79E-03	8,74E-08	5,81	5,72	2,00E-07	-	-	5,00E-02
Benzo(a)pyrene	2,52E+02	8,42E-04	1,25E-07	6,13	5,82	2,00E-07	-	-	5,00E-04
Benzo(ghy)perylene	2,76E+02	1,86E-04	5,04E-09	6,22	6,43	2,00E-07	-	-	3,00E-02
Benzo(k)fluoranthene	2,52E+02	4,84E-04	1,24E-08	6,11	6,24	2,00E-07	-	-	5,00E-03
Indeno, 1,2,3-cd pyrene	2,76E+02	2,65E-04	2,65E-09	6,87	6,02	2,00E-07	-	-	5,00E-03
Pyrene	2,02E+02	1,06E-01	9,20E-05	4,99	4,83	2,00E-07	-	-	5,00E-01
acenaphthene	1,54E+02	2,57E+00	4,22E-01	3,92	3,53	5,00E-07	-	-	5,00E-01
Acenaphthylene	1,52E+02	4,01E+00	1,79E-01	3,94	3,47	5,00E-07	-	-	5,00E-02
Benzo(b)fluoranthene	2,52E+02	1,68E-02	1,82E-06	5,78	5,34	5,00E-07	-	-	5,00E-03
Benzo(j)fluoranthene	2,52E+02	8,81E-03	1,82E-06	6,11	5,48	5,00E-07	-	-	5,00E-03
Dibenz(a,h)anthracene	2,78E+02	8,28E-04	2,67E-07	7,11	6,14	5,00E-07	-	-	5,00E-04
9H-Fluorene	1,66E+02	1,32E+00	1,16E-01	4,18	3,77	5,00E-07	-	-	4,00E-02
Chlorinated hydrocarbons									
1,2-dichloroethane	9,90E+01	1,02E+04	7,39E+03	1,47	1,49	3,00E-07	-	4,80E-02	1,40E-02
dichloromethane (methylenechloride	8,49E+01	1,80E+04	4,30E+04	1,25	1,22	5,00E-07	-	3,00E+00	6,00E-02
tetrachloromethane (carbontetrachlo	1,54E+02	9,38E+02	9,49E+03	2,83	1,75	8,00E-07	-	6,00E-02	4,00E-03
tetrachloroethene	1,66E+02	1,19E+02	1,57E+03	3,40	2,42	8,00E-07	-	2,50E-01	1,60E-02
trichloromethane(chloroform)	1,19E+02	9,39E+03	2,01E+04	1,97	1,66	1,00E-06	-	1,00E-01	3,00E-02
trichloroethene	1,31E+02	1,16E+03	5,81E+03	2,61	2,06	1,60E-06	-	2,00E-01	5,00E-02
vinylchloride	6,25E+01	4,28E+02	2,98E+05	1,52	1,56	1,00E-06	-	3,60E-03	6,00E-04
Chlorobenzenes									
Monochlorobenzene	1,13E+02	5,07E+02	1,19E+03	2,89	2,34	3,50E-06	-	5,00E-01	2,00E-01
1,2-Dichlorobenzene	1,47E+02	1,40E+02	1,30E+02	3,43	2,60	2,00E-06	-	6,00E-01	4,30E-01
1,3-Dichlorobenzene	1,47E+02	1,13E+02	1,49E+02	3,53	2,69	2,00E-06	-	-	-
1,4-Dichlorobenzene	1,47E+02	6,05E+01	9,06E+01	3,44	2,82	2,00E-06	-	6,70E-01	1,00E-01
1,2,3-Trichlorobenzene	1,81E+02	1,36E+01	2,47E+01	4,14	3,23	1,00E-06	-	5,00E-02	8,00E-03
1,2,4-Trichlorobenzene	1,81E+02	2,88E+01	4,07E+01	4,05	3,28	1,00E-06	-	5,00E-02	8,00E-03
1,3,5-Trichlorobenzene	1,81E+02	4,71E+00	2,80E+02	4,19	3,98	1,00E-06	-	5,00E-02	8,00E-03
1,2,3,4-Tetrachlorobenzene	2,16E+02	3,40E+00	6,78E-01	4,64	3,91	1,00E-06	-	-	5,00E-04
1,2,3,5-Tetrachlorobenzene	2,16E+02	2,61E+00	1,29E+00	4,66	3,57	1,00E-06	-	-	5,00E-04
1,2,4,5-Tetrachlorobenzene	2,16E+02	6,82E-01	4,00E+00	4,60	3,77	1,00E-06	-	-	5,00E-04
Pentachlorobenzene	2,50E+02	3,23E-01	4,52E-01	5,18	3,92	1,00E-06	-	-	5,00E-04
Hexachlorobenzene	2,85E+02	1,17E-02	6,13E-04	5,73	4,06	1,00E-06	-	7,50E-04	1,60E-04
Chlorophenols									
2-Chlorophenol	1,29E+02	8,71E+03	2,25E+02	2,15	1,97	5,00E-09	8,43	-	3,00E-03
3-Chlorophenol	1,29E+02	7,97E+03	1,93E+01	2,50	2,56	5,00E-09	9,06	-	3,00E-03
4-Chlorophenol	1,29E+02	7,67E+03	1,13E+01	2,39	1,93	5,00E-09	9,23	-	3,00E-03
2,3-Dichlorophenol	1,63E+02	9,05E+02	1,27E+01	2,84	2,56	1,00E-07	7,66	-	3,00E-03
2,4-Dichlorophenol	1,63E+02	1,91E+03	4,09E+00	3,06	2,54	1,00E-07	7,81	-	3,00E-03
2,5-Dichlorophenol	1,63E+02	4,21E+02	1,04E+01	3,06	2,83	1,00E-07	7,54	-	3,00E-03
2,6-Dichlorophenol	1,63E+02	5,34E+02	7,14E+00	2,75	2,63	1,00E-07	6,84	-	3,00E-03
3,4-Dichlorophenol	1,63E+02	3,02E+01	4,40E-01	3,33	2,90	1,00E-07	8,60	-	3,00E-03
3,5-Dichlorophenol	1,63E+02	3,99E+01	2,46E+00	3,52	2,34	1,00E-07	8,17	-	3,00E-03
2,3,4-Trichlorophenol	1,97E+02	7,11E+01	7,93E-01	3,46	3,08	5,00E-07	7,01	-	3,00E-03
2,3,5-Trichlorophenol	1,97E+02	1,26E+02	2,02E-01	3,58	3,16	5,00E-07	-	-	3,00E-03

	M [g.mol-1]	S [mg/dm3]	Vp [Pa]	log Kow [-]	log Koc [dm3/kg]	Dpe [m2/d]	pKa [-]	TCA/CRinhal [mg/m3]	TDI/CRoral [mg/kg.d]
2,3,6-Trichlorophenol	1,97E+02	1,26E+02	2,02E-01	3,77	3,28	5,00E-07	5,95	-	3,00E-03
2,4,5-Trichlorophenol	1,97E+02	3,80E+02	1,00E+00	3,72	3,36	5,00E-07	7,07	-	3,00E-03
2,4,6-Trichlorophenol	1,97E+02	2,43E+02	9,83E-01	3,69	3,47	5,00E-07	6,22	-	3,00E-03
3,4,5-Trichlorophenol	1,97E+02	3,46E+01	2,02E-01	4,01	3,54	5,00E-07	7,46	-	3,00E-03
2,3,4,5-Tetrachlorophenol	2,32E+02	3,61E+00	3,94E-02	4,21	3,87	1,00E-06	6,07	-	3,00E-03
2,3,4,6-Tetrachlorophenol	2,32E+02	1,47E+01	6,03E-02	4,12	3,10	1,00E-06	5,29	-	3,00E-03
2,3,5,6-Tetrachlorophenol	2,32E+02	4,79E+00	3,94E-02	3,88	3,34	1,00E-06	5,21	-	3,00E-03
Pentachlorophenol	2,66E+02	4,28E+00	8,53E-03	5,12	3,20	2,24E-06	4,85	-	3,00E-03
Chloronaphthalenes									
1-chloronaphatalene	1,63E+02	1,68E+01	4,25E+00	4,10	3,42	5,00E-07	-	1,00E-03	8,00E-02
2-chloronaphatalene	1,63E+02	9,71E+00	1,00E+00	4,14	3,42	5,00E-07	-	1,00E-03	8,00E-02
Polychlorobiphenyls									
PCB 28	2,58E+02	1,21E-01	1,60E-02	5,62	4,61	2,00E-07	-	5,00E-04	1,00E-05
PCB 52	2,92E+02	2,65E-02	6,07E-03	6,26	4,70	2,00E-07	-	5,00E-04	1,00E-05
PCB101	3,26E+02	1,32E-02	9,27E-03	6,85	5,53	2,00E-07	-	5,00E-04	1,00E-05
PCB118	3,26E+02	6,54E-03	2,96E-04	7,12	6,35	2,00E-07	-	5,00E-04	1,00E-05
PCB138	3,61E+02	6,96E-04	4,30E-06	7,45	5,71	5,00E-07	-	5,00E-04	1,00E-05
PCB153	3,61E+02	2,74E-03	1,75E-04	7,44	5,87	5,00E-07	-	5,00E-04	1,00E-05
PCB180	3,95E+02	7,69E-04	4,96E-05	8,16	5,99	5,00E-07	-	5,00E-04	1,00E-05
PCB 18	1,97E+02	3,46E+01	2,02E-01	4,01	3,54	5,00E-07	7,46	-	3,00E-03
Dioxins (+PCDF and PCB)									
2,3,7,8-TCDD	3,22E+02	3,00E-04	1,40E-06	6,80	5,61	1,00E-07	-	-	4,00E-09
PCDD	3,56E+02	1,20E-04	8,88E-08	7,40	6,09	1,00E-07	-	-	4,00E-09
HxCDD	3,91E+02	4,40E-06	5,08E-08	7,80	6,42	1,00E-07	-	-	4,00E-09
HpCDD	4,25E+02	2,40E-06	7,51E-10	8,00	6,58	1,00E-07	-	-	4,00E-09
OCDD	4,60E+02	4,00E-07	5,93E-10	8,20	6,74	1,00E-07	-	-	4,00E-09
PCB 77	2,92E+02	1,91E-03	5,09E-05	6,63	5,85	2,00E-07	-	-	4,00E-09
PCB 105	3,26E+02	7,15E-03	1,55E-04	6,98	6,13	2,00E-07	-	-	4,00E-09
PCB 118	3,26E+02	6,54E-03	2,96E-04	7,12	6,35	2,00E-07	-	-	4,00E-09
PCB 126	3,26E+02	7,00E-03	1,55E-04	7,23	5,94	2,00E-07	-	-	4,00E-09
PCB 156	3,61E+02	1,22E-03	4,05E-05	7,70	6,34	5,00E-07	-	-	4,00E-09
PCB 157	3,61E+02	1,22E-03	4,05E-05	7,60	6,26	5,00E-07	-	-	4,00E-09
PCB 169	3,61E+02	5,58E-04	1,26E-06	7,41	6,01	5,00E-07	-	-	4,00E-09
TetraCDF	3,06E+02	4,13E-04	7,89E-06	6,53	5,39	1,00E-07	-	-	4,00E-09
PentaCDF	3,40E+02	2,36E-04	2,17E-05	6,85	5,65	1,00E-07	-	-	4,00E-09
HexaCDF	3,75E+02	8,25E-06	8,09E-06	7,81	6,42	1,00E-07	-	-	4,00E-09
HeptaCDF	4,09E+02	1,35E-06	1,55E-06	7,92	6,52	1,00E-07	-	-	4,00E-09
OctaCDF	4,44E+02	2,15E-07	2,91E-08	8,28	6,80	1,00E-07	-	-	4,00E-09
Pesticides									
DDT	3,55E+02	6,48E-03	1,22E-05	6,91	5,58	5,00E-07	-	-	5,00E-04
DDE	3,18E+02	4,09E-02	4,29E-05	6,96	5,35	5,00E-07	-	-	5,00E-04
DDD	3,20E+02	6,23E-02	1,93E-05	6,22	5,18	5,00E-07	-	-	5,00E-04
Aldrin	3,65E+02	2,46E-02	2,33E-03	6,50	3,94	5,00E-07	-	3,50E-04	1,00E-04
Dieldrin	3,81E+02	2,99E-01	2,94E-05	4,55	3,99	5,00E-07	-	3,50E-04	1,00E-04
Endrin	3,81E+02	4,66E-01	1,25E-05	4,55	3,95	5,00E-07	-	7,00E-04	2,00E-04
a-HCH	2,91E+02	1,63E+00	3,50E-02	3,72	3,33	5,00E-07	-	2,50E-04	1,00E-03
b-HCH	2,91E+02	9,38E-01	1,98E-02	3,72	3,37	5,00E-07	-	-	2,00E-05
g-HCH	2,91E+02	5,81E+00	1,23E-03	3,72	2,99	5,00E-07	-	1,40E-04	4,00E-05
d-HCH	2,91E+02	1,01E+01	3,06E-02	3,72	3,14	5,00E-07	-	-	-
Carbaryl	2,01E+02	8,16E+01	1,43E-01	2,36	2,27	2,00E-07	-	1,00E-02	3,00E-03
Carbofuran	2,21E+02	3,76E+02	2,03E-03	1,63	1,64	2,00E-07	-	-	2,00E-03
Maneb	2,65E+02	8,50E-05	2,08E-06	8,00	8,00	2,00E-07	-	1,80E-02	5,00E-02
Atrazine	2,16E+02	3,81E+01	2,70E-05	2,61	2,20	2,00E-07	-	-	5,00E-03
Mineral oil									
aliphatic >EC5-EC6	8,10E+01	2,80E+01	5,07E+04	3,52	2,90	4,00E-06	-	1,84E+01	2,00E+00
aliphatic >EC6-EC8	1,00E+02	4,20E+00	8,61E+03	3,60	3,60	4,00E-06	-	1,84E+01	2,00E+00
aliphatic >EC8-EC10	1,30E+02	3,25E-01	8,21E+02	3,69	4,50	4,00E-06	-	1,00E+00	1,00E-01
aliphatic >EC10-EC12	1,60E+02	2,61E-02	7,90E+01	3,76	5,40	4,00E-06	-	1,00E+00	1,00E-01
aliphatic >EC12-EC16	2,00E+02	5,90E-04	3,55E+00	3,85	6,70	4,00E-06	-	1,00E+00	1,00E-01
aliphatic >EC16-EC21	2,70E+02	9,99E-07	1,72E-01	3,97	9,00	4,00E-06	-	-	2,00E+00
aromatic >EC5-EC7	7,80E+01	2,20E+02	1,11E+04	3,53	3,00	1,40E-06	-	4,00E-01	2,00E-01
aromatic >EC7-EC8	9,20E+01	1,30E+02	3,24E+03	3,54	3,10	1,40E-06	-	4,00E-01	2,00E-01
aromatic >EC8-EC10	1,20E+02	6,50E+01	8,21E+02	3,55	3,20	1,40E-06	-	2,00E-01	4,00E-02
aromatic >EC10-EC12	1,30E+02	2,48E+01	7,90E+01	3,58	3,40	1,40E-06	-	2,00E-01	4,00E-02
aromatic >EC12-EC16	1,50E+02	5,81E+00	3,55E+00	3,61	3,70	1,40E-06	-	2,00E-01	4,00E-02
aromatic >EC16-EC21	1,90E+02	5,43E-01	1,72E-01	3,66	4,20	1,40E-06	-	-	3,00E-02
aromatic >EC21-EC35	2,40E+02	6,60E-03	8,00E-04	3,74	5,10	1,40E-06	-	-	3,00E-02
Other pollutants									
Phthalates									
Butylbenzylphthalate	3,12E+02	4,22E+00	6,53E-04	4,91	3,91	2,00E-06	-	-	5,00E-01
Di(2-ethylhexyl)phthalate	3,91E+02	4,57E-02	2,72E-04	7,45	5,37	2,00E-06	-	-	4,00E-03
dihexyl phthalate (DHP)	3,35E+02	1,15E-02	1,61E-03	6,85	4,65	2,00E-06	-	-	4,00E-03
dimethyl phthalate (DMP)	1,94E+02	2,01E+03	3,87E+00	1,56	2,25	2,00E-06	-	-	4,00E-03
dibuthyl phthalate (DBP)	2,78E+02	2,35E+00	3,40E-02	4,72	2,98	2,00E-06	-	-	5,20E-02
diethyl phthalate (DEP)	2,22E+02	2,87E+02	6,68E-01	2,47	2,64	2,00E-06	-	-	2,00E-01
diisobutylphthalate (DIBP)	2,78E+02	9,60E+00	1,37E-02	4,46	3,24	2,00E-06	-	-	4,00E-03
Others									
Cyclohexanone	9,81E+01	1,90E+04	4,90E+02	0,81	0,99	1,00E-07	-	1,36E-01	4,60E+00
Pyridine	7,91E+01	6,65E+05	2,02E+03	0,65	1,93	2,00E-06	-	1,20E-01	1,00E-03
Tetrahydrofuran	7,21E+01	4,06E+05	1,47E+04	0,47	0,47	2,00E-06	-	3,50E-02	1,00E-02
Tetrahydrothiophene	8,82E+01	1,29E+04	2,05E+03	1,61	1,40	2,00E-06	-	6,50E-01	1,80E-01

Appendix 3A Relevance of human exposure routes in CSOIL

CONTRIBUTION (PERCENTAGE) OF THE DIFFERENT EXPOSURE ROUTES TO THE TOTAL HUMAN EXPOSURE													*Alternative standard soil*		
													pH=5, H=5, L=15		*SRChuman*
CONTAMINANT	SRChuman for soil mg/kg d.m.	ingestion soil	dermal abs. indoor	dermal abs. outdoor	inhalation soil	inhalation indoor air	inhalation outdoor air	ingestion crops	permeation drinkingw	inhalation showering	dermal abs. showering	total exp air	*SRChuman mg/kg d.w.*	*percentage of std soil*	*groundwater percentage*
Metals															
arsenic	576,10	71,4%	0,0%	0,0%	0,6%	0,0%	0,0%	28,0%	0,0%	0,0%	0,0%	0,55%	576,10	100%	100%
barium	9.341,98	57,2%	0,0%	0,0%	0,4%	0,0%	0,0%	42,4%	0,0%	0,0%	0,0%	0,44%	9.341,98	100%	100%
cadmium	28,14	6,9%	0,0%	0,0%	0,1%	0,0%	0,0%	93,1%	0,0%	0,0%	0,0%	0,05%	25,12	89%	317%
chromium (III)	2.756,50	67,3%	0,0%	0,0%	0,5%	0,0%	0,0%	32,2%	0,0%	0,0%	0,0%	0,52%	2.756,50	100%	100%
chromium (VI)	77,82	67,3%	0,0%	0,0%	0,5%	0,0%	0,0%	32,2%	0,0%	0,0%	0,0%	0,52%	77,82	100%	100%
cobalt	43,41	3,8%	0,0%	0,0%	0,0%	0,0%	0,0%	96,2%	0,0%	0,0%	0,0%	0,03%	43,41	100%	100%
copper	8.607,60	10,3%	0,0%	0,0%	0,1%	0,0%	0,0%	89,6%	0,0%	0,0%	0,0%	0,08%	6.034,58	70%	70%
mercury	209,68	13,3%	0,0%	0,0%	0,1%	0,0%	0,0%	86,6%	0,0%	0,0%	0,0%	0,10%	209,68	100%	100%
lead	621,83	69,1%	0,0%	0,0%	0,3%	0,0%	0,0%	30,6%	0,0%	0,0%	0,0%	0,27%	590,00	95%	305%
molybdenum	1.306,85	16,0%	0,0%	0,0%	0,1%	0,0%	0,0%	83,8%	0,0%	0,0%	0,0%	0,12%	1.306,85	100%	100%
nickel	1.473,19	44,9%	0,0%	0,0%	0,3%	0,0%	0,0%	54,8%	0,0%	0,0%	0,0%	0,35%	1.468,57	100%	199%
zinc	46.141,51	11,3%	0,0%	0,0%	0,1%	0,0%	0,0%	88,6%	0,0%	0,0%	0,0%	0,09%	46.141,51	100%	500%
Anorganic compounds															
cyaniden vrij	n.a.												n.a.		
cyaniden complex	n.a.												n.a.		
thiocyanates	n.a.												n.a.		
Aromatic compounds															
Benzene	1,15	0,0%	0,0%	0,0%	0,0%	97,8%	0,0%	0,9%	0,9%	0,2%	0,2%	98,00%	0,61	53%	100%
Ethylbenzene	111,02	0,1%	0,0%	0,0%	0,0%	96,4%	0,0%	1,2%	0,8%	0,2%	1,4%	96,59%	56,38	51%	100%
Phenol	390,95	1,3%	0,0%	0,1%	0,0%	1,4%	0,0%	96,5%	0,6%	0,0%	0,0%	1,43%	219,52	56%	101%
p-Cresol	353,68	0,9%	0,0%	0,1%	0,0%	1,1%	0,0%	55,7%	36,9%	0,0%	5,3%	1,15%	193,70	55%	101%
Toluene	32,31	0,0%	0,0%	0,0%	0,0%	97,5%	0,0%	1,1%	0,6%	0,1%	0,5%	97,70%	16,77	52%	100%
m-Xylene	139,90	0,1%	0,0%	0,0%	0,0%	95,3%	0,0%	1,9%	0,8%	0,2%	1,7%	95,53%	71,29	51%	100%
Catechol	457,01	1,4%	0,0%	0,1%	0,0%	0,1%	0,0%	94,5%	3,8%	0,0%	0,0%	0,10%	243,66	53%	101%
Resorcinol	19,40	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%	98,5%	1,3%	0,0%	0,0%	0,03%	12,01	62%	100%
Hydroquinone	96,34	0,5%	0,0%	0,0%	0,0%	0,0%	0,0%	98,4%	1,0%	0,0%	0,0%	0,03%	50,54	52%	100%
o-Cresol	324,11	0,8%	0,0%	0,1%	0,0%	2,7%	0,0%	53,3%	37,5%	0,1%	5,5%	2,80%	179,03	55%	100%
m-Cresol	422,96	1,0%	0,0%	0,1%	0,0%	3,0%	0,0%	52,9%	37,2%	0,1%	5,6%	3,16%	228,93	54%	101%
o-Xylene	108,70	0,1%	0,0%	0,0%	0,0%	94,5%	0,0%	2,2%	1,1%	0,2%	1,9%	94,77%	56,02	52%	100%
p-Xylene	247,77	0,1%	0,0%	0,0%	0,0%	95,5%	0,0%	1,8%	0,8%	0,2%	1,5%	95,74%	125,34	51%	100%
Polycyclic Aromatic Hydrocarbons (PAHs)															
Anthracene	25.457,67	77,9%	0,5%	6,8%	0,6%	0,0%	0,0%	14,1%	0,0%	0,0%	0,1%	0,63%	25.453,62	100%	100%
Benzo(a)anthracene	3.008,92	73,7%	0,5%	6,4%	0,6%	0,0%	0,0%	18,8%	0,0%	0,0%	0,0%	0,57%	3.008,59	100%	100%
Benzo(k)fluoranthene	3.185,01	78,0%	0,5%	6,8%	0,6%	0,0%	0,0%	14,1%	0,0%	0,0%	0,0%	0,61%	3.184,93	100%	100%
Benzo(a)pyrene	278,62	68,3%	0,4%	5,9%	0,5%	0,0%	0,0%	24,8%	0,0%	0,0%	0,0%	0,53%	278,53	100%	100%
Chrysene	32.034,30	78,5%	0,5%	6,8%	0,6%	0,0%	0,0%	13,6%	0,0%	0,0%	0,0%	0,61%	32.034,23	100%	100%
Phenanthrene	23.108,20	70,8%	0,4%	6,1%	0,5%	0,4%	0,0%	20,3%	0,2%	0,0%	1,2%	0,96%	23.101,99	100%	100%
Fluoranthene	30.310,84	74,2%	0,5%	6,4%	0,6%	0,1%	0,0%	18,1%	0,0%	0,0%	0,1%	0,67%	30.306,03	100%	100%
Indeno, 1,2,3-cd pyrene	3.154,30	77,3%	0,5%	6,7%	0,6%	0,0%	0,0%	14,9%	0,0%	0,0%	0,0%	0,60%	3.156,80	100%	100%
Benzo(ghy)perylene	19.235,55	78,5%	0,5%	6,8%	0,6%	0,0%	0,0%	13,6%	0,0%	0,0%	0,0%	0,61%	19.231,40	100%	100%
Pyrene	#########	78,4%	0,5%	6,8%	0,6%	0,0%	0,0%	13,7%	0,0%	0,0%	0,0%	0,61%	320139	100%	100%
Naphthalene	869,97	2,7%	0,0%	0,2%	0,0%	65,0%	0,0%	23,3%	2,8%	0,4%	5,5%	65,46%	444,45	51%	102%
acenaphthene	#########	77,2%	0,5%	6,7%	0,6%	0,8%	0,0%	14,0%	0,0%	0,0%	0,2%	1,38%	#########	100%	100%
Benzo(b)fluoranthene	2.759,72	67,6%	0,4%	5,9%	0,5%	0,0%	0,0%	25,4%	0,0%	0,0%	0,1%	0,53%	2.760,95	100%	100%
Benzo(j)fluoranthene	2.780,11	68,1%	0,4%	5,9%	0,5%	0,0%	0,0%	24,9%	0,0%	0,0%	0,1%	0,53%	2.781,54	100%	100%
Dibenz(a,h)anthracene	69,96	17,1%	0,1%	1,5%	0,1%	0,0%	0,0%	81,1%	0,0%	0,0%	0,0%	0,13%	69,97	100%	100%
9H-Fluorene	22.528,21	69,0%	0,4%	6,0%	0,5%	2,9%	0,0%	19,5%	0,2%	0,0%	1,5%	3,44%	22.524,49	100%	100%
Acenaphthylene	25.884,76	63,4%	0,4%	5,5%	0,5%	3,3%	0,0%	23,3%	0,6%	0,0%	3,1%	3,80%	25.875,09	100%	100%
Chlorinated hydrocarbons, Volatile Organic Compounds (VOC's)															
1,2-dichloroethane	6,43	0,1%	0,0%	0,0%	0,0%	95,0%	0,0%	3,8%	0,9%	0,2%	0,0%	95,15%	3,62	56%	100%
dichloromethane (methylenechloride)	68,49	0,0%	0,0%	0,0%	0,0%	97,9%	0,0%	1,3%	0,6%	0,1%	0,0%	98,06%	41,66	61%	100%
tetrachloromethane (carbontetrachloride)	0,69	0,0%	0,0%	0,0%	0,0%	99,4%	0,0%	0,4%	0,1%	0,0%	0,1%	99,46%	0,38	55%	100%
tetrachloroethene	8,77	0,0%	0,0%	0,0%	0,0%	99,2%	0,0%	0,5%	0,1%	0,0%	0,1%	99,28%	4,50	51%	100%
trichloromethane(chloroform)	5,57	0,0%	0,0%	0,0%	0,0%	97,5%	0,0%	1,2%	0,9%	0,2%	0,1%	97,72%	3,04	55%	100%
trichloroethene	10,46	0,0%	0,0%	0,0%	0,0%	98,4%	0,0%	0,7%	0,6%	0,1%	0,2%	98,49%	5,46	52%	100%
vinylchloride	0,00	0,0%	0,0%	0,0%	0,0%	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%	99,99%	0,00	81%	100%
1,1-dichloroethane	8,86	0,0%	0,0%	0,0%	0,0%	99,0%	0,0%	0,6%	0,3%	0,1%	0,0%	99,07%	4,98	56%	100%
Chlorinated hydrocarbons, chlorobenzenes, chlorofenols, others															
Monochlorobenzene	113,95	0,1%	0,0%	0,0%	0,0%	91,7%	0,0%	2,1%	2,9%	0,6%	2,7%	92,26%	58,18	51%	100%
1,4-Dichlorobenzene	474,62	0,3%	0,0%	0,0%	0,0%	88,9%	0,0%	4,8%	2,0%	0,3%	3,6%	89,27%	239,82	51%	100%
1,2,4-Trichlorobenzene	82,31	0,8%	0,0%	0,1%	0,0%	85,0%	0,0%	10,4%	0,8%	0,1%	2,9%	85,13%	41,59	51%	101%
1,2,3,4-Tetrachlorobenzene	25,33	6,2%	0,0%	0,5%	0,0%	27,6%	0,0%	56,3%	1,6%	0,2%	7,6%	27,79%	13,19	52%	104%
Pentachlorobenzene	6,71	1,6%	0,0%	0,1%	0,0%	57,9%	0,0%	38,2%	0,4%	0,1%	1,6%	58,00%	3,39	51%	101%
Hexachlorobenzene	2,70	2,1%	0,0%	0,2%	0,0%	2,2%	0,0%	94,1%	0,4%	0,0%	1,0%	2,28%	1,37	51%	101%
2-Chlorophenol	40,18	1,6%	0,0%	0,1%	0,0%	47,5%	0,0%	50,5%	0,2%	0,0%	0,0%	47,49%	21,19	53%	101%
2,4-Dichlorophenol	113,57	4,6%	0,0%	0,4%	0,0%	3,9%	0,0%	86,3%	2,7%	0,0%	2,0%	3,94%	59,21	52%	103%
2,3,4-Trichlorophenol	186,48	7,6%	0,0%	0,7%	0,1%	11,7%	0,0%	66,8%	6,4%	0,1%	6,6%	11,87%	98,32	53%	105%
2,3,4,5-Tetrachlorophenol	343,05	14,0%	0,1%	1,2%	0,1%	4,0%	0,0%	67,4%	3,9%	0,1%	9,3%	4,20%	188,40	55%	110%
Pentachlorophenol	19,69	0,8%	0,0%	0,1%	0,0%	0,2%	0,0%	88,7%	2,3%	0,0%	7,9%	0,24%	9,92	50%	101%
1-chloronaphatalene	18,66	3,6%	0,0%	0,3%	0,0%	47,5%	0,0%	39,3%	1,4%	0,2%	7,6%	47,74%	9,35	50%	100%
PCB 28	0,69	8,0%	0,0%	0,7%	0,1%	5,5%	0,0%	85,3%	0,1%	0,0%	0,3%	5,61%	0,36	53%	106%
PCB 52	0,28	3,3%	0,0%	0,3%	0,0%	3,7%	0,0%	92,5%	0,0%	0,0%	0,1%	3,73%	0,14	51%	102%
PCB101	0,61	7,2%	0,0%	0,6%	0,1%	4,0%	0,0%	88,1%	0,0%	0,0%	0,0%	4,10%	0,32	52%	105%
PCB118	1,90	23,3%	0,1%	2,0%	0,2%	0,1%	0,0%	74,3%	0,0%	0,0%	0,0%	0,31%	1,12	59%	117%
PCB138	0,32	3,9%	0,0%	0,3%	0,0%	0,0%	0,0%	95,7%	0,0%	0,0%	0,0%	0,04%	0,16	51%	103%
PCB153	0,46	5,6%	0,0%	0,5%	0,0%	0,1%	0,0%	93,6%	0,0%	0,0%	0,0%	0,19%	0,24	52%	104%
PCB180	0,17	2,1%	0,0%	0,2%	0,0%	0,0%	0,0%	97,7%	0,0%	0,0%	0,0%	0,06%	0,09	51%	101%
1,2-Dichlorobenzene	476,56	0,3%	0,0%	0,0%	0,0%	83,6%	0,0%	7,2%	3,0%	0,5%	5,4%	84,16%	241,14	51%	100%
1,3-Dichlorobenzene	n.a.												n.a.		
1,2,3-Trichlorobenzene	58,78	0,5%	0,0%	0,0%	0,0%	86,5%	0,0%	9,5%	0,6%	0,1%	2,7%	86,62%	29,63884	50%	101%
1,3,5-Trichlorobenzene	12,91	0,1%	0,0%	0,0%	0,0%	99,4%	0,0%	0,4%	0,0%	0,0%	0,1%	99,38%	6,47	50%	100%
1,2,4,5-Tetrachlorobenzene	2,10	0,5%	0,0%	0,0%	0,0%	92,5%	0,0%	6,0%	0,2%	0,0%	0,8%	92,50%	1,05	50%	100%
1,2,3,5-Tetrachlorobenzene	8,38	2,1%	0,0%	0,2%	0,0%	49,3%	0,0%	41,7%	1,1%	0,2%	5,5%	49,43%	4,25	51%	101%
3-Chlorophenol	199,47	8,1%	0,1%	0,7%	0,1%	5,9%	0,0%	84,8%	0,2%	0,0%	0,1%	5,95%	106,35	53%	105%
4-Chlorophenol	56,68	2,3%	0,0%	0,2%	0,0%	4,2%	0,0%	92,9%	0,3%	0,0%	0,1%	4,18%	30,13	53%	101%
2,3-Dichlorophenol	119,07	4,9%	0,0%	0,4%	0,0%	25,6%	0,0%	65,0%	2,7%	0,1%	1,2%	25,75%	62,13	52%	103%
2,5-Dichlorophenol	155,19	6,3%	0,0%	0,5%	0,0%	31,6%	0,0%	58,1%	1,9%	0,1%	1,4%	31,72%	81,35	52%	104%
2,6-Dichlorophenol	148,04	6,0%	0,0%	0,5%	0,0%	25,8%	0,0%	63,6%	2,9%	0,1%	1,1%	25,92%	77,72	52%	104%

CONTRIBUTION (PERCENTAGE) OF THE DIFFERENT EXPOSURE ROUTES TO THE TOTAL HUMAN EXPOSURE														*Alternative standard soil pH=5, H=5, L=15*		
CONTAMINANT		SRChuman for soil mg/kg d.m.	ingestion soil	dermal abs. indoor	dermal abs. outdoor	inhalation soil	inhalation indoor air	inhalation outdoor air	ingestion crops	permeation drinkingw	inhalation showering	dermal abs. showering	total exp air	*SRChuman mg/kg d.w.*	*percentage of std soil*	*SRChuman groundwater percentage*
3,4-Dichlorophenol		161,02	6,6%	0,0%	0,6%	0,1%	16,5%	0,0%	72,3%	1,7%	0,0%	2,2%	16,62%	84,46	52%	104%
3,5-Dichlorophenol		26,57	1,1%	0,0%	0,1%	0,0%	41,1%	0,0%	54,7%	1,0%	0,1%	1,9%	41,24%	13,64	51%	101%
2,3,5-Trichlorophenol		199,07	8,1%	0,1%	0,7%	0,1%	1,5%	0,0%	76,2%	5,7%	0,0%	7,7%	1,57%	105,51	53%	98%
2,3,6-Trichlorophenol		197,95	8,1%	0,1%	0,7%	0,1%	1,1%	0,0%	77,2%	4,3%	0,0%	8,5%	1,21%	104,56	53%	105%
3,4,5-Trichlorophenol		247,35	10,1%	0,1%	0,9%	0,1%	2,8%	0,0%	74,1%	3,0%	0,0%	9,0%	2,93%	132,32	53%	107%
2,4,6-Trichlorophenol		326,70	13,3%	0,1%	1,2%	0,1%	3,0%	0,0%	70,0%	4,6%	0,0%	7,7%	3,18%	178,73	55%	109%
2,4,5-Trichlorophenol		253,12	10,3%	0,1%	0,9%	0,1%	2,0%	0,0%	73,9%	4,6%	0,0%	8,1%	2,08%	135,70	54%	107%
2,3,4,6-Tetrachlorophenol		79,68	3,3%	0,0%	0,3%	0,0%	2,1%	0,0%	77,9%	5,3%	0,1%	11,1%	2,13%	40,82	51%	102%
2,3,5,6-Tetrachlorophenol		184,24	7,5%	0,0%	0,7%	0,1%	5,5%	0,0%	69,5%	7,0%	0,1%	9,6%	5,67%	96,93	53%	105%
PCB 77	*	0,00063	19,4%	0,1%	1,7%	0,2%	0,2%	0,0%	78,5%	0,0%	0,0%	0,0%	0,33%	0,00036	57%	114%
PCB 169	*	0,00026	8,0%	0,0%	0,7%	0,1%	0,0%	0,0%	91,2%	0,0%	0,0%	0,0%	0,07%	0,00014	53%	105%
2-chloronaphatalene		45,13	4,8%	0,0%	0,4%	0,0%	25,8%	0,0%	55,7%	1,9%	0,2%	11,2%	25,99%	22,63	50%	100%
3,4,5-Trichlorophenol		247,35	10,1%	0,1%	0,9%	0,1%	2,8%	0,0%	74,1%	3,0%	0,0%	9,0%	2,93%	132,32	53%	107%
PCB 105	*	0,00063	19,4%	0,1%	1,7%	0,2%	0,1%	0,0%	78,5%	0,0%	0,0%	0,0%	0,24%	0,00036	57%	114%
PCB 126	*	0,00030	9,3%	0,1%	0,8%	0,1%	0,1%	0,0%	89,7%	0,0%	0,0%	0,0%	0,14%	0,00016	53%	106%
PCB 156	*	0,00032	9,7%	0,1%	0,8%	0,1%	0,0%	0,0%	89,2%	0,0%	0,0%	0,0%	0,12%	0,00017	53%	107%
PCB 157	*	0,00032	9,7%	0,1%	0,8%	0,1%	0,1%	0,0%	89,2%	0,0%	0,0%	0,0%	0,13%	0,00017	53%	107%
Pesticides																
DDT		30,55	7,5%	0,0%	0,6%	0,1%	0,0%	0,0%	91,7%	0,0%	0,0%	0,0%	0,07%	16,04	52%	105%
DDE		17,16	4,2%	0,0%	0,4%	0,0%	0,0%	0,0%	95,3%	0,0%	0,0%	0,0%	0,04%	8,82	51%	103%
Aldrin		0,32	0,4%	0,0%	0,0%	0,0%	1,3%	0,0%	98,2%	0,0%	0,0%	0,0%	1,32%	0,16	50%	100%
Dieldrin		9,12	11,2%	0,1%	1,0%	0,1%	0,0%	0,0%	86,1%	1,2%	0,0%	0,4%	0,12%	4,91	54%	108%
Endrin		16,21	9,9%	0,1%	0,9%	0,1%	0,0%	0,0%	87,5%	1,1%	0,0%	0,4%	0,09%	8,66	53%	107%
a-HCH		19,71	8,7%	0,1%	0,8%	0,1%	21,1%	0,0%	63,4%	4,2%	0,2%	1,6%	21,39%	10,04	51%	102%
b-HCH		1,55	9,5%	0,1%	0,8%	0,1%	20,7%	0,0%	63,0%	4,1%	0,2%	1,6%	20,95%	0,82	53%	106%
g-HCH		1,33	4,1%	0,0%	0,4%	0,0%	0,2%	0,0%	89,3%	4,3%	0,0%	1,7%	0,25%	0,69	52%	103%
d-HCH		n.a.	7,1%	0,0%	0,6%	0,1%	3,8%	0,0%	81,1%	5,2%	0,0%	2,1%	3,86%	n.a.		n.a.
Carbaryl		106,03	4,3%	0,0%	0,4%	0,0%	6,7%	0,0%	78,4%	9,3%	0,0%	0,8%	6,78%	55,71	53%	103%
Carbofuran		5,67	0,3%	0,0%	0,0%	0,0%	0,0%	0,0%	96,6%	3,0%	0,0%	0,0%	0,03%	3,10	55%	100%
Propoxur		1,24	0,2%	0,0%	0,0%	0,0%	0,0%	0,0%	98,4%	1,4%	0,0%	0,0%	0,01%	0,68	55%	100%
Maneb		30.443,19	78,2%	0,5%	6,8%	0,6%	0,0%	0,0%	13,9%	0,0%	0,0%	0,0%	0,61%	30.443,06	100%	100%
Atrazine		18,25	0,4%	0,0%	0,0%	0,0%	0,0%	0,0%	98,2%	1,1%	0,0%	0,1%	0,01%	9,39	51%	100%
DDD		41,54	10,2%	0,1%	0,9%	0,1%	0,0%	0,0%	88,6%	0,1%	0,0%	0,1%	0,08%	22,21	53%	107%
Other contaminants																
Cyclohexanone		214,39	0,3%	0,0%	0,0%	0,0%	46,0%	0,0%	49,2%	4,3%	0,2%	0,1%	46,15%	140,03	65%	100%
Butylbenzylphthalate		#########	72,1%	0,4%	6,3%	0,6%	0,0%	0,0%	20,0%	0,2%	0,0%	0,4%	0,56%	#########	100%	100%
Di(2-ethylhexyl)phthalate		60,18	1,8%	0,0%	0,2%	0,0%	0,0%	0,0%	97,9%	0,0%	0,0%	0,0%	0,03%	30,45	51%	100%
Pyridine		11,06	1,3%	0,0%	0,1%	0,0%	3,1%	0,0%	34,6%	59,9%	0,3%	0,7%	3,36%	5,85	53%	101%
Styrene		471,92	0,2%	0,0%	0,0%	0,0%	90,3%	0,0%	3,4%	2,5%	0,5%	3,1%	90,83%	239,46	51%	100%
Tetrahydrofuran		6,76	0,1%	0,0%	0,0%	0,0%	25,9%	0,0%	25,8%	45,8%	2,0%	0,4%	27,87%	5,39	80%	100%
Tetrahydrothiophene		233,61	0,1%	0,0%	0,0%	0,0%	61,9%	0,0%	12,9%	20,8%	2,5%	1,7%	64,39%	134,09	57%	100%
dihexyl phthalate (DHP)		380,97	11,7%	0,1%	1,0%	0,1%	0,8%	0,0%	86,2%	0,1%	0,0%	0,1%	0,90%	380,77	100%	100%
disodecyl phthalate (DIDP)		2.176,14	66,6%	0,4%	5,8%	0,5%	0,0%	0,0%	26,6%	0,0%	0,0%	0,0%	0,52%	2.176,14	100%	100%
dimethyl phthalate (DMP)		81,89	2,5%	0,0%	0,2%	0,0%	4,3%	0,0%	35,6%	56,3%	0,2%	0,8%	4,58%	42,58	52%	100%
dibuthyl phthalate (DBP)		22.621,75	53,3%	0,3%	4,6%	0,4%	1,1%	0,0%	36,1%	1,3%	0,0%	2,8%	1,54%	22.607,00	100%	100%
diethyl phthalate (DEP)		17.039,04	10,4%	0,1%	0,9%	0,1%	4,4%	0,0%	38,9%	41,7%	0,2%	3,2%	4,74%	17.039,66	100%	100%
aliphatic >EC5-EC6		34,75	0,0%	0,0%	0,0%	0,0%	99,9%	0,0%	0,0%	0,0%	0,0%	0,0%	99,95%	20,63	59%	100%
aliphatic >EC6-EC8		109,18	0,0%	0,0%	0,0%	0,0%	99,9%	0,0%	0,0%	0,0%	0,0%	0,0%	99,96%	57,88	53%	100%
aliphatic >EC8-EC10		28,38	0,0%	0,0%	0,0%	0,0%	99,9%	0,0%	0,0%	0,0%	0,0%	0,0%	99,97%	14,37	51%	100%
aliphatic >EC10-EC12		152,00	0,1%	0,0%	0,0%	0,0%	99,9%	0,0%	0,0%	0,0%	0,0%	0,0%	99,91%	76,27	50%	100%
aliphatic >EC12-EC16		55.418,24	52,7%	0,3%	4,6%	0,4%	32,9%	0,0%	9,1%	0,0%	0,0%	0,0%	33,31%	55.399,74	100%	100%
aliphatic >EC16-EC21		1281535	78,5%	0,5%	6,8%	0,6%	0,1%	0,0%	13,5%	0,0%	0,0%	0,0%	0,75%	1281461	100%	100%
aromatic >EC5-EC7		28,81	0,0%	0,0%	0,0%	0,0%	99,0%	0,0%	0,3%	0,1%	0,0%	0,5%	99,05%	14,54	50%	100%
aromatic >EC7-EC8		62,43	0,1%	0,0%	0,0%	0,0%	98,4%	0,0%	0,6%	0,1%	0,0%	0,7%	98,48%	31,40	50%	100%
aromatic >EC8-EC10		59,10	0,1%	0,0%	0,0%	0,0%	97,9%	0,0%	0,9%	0,2%	0,0%	0,8%	97,98%	29,70	50%	100%
aromatic >EC10-EC12		316,59	0,7%	0,0%	0,1%	0,0%	92,6%	0,0%	3,3%	0,8%	0,1%	2,4%	92,79%	159,58	50%	101%
aromatic >EC12-EC16		5.948,16	14,3%	0,1%	1,2%	0,1%	62,8%	0,0%	12,8%	2,3%	0,4%	6,0%	63,28%	5.946,46	100%	100%
aromatic >EC16-EC21		17.461,84	71,3%	0,4%	6,2%	0,6%	6,5%	0,0%	14,0%	0,4%	0,0%	0,6%	7,11%	17.457,66	100%	100%
aromatic >EC21-EC35		19.233,10	78,5%	0,5%	6,8%	0,6%	0,0%	0,0%	13,5%	0,0%	0,0%	0,0%	0,65%	19.229,22	100%	100%
diisobutylphthalate (DIBP)		82,63	2,5%	0,0%	0,2%	0,0%	0,5%	0,0%	81,0%	5,9%	0,0%	9,8%	0,52%	42,09	51%	100%
Dioxins																
2,3,7,8-TCDD	*	0,00031	9,5%	0,1%	0,8%	0,1%	0,0%	0,0%	89,5%	0,0%	0,0%	0,0%	0,10%	0,00017	53%	106%
1-MCDD	*	0,00027	8,2%	0,1%	0,7%	0,1%	6,5%	0,0%	83,2%	0,2%	0,0%	1,0%	6,59%	0,00014	53%	106%
2-MCDD	*	0,00027	8,3%	0,1%	0,7%	0,1%	7,3%	0,0%	82,7%	0,1%	0,0%	0,8%	7,38%	0,00014	53%	106%
27-DCDD	*	0,00030	9,1%	0,1%	0,8%	0,1%	1,1%	0,0%	88,7%	0,0%	0,0%	0,2%	1,16%	0,00016	53%	106%
28-DCDD	*	0,00030	9,2%	0,1%	0,8%	0,1%	0,4%	0,0%	89,3%	0,0%	0,0%	0,2%	0,45%	0,00016	53%	106%
124-TrCDD	*	0,00031	9,4%	0,1%	0,8%	0,1%	0,2%	0,0%	89,5%	0,0%	0,0%	0,0%	0,24%	0,00016	53%	106%
1368-TeCDD	*	0,00031	9,6%	0,1%	0,8%	0,1%	0,0%	0,0%	89,5%	0,0%	0,0%	0,0%	0,08%	0,00017	53%	106%
PCDD	*	0,00031	9,6%	0,1%	0,8%	0,1%	0,0%	0,0%	89,4%	0,0%	0,0%	0,0%	0,08%	0,00017	53%	107%
HxCDD	*	0,00032	9,7%	0,1%	0,8%	0,1%	0,0%	0,0%	89,3%	0,0%	0,0%	0,0%	0,09%	0,00017	53%	107%
HpCDD	*	0,00032	9,7%	0,1%	0,8%	0,1%	0,0%	0,0%	89,3%	0,0%	0,0%	0,0%	0,08%	0,00017	53%	107%
OCDD	*	0,00032	9,8%	0,1%	0,8%	0,1%	0,0%	0,0%	89,2%	0,0%	0,0%	0,0%	0,08%	0,00017	53%	107%
2,3,7,8-TetraCDF	*	0,00031	9,4%	0,1%	0,8%	0,1%	0,2%	0,0%	89,4%	0,0%	0,0%	0,0%	0,26%	0,00016	53%	106%
1,2,3,7,8-PentaCDF	*	0,00031	9,5%	0,1%	0,8%	0,1%	0,3%	0,0%	89,2%	0,0%	0,0%	0,0%	0,39%	0,00017	53%	106%
2,3,4,7,8,-PentaCDF	*	0,00031	9,5%	0,1%	0,8%	0,1%	0,6%	0,0%	89,0%	0,0%	0,0%	0,0%	0,63%	0,00016	53%	106%
1,2,3,4,7,8-HexaCDF	*	0,00032	9,7%	0,1%	0,8%	0,1%	1,1%	0,0%	88,3%	0,0%	0,0%	0,0%	1,18%	0,00017	53%	107%
1,2,3,6,7,8-HexaCDF	*	0,00032	9,7%	0,1%	0,8%	0,1%	0,8%	0,0%	88,5%	0,0%	0,0%	0,0%	0,85%	0,00017	53%	107%
1,2,3,7,8,9-HexaCDF	*	0,00032	9,6%	0,1%	0,8%	0,1%	0,2%	0,0%	89,2%	0,0%	0,0%	0,0%	0,23%	0,00017	53%	107%
2,3,4,6,7,8-HexaCDF	*	0,00032	9,8%	0,1%	0,8%	0,1%	0,2%	0,0%	89,0%	0,0%	0,0%	0,0%	0,31%	0,00017	53%	107%
1,2,3,4,6,7,8-HeptaCDF	*	0,00032	9,8%	0,1%	0,8%	0,1%	0,2%	0,0%	89,0%	0,0%	0,0%	0,0%	0,31%	0,00017	53%	107%
1,2,3,4,7,8,9-HeptaCDF	*	0,00032	9,8%	0,1%	0,8%	0,1%	0,0%	0,0%	89,2%	0,0%	0,0%	0,0%	0,09%	0,00017	53%	107%
OctaCDF	*	0,00032	9,7%	0,1%	0,8%	0,1%	0,1%	0,0%	89,3%	0,0%	0,0%	0,0%	0,15%	0,00017	53%	107%
TetraCDF	*	0,00031	9,4%	0,1%	0,8%	0,1%	0,2%	0,0%	89,4%	0,0%	0,0%	0,0%	0,26%	0,00016	53%	106%
PentaCDF	*	0,00031	9,5%	0,1%	0,8%	0,1%	0,6%	0,0%	89,0%	0,0%	0,0%	0,0%	0,63%	0,00016	53%	106%
HexaCDF	*	0,00031	9,6%	0,1%	0,8%	0,1%	1,1%	0,0%	88,3%	0,0%	0,0%	0,0%	1,19%	0,00017	53%	107%
HeptaCDF	*	0,00032	9,7%	0,1%	0,8%	0,1%	1,1%	0,0%	88,2%	0,0%	0,0%	0,0%	1,22%	0,00017	53%	107%
OctaCDF	*	0,00032	9,7%	0,1%	0,8%	0,1%	0,1%	0,0%	89,3%	0,0%	0,0%	0,0%	0,15%	0,00017	53%	107%

* = Value expressed as Toxicity equivalent (TEQ) of the most toxic dioxin 2,3,7,8 TCDD

Appendix 3B Concentrations in environmental compartments in CSOIL

CONTAMINANT	C soil mg/kg d.m.	C porewater mg/dm3	C pore air g/m3	groundwater ug/dm3	Cplant root mg/kg fresh	Cplant leaf mg/kg fresh	Cplant mg/kg dm	**RATIO Cpw : S**	C-indoor air 1995 concept	C-kruipr g/m3	C-indoor air g/m3
Metals											
arsenic	5,761E+02	3,20E-01	0,00E+00	3,20E+02			5,18E+00	**1,07E-04**			
barium	9,342E+03	3,74E+00	0,00E+00	3,74E+03			1,59E+02	**1,25E-03**			
cadmium	2,814E+01	1,10E-02	0,00E+00	1,10E+01			8,72E+00	**3,66E-06**			
chromium (III)	2,756E+03	5,74E-01	0,00E+00	5,74E+02			3,03E+01	**1,91E-04**			
chromium (VI)	7,782E+01	1,62E-02	0,00E+00	1,62E+01			8,56E-01	**5,40E-06**			
cobalt	4,341E+01	3,61E-01	0,00E+00	3,61E+02			2,52E+01	**1,20E-04**			
copper	8,608E+03	4,06E+00	0,00E+00	4,06E+03			1,72E+03	**1,35E-03**			
mercury	2,097E+02	2,80E-02	0,00E+00	2,80E+01			3,15E+01	**9,32E-06**			
lead	1,682E+03	4,67E-02	0,00E+00	4,67E+01			2,86E+01	**1,56E-05**			
molybdenum	1,307E+03	3,25E+01	0,00E+00	3,25E+04			1,57E+02	**1,08E-02**			
nickel	1,473E+03	7,37E-01	0,00E+00	7,37E+02			4,12E+01	**2,46E-04**			
zinc	4,614E+04	1,77E+01	0,00E+00	1,77E+04			8,31E+03	**5,92E-03**			
Anorganic compounds											
cyaniden vrij	n.a.	n.a.	n.a.	n.a.							
cyaniden complex	n.a.	n.a.	n.a.	n.a.							
thiocyanates	n.a.	n.a.	n.a.	n.a.							
Aromatic compounds											
Benzene	1,149E+00	2,51E-01	3,98E-02	2,51E+02	2,73E-01	1,14E-03	-	**1,26E-04**	6,63E-06	2,03E-04	2,03E-05
Ethylbenzene	1,110E+02	5,57E+00	1,50E+00	5,57E+03	1,39E+01	1,10E-01	-	**3,49E-02**	2,12E-04	7,50E-03	7,50E-04
Phenol	3,909E+02	1,80E+02	3,61E-03	1,80E+05	1,64E+02	1,93E+01	-	**2,75E-03**	1,47E-04	1,82E-05	1,82E-06
p-Cresol	3,537E+02	1,27E+02	3,83E-03	1,27E+05	1,29E+02	1,40E+01	-	**4,44E-03**	1,04E-04	1,91E-05	1,91E-06
Toluene	3,231E+01	4,36E+00	8,27E-01	4,36E+03	6,96E+00	3,20E-02	-	**7,13E-03**	1,26E-04	4,17E-03	4,17E-04
m-Xylene	1,399E+02	9,21E+00	1,70E+00	9,21E+03	2,44E+01	1,39E-01	-	**4,67E-02**	2,42E-04	8,48E-03	8,48E-04
Catechol	4,570E+02	1,05E+02	1,34E-04	1,05E+05	9,00E+01	9,49E+01	-	**8,46E-04**	8,50E-05	6,69E-07	1,13E-07
Resorcinol	1,940E+01	1,85E+01	2,87E-06	1,85E+04	1,58E+01	7,75E+01	-	**7,63E-05**	3,12E-06	1,43E-08	1,98E-08
Hydroquinone	9,634E+01	1,78E+01	8,19E-07	1,78E+04	1,51E+01	1,01E+02	-	**4,53E-04**	8,91E-07	4,09E-09	1,91E-08
o-Cresol	3,241E+02	1,29E+02	9,38E-03	1,29E+05	1,31E+02	6,18E+00	-	**8,70E-03**	1,06E-04	4,69E-05	4,69E-06
m-Cresol	4,230E+02	1,28E+02	1,06E-02	1,28E+05	1,31E+02	5,59E+00	-	**2,03E-02**	1,06E-04	5,29E-05	5,29E-06
o-Xylene	1,087E+02	1,20E+01	1,67E+00	1,20E+04	2,88E+01	1,09E-01	-	**5,49E-02**	2,41E-04	8,36E-03	8,36E-04
p-Xylene	2,478E+02	9,25E+00	1,70E+00	9,25E+03	2,30E+01	2,45E-01	-	**4,38E-02**	2,43E-04	8,51E-03	8,51E-04
Polycyclic aromatic hydrocarbons (PAHs)											
Anthracene	2,546E+04	7,13E-02	7,05E-05	7,13E+01	1,35E+00	2,50E+01	-	**C pw > S**	6,45E-08	3,46E-07	3,46E-08
Benzo(a)anthracene	3,009E+03	1,16E-02	2,01E-08	1,16E+01	1,57E+00	2,96E+00	-	**C pw > S**	9,19E-09	9,79E-11	9,79E-12
Benzo(k)fluoranthene	3,185E+03	4,84E-04	1,33E-09	4,84E-01	1,87E-01	3,12E+00	-	**C pw > S**	3,84E-10	6,50E-12	6,50E-13
Benzo(a)pyrene	2,786E+02	8,42E-04	1,34E-08	8,42E-01	3,38E-01	2,74E-01	-	**C pw > S**	6,68E-10	6,55E-11	6,55E-12
Chrysene	3,203E+04	1,79E-03	8,48E-09	1,79E+00	4,00E-01	3,14E+01	-	**C pw > S**	1,42E-09	4,13E-11	4,13E-12
Phenanthrene	2,311E+04	8,50E-01	1,14E-03	8,50E+02	1,67E+01	2,28E+01	-	**C pw > S**	8,01E-07	5,61E-06	5,61E-07
Fluoranthene	3,031E+04	2,01E-01	3,27E-04	2,01E+02	1,37E+01	2,97E+01	-	**C pw > S**	1,93E-07	1,60E-06	1,60E-07
Indeno, 1,2,3-cd pyrene	3,154E+03	2,65E-04	3,11E-10	2,65E-01	4,15E-01	3,09E+00	-	**C pw > S**	2,10E-10	1,51E-12	1,80E-13
Benzo(ghy)perylene	1,924E+04	1,86E-04	5,92E-10	1,86E-01	8,83E-02	1,89E+01	-	**C pw > S**	1,47E-10	2,88E-12	2,88E-13
Pyrene	3,201E+05	1,06E-01	7,90E-06	1,06E+02	5,27E+00	3,14E+02	-	**C pw > S**	8,48E-08	3,86E-08	3,86E-09
Naphthalene	8,700E+02	1,56E+01	1,83E-01	1,56E+04	4,71E+01	8,95E-01	-	**4,92E-01**	3,56E-05	9,06E-04	9,06E-05
acenaphthene	3,152E+05	2,57E+00	2,77E-02	2,57E+03	1,97E+01	3,09E+02	-	**C pw > S**	5,23E-06	1,36E-04	1,36E-05
Benzo(b)fluoranthene	2,760E+03	1,68E-02	1,95E-07	1,68E+01	3,55E+00	2,72E+00	-	**C pw > S**	1,33E-08	9,49E-10	9,49E-11
Benzo(j)fluoranthene	2,780E+03	8,81E-03	1,95E-07	8,81E+00	3,41E+00	2,73E+00	-	**C pw > S**	6,99E-09	9,49E-10	9,49E-11
Dibenz(a,h)anthracene	6,996E+01	8,28E-04	3,15E-08	8,28E-01	2,02E+00	6,91E-02	-	**C pw > S**	6,57E-10	1,53E-10	1,53E-11
9H-Fluorene	2,253E+04	1,32E+00	8,18E-03	1,32E+03	1,57E+01	2,21E+01	-	**C pw > S**	1,96E-06	4,02E-05	4,02E-06
Acenaphthylene	2,588E+04	4,01E+00	1,16E-02	4,01E+03	3,18E+01	2,55E+01	-	**C pw > S**	4,55E-06	5,70E-05	5,70E-06
Chlorinated hydrocarbons, Volatile Organic Compounds (VOC's)											
1,2-dichloroethane	6,431E+00	3,14E+00	9,58E-02	3,14E+03	2,85E+00	6,54E-03	-	**3,08E-04**	1,63E-05	4,81E-04	4,81E-05
dichloromethane (methylenechloride)	6,849E+01	5,58E+01	4,81E+00	5,58E+04	4,93E+01	6,86E-02	-	**3,10E-03**	7,88E-04	2,44E-02	2,44E-03
tetrachloromethane (carbontetrachloride)	6,886E-01	1,90E-01	1,26E-01	1,90E+02	3,33E-01	6,84E-04	-	**2,03E-04**	1,46E-05	6,18E-04	6,18E-05
tetrachloroethene	8,768E+00	5,60E-01	5,20E-01	5,60E+02	1,94E+00	8,67E-03	-	**4,71E-03**	5,79E-05	2,55E-03	2,55E-04
trichloromethane(chloroform)	5,566E+00	1,91E+00	2,07E-01	1,91E+03	1,95E+00	5,53E-03	-	**2,03E-04**	2,86E-05	1,03E-03	1,03E-04
trichloroethene	1,046E+01	1,50E+00	4,19E-01	1,50E+03	2,17E+00	1,03E-02	-	**1,29E-03**	5,32E-05	2,07E-03	2,07E-04
vinylchloride	2,152E-03	3,96E-04	7,31E-03	3,96E-01	3,63E-04	2,11E-06	-	**9,25E-07**	1,32E-06	3,80E-05	3,80E-06
1,1-dichloroethane	8,864E+00	3,86E+00	7,68E-01	3,86E+03	3,74E+00	8,77E-03	-	**7,40E-04**	1,13E-04	3,86E-03	3,86E-04
Chlorinated hydrocarbons, chlorobenzenes, chlorofenols, others											
Monochlorobenzene	1,140E+02	8,79E+00	9,91E-01	8,79E+03	1,63E+01	1,13E-01	-	**1,73E-02**	1,40E-04	4,94E-03	4,94E-04
1,4-Dichlorobenzene	4,746E+02	1,23E+01	1,15E+00	1,23E+04	4,50E+01	4,72E-01	-	**2,03E-01**	1,45E-04	5,67E-03	5,67E-04
1,2,4-Trichlorobenzene	8,231E+01	7,43E-01	8,09E-02	7,43E+02	7,07E+00	8,17E-02	-	**2,58E-02**	9,14E-06	3,96E-04	3,96E-05
1,2,3,4-Tetrachlorobenzene	2,533E+01	5,37E-02	9,83E-04	5,37E+01	1,43E+00	2,56E-02	-	**1,58E-02**	1,38E-07	4,80E-06	4,80E-07
Pentachlorobenzene	6,714E+00	1,39E-02	2,07E-03	1,39E+01	9,81E-01	6,67E-03	-	**4,31E-02**	1,98E-07	1,01E-05	1,01E-06
Hexachlorobenzene	2,699E+00	4,05E-03	2,58E-05	4,05E+00	7,81E-01	2,97E-03	-	**3,47E-01**	5,38E-09	1,25E-07	1,25E-08
2-Chlorophenol	4,018E+01	7,10E+00	1,00E-02	7,10E+03	7,77E+00	5,99E-02	-	**8,15E-04**	6,98E-06	4,96E-05	4,96E-06
2,4-Dichlorophenol	1,136E+02	5,58E+00	8,28E-04	5,58E+03	1,25E+01	8,22E-01	-	**2,92E-03**	4,56E-06	4,07E-06	4,07E-07
2,3,4-Trichlorophenol	1,865E+02	2,66E+00	2,49E-03	2,66E+03	1,00E+01	3,01E-01	-	**3,75E-02**	2,38E-06	1,22E-05	1,22E-06
2,3,4,5-Tetrachlorophenol	3,431E+02	7,97E-01	8,57E-04	7,97E+02	9,97E+00	4,37E-01	-	**2,21E-01**	7,13E-07	4,18E-06	4,18E-07
Pentachlorophenol	1,969E+01	2,14E-01	4,82E-05	2,14E+02	1,35E+01	2,34E-01	-	**4,99E-02**	1,73E-07	2,35E-07	2,35E-08
1-chloronaphatalene	1,866E+01	1,22E-01	2,13E-03	1,22E+02	1,27E+00	1,92E-02	-	**7,27E-03**	3,36E-07	1,05E-05	1,05E-06
PCB 28	6,869E-01	2,91E-04	4,18E-06	2,91E-01	4,58E-02	6,85E-04	-	**2,39E-03**	6,01E-10	2,04E-08	2,04E-09
PCB 52	2,808E-01	9,66E-05	2,75E-06	9,66E-02	4,93E-02	2,82E-04	-	**3,65E-03**	3,05E-10	1,34E-08	1,34E-09
PCB101	6,074E-01	3,09E-05	3,02E-06	3,09E-02	4,67E-02	6,00E-04	-	**2,35E-03**	2,62E-10	1,47E-08	1,47E-09
PCB118	1,905E+00	1,47E-05	9,21E-08	1,47E-02	3,64E-02	1,87E-03	-	**2,24E-03**	1,88E-11	4,48E-10	4,48E-11
PCB138	3,205E-01	1,08E-05	1,02E-08	1,08E-02	4,91E-02	3,21E-04	-	**1,55E-02**	9,24E-12	4,96E-11	4,96E-12
PCB153	4,610E-01	1,07E-05	1,05E-07	1,07E-02	4,80E-02	4,58E-04	-	**3,91E-03**	1,63E-11	5,10E-10	5,10E-11
PCB180	1,692E-01	2,99E-06	3,24E-08	2,99E-03	5,04E-02	1,68E-04	-	**3,88E-03**	4,66E-12	1,57E-10	1,57E-11
1,2-Dichlorobenzene	4,766E+02	2,04E+01	1,18E+00	2,04E+04	7,36E+01	4,83E-01	-	**1,46E-01**	1,55E-04	5,84E-03	5,84E-04
1,3-Dichlorobenzene	check invoer	7,38E-18	6,11E-19	7,38E-15	3,07E-17	2,13E-19	-	**6,55E-20**	7,76E-23	3,01E-21	3,01E-22
1,2,3-Trichlorobenzene	5,878E+01	5,95E-01	8,33E-02	5,95E+02	6,60E+00	5,84E-02	-	**4,37E-02**	9,28E-06	4,08E-04	4,08E-05
1,3,5-Trichlorobenzene	1,291E+01	2,33E-02	1,07E-01	2,33E+01	2,81E-01	1,27E-02	-	**4,94E-03**	1,13E-05	5,22E-04	5,22E-05
1,2,4,5-Tetrachlorobenzene	2,098E+00	6,14E-03	3,30E-03	6,14E+00	1,52E-01	2,07E-03	-	**8,99E-03**	3,25E-07	1,61E-05	1,61E-06
1,2,3,5-Tetrachlorobenzene	8,378E+00	3,88E-02	1,76E-03	3,88E+01	1,07E+00	8,46E-03	-	**1,48E-02**	2,01E-07	8,58E-06	8,58E-07
3-Chlorophenol	1,995E+02	9,36E+00	1,24E-03	9,36E+03	1,25E+01	6,17E-01	-	**1,17E-03**	7,70E-06	6,14E-06	6,14E-07
4-Chlorophenol	5,668E+01	1,09E+01	8,78E-04	1,09E+04	1,36E+01	7,72E-01	-	**1,43E-03**	8,92E-06	4,35E-06	4,35E-07
2,3-Dichlorophenol	1,191E+02	5,59E+00	5,45E-03	5,59E+03	9,88E+00	1,86E-01	-	**6,18E-03**	5,08E-06	2,68E-05	2,68E-06
2,5-Dichlorophenol	1,552E+02	3,93E+00	6,72E-03	3,93E+03	8,79E+00	1,96E-01	-	**9,34E-03**	3,90E-06	3,30E-05	3,30E-06
2,6-Dichlorophenol	1,480E+02	5,92E+00	5,49E-03	5,92E+03	9,63E+00	2,09E-01	-	**1,11E-02**	5,35E-06	2,70E-05	2,70E-06
3,4-Dichlorophenol	1,610E+02	3,48E+00	3,51E-03	3,48E+03	1,09E+01	2,70E-01	-	**1,15E-01**	3,18E-06	1,73E-05	1,73E-06
3,5-Dichlorophenol	2,657E+01	2,05E+00	8,75E-03	2,05E+03	8,43E+00	4,86E-02	-	**5,14E-02**	2,62E-06	4,30E-05	4,30E-06

CONTAMINANT		C soil mg/kg d.m.	C porewater mg/dm3	C pore air g/m3	groundwater ug/dm3	Cplant root mg/kg fresh	Cplant leaf mg/kg fresh	Cplant mg/kg dm	**RATIO Cpw : S**	C-indoor air 1995 concept	C-kruipr g/m3	C-indoor air g/m3
2,3,5-Trichlorophenol		1,990E+02	2,37E+00	3,19E-04	2,37E+03	1,06E+01	1,07E+00	-	**1,77E-02**	1,80E-06	1,56E-06	1,56E-07
2,3,6-Trichlorophenol		1,979E+02	1,79E+00	2,41E-04	1,79E+03	1,08E+01	1,09E+00	-	**1,42E-02**	1,45E-06	1,18E-06	1,18E-07
3,4,5-Trichlorophenol		2,473E+02	1,23E+00	6,01E-04	1,23E+03	1,09E+01	4,97E-01	-	**3,55E-02**	1,04E-06	2,94E-06	2,94E-07
2,4,6-Trichlorophenol		3,267E+02	1,91E+00	6,48E-04	1,91E+03	1,01E+01	6,64E-01	-	**7,85E-03**	1,58E-06	3,17E-06	3,17E-07
2,4,5-Trichlorophenol		2,531E+02	1,90E+00	4,21E-04	1,90E+03	1,06E+01	7,96E-01	-	**5,01E-03**	1,56E-06	2,06E-06	2,06E-07
2,3,4,6-Tetrachlorophenol		7,968E+01	1,09E+00	4,41E-04	1,09E+03	1,17E+01	3,94E-01	-	**7,42E-02**	9,04E-07	2,15E-06	2,15E-07
2,3,5,6-Tetrachlorophenol		1,842E+02	1,45E+00	1,17E-03	1,45E+03	1,04E+01	3,31E-01	-	**3,03E-01**	1,26E-06	5,73E-06	5,73E-07
PCB 77	*	6,330E-04	1,54E-08	5,09E-11	1,54E-05	1,55E-05	6,26E-07	-	**8,06E-06**	1,64E-14	2,47E-13	2,47E-14
PCB 169	*	2,603E-04	4,39E-09	1,52E-12	4,39E-06	1,86E-05	2,58E-07	-	**7,86E-06**	3,56E-15	7,38E-15	7,38E-16
2-chloronaphatalene		4,513E+01	2,95E-01	2,11E-03	2,95E+02	3,27E+00	4,95E-02	-	**3,04E-02**	4,72E-07	1,04E-05	1,04E-06
3,4,5-Trichlorophenol		2,473E+02	1,23E+00	6,01E-04	1,23E+03	1,09E+01	4,98E-01	-	**3,55E-02**	1,04E-06	2,94E-06	2,94E-07
PCB 105	*	6,340E-04	8,10E-09	2,44E-11	8,10E-06	1,56E-05	6,26E-07	-	**1,13E-06**	8,31E-15	1,18E-13	1,18E-14
PCB 126	*	3,028E-04	5,99E-09	1,84E-11	5,99E-06	1,82E-05	3,00E-07	-	**8,56E-07**	6,17E-15	8,95E-14	8,95E-15
PCB 156	*	3,180E-04	2,51E-09	1,28E-11	2,51E-06	1,81E-05	3,13E-07	-	**2,05E-06**	2,93E-15	6,20E-14	6,20E-15
PCB 157	*	3,179E-04	3,01E-09	1,53E-11	3,01E-06	1,81E-05	3,13E-07	-	**2,47E-06**	3,52E-15	7,45E-14	7,45E-15
Pesticides												
DDT		3,055E+01	1,39E-03	3,94E-07	1,39E+00	2,34E+00	3,09E-02	-	**2,14E-01**	1,12E-09	1,91E-09	1,91E-10
DDE		1,716E+01	1,32E-03	1,87E-07	1,32E+00	2,45E+00	1,77E-02	-	**3,23E-02**	1,06E-09	9,11E-10	9,11E-11
Aldrin		3,234E-01	6,40E-04	9,39E-06	6,40E-01	5,08E-01	4,15E-04	-	**2,60E-02**	1,20E-09	4,56E-08	4,56E-09
Dieldrin		9,120E+00	1,61E-02	2,57E-07	1,61E+01	3,64E-01	7,28E-02	-	**5,38E-02**	1,27E-08	1,25E-09	1,25E-10
Endrin		1,621E+01	3,14E-02	1,36E-07	3,14E+01	7,10E-01	1,75E-01	-	**6,73E-02**	2,46E-08	6,59E-10	6,59E-11
a-HCH		1,971E+01	1,59E-01	4,20E-04	1,59E+02	8,83E-01	2,33E-02	-	**9,71E-02**	1,60E-07	2,04E-06	2,04E-07
b-HCH		1,546E+00	1,14E-02	2,97E-05	1,14E+01	6,32E-02	1,80E-03	-	**1,21E-02**	1,14E-08	1,44E-07	1,44E-08
g-HCH		1,334E+00	2,34E-02	6,11E-07	2,34E+01	1,30E-01	4,90E-02	-	**4,03E-03**	1,86E-08	2,97E-09	2,97E-10
d-HCH		-	-	-	-	-	-	-	-	-	-	-
Carbaryl		1,060E+02	9,59E+00	1,44E-03	9,59E+03	1,17E+01	4,31E-01	-	**1,18E-01**	7,79E-06	7,01E-06	7,01E-07
Carbofuran		5,669E+00	2,04E+00	1,03E-06	2,04E+03	1,90E+00	7,28E+00	-	**5,42E-03**	7,93E-07	5,05E-09	1,54E-09
Propoxur		1,244E+00	4,96E-01	5,02E-08	4,96E+02	4,54E-01	4,17E+00	-	**2,72E-04**	3,96E-08	2,45E-10	3,86E-10
Maneb		3,044E+04	8,50E-05	2,35E-07	8,50E-02	1,07E+00	2,98E+01	-	**C pw > S**	8,78E-11	1,14E-09	1,14E-10
Atrazine		1,825E+01	1,93E+00	1,26E-07	1,93E+03	2,79E+00	2,03E+01	-	**5,07E-02**	9,76E-08	6,13E-10	1,48E-09
DDD		4,154E+01	4,73E-03	2,00E-07	4,73E+00	2,24E+00	4,40E-02	-	**7,60E-02**	3,75E-09	9,70E-10	9,70E-11
Other contaminants												
Cyclohexanone		2,144E+02	2,62E+02	2,82E-01	2,62E+05	2,24E+02	5,00E-01	-	**1,38E-02**	2,54E-04	1,42E-03	1,42E-04
Butylbenzylphthalate		2,944E+05	4,22E+00	8,68E-05	4,22E+03	1,82E+02	3,01E+02	-	**C pw > S**	3,33E-06	4,22E-07	4,22E-08
Di(2-ethylhexyl)phthalate		6,018E+01	4,43E-03	4,37E-06	4,43E+00	2,02E+01	6,21E-02	-	**9,68E-02**	3,79E-09	2,12E-08	2,12E-09
Pyridine		1,106E+01	2,13E+00	2,18E-04	2,13E+03	1,81E+00	3,18E-02	-	**3,21E-06**	1,78E-06	1,11E-06	1,11E-07
Styrene		4,719E+02	2,12E+01	1,54E+00	2,12E+04	4,18E+01	4,68E-01	-	**6,61E-02**	2,32E-04	7,69E-03	7,69E-04
Tetrahydrofuran		6,759E+00	1,60E+01	1,79E-02	1,60E+04	1,36E+01	1,86E-02	-	**3,95E-05**	1,62E-05	9,17E-05	9,17E-06
Tetrahydrothiophene		2,336E+02	1,37E+02	8,13E-01	1,37E+05	1,27E+02	2,85E-01	-	**1,06E-02**	2,35E-04	4,11E-03	4,11E-04
dihexyl phthalate (DHP)		3,810E+02	1,15E-02	2,29E-04	1,15E+01	1,74E+01	3,76E-01	-	**C pw > S**	2,69E-08	1,11E-06	1,11E-07
disodecyl phthalate (DIDP)		2,176E+03	2,24E-06	9,34E-07	2,24E-03	3,14E+00	2,13E+00	-	**C pw > S**	6,47E-11	4,53E-09	4,53E-10
dimethyl phthalate (DMP)		8,189E+01	7,75E+00	1,23E-03	7,75E+03	7,14E+00	1,92E-01	-	**3,85E-03**	6,30E-06	6,01E-06	6,01E-07
dibuthyl phthalate (DBP)		2,262E+04	2,35E+00	4,02E-03	2,35E+03	7,21E+01	2,25E+01	-	**C pw > S**	2,20E-06	1,96E-05	1,96E-06
diethyl phthalate (DEP)		1,704E+04	2,87E+02	6,31E-02	2,87E+05	3,75E+02	2,43E+01	-	**C pw > S**	2,34E-04	3,08E-04	3,08E-05
aliphatic >EC5-EC6		3,475E+01	6,13E-01	3,82E+01	6,13E+02	2,50E+00	3,42E-02	-	**2,19E-02**	6,04E-03	1,94E-01	1,94E-02
aliphatic >EC6-EC8		1,092E+02	4,44E-01	3,87E+01	4,44E+02	2,06E+00	1,07E-01	-	**1,06E-01**	5,51E-03	1,94E-01	1,94E-02
aliphatic >EC8-EC10		2,838E+01	1,53E-02	2,13E+00	1,53E+01	8,10E-02	2,78E-02	-	**4,70E-02**	2,66E-04	1,06E-02	1,06E-03
aliphatic >EC10-EC12		1,520E+02	1,04E-02	2,14E+00	1,04E+01	6,19E-02	1,49E-01	-	**3,99E-01**	2,41E-04	1,05E-02	1,05E-03
aliphatic >EC12-EC16		5,542E+04	5,90E-04	3,02E-01	5,90E-01	4,04E-03	5,43E+01	-	**C pw > S**	3,04E-05	1,47E-03	1,47E-04
aliphatic >EC16-EC21		1,282E+06	9,99E-07	1,97E-02	9,99E-04	8,36E-06	1,26E+03	-	**C pw > S**	1,71E-06	9,60E-05	9,60E-06
aromatic >EC5-EC7		2,881E+01	4,92E-01	8,24E-01	4,92E+02	2,05E+00	2,83E-02	-	**2,24E-03**	1,33E-04	4,20E-03	4,20E-04
aromatic >EC7-EC8		6,243E+01	8,50E-01	8,30E-01	8,50E+02	3,61E+00	6,14E-02	-	**6,55E-03**	1,24E-04	4,19E-03	4,19E-04
aromatic >EC8-EC10		5,910E+01	6,40E-01	4,12E-01	6,40E+02	2,77E+00	5,81E-02	-	**9,85E-03**	5,41E-05	2,05E-03	2,05E-04
aromatic >EC10-EC12		3,166E+02	2,17E+00	3,81E-01	2,17E+03	9,71E+00	3,11E-01	-	**8,73E-02**	4,94E-05	1,89E-03	1,89E-04
aromatic >EC12-EC16		5,948E+03	5,81E+00	2,26E-01	5,81E+03	2,73E+01	5,84E+00	-	**C pw > S**	3,10E-05	1,11E-03	1,11E-04
aromatic >EC16-EC21		1,746E+04	5,43E-01	1,39E-02	5,43E+02	2,76E+00	1,71E+01	-	**C pw > S**	1,87E-06	6,80E-05	6,80E-06
aromatic >EC21-EC35		1,923E+04	6,60E-03	8,16E-05	6,60E+00	3,79E-02	1,88E+01	-	**C pw > S**	1,27E-08	3,98E-07	3,98E-08
diisobutylphthalate (DIBP)		8,263E+01	8,18E-01	1,38E-04	8,18E+02	1,58E+01	8,59E-01	-	**8,52E-02**	6,58E-07	6,72E-07	6,72E-08
Dioxins												
2,3,7,8-TCDD	*	3,101E-04	1,32E-08	8,42E-12	1,32E-05	1,82E-05	3,12E-07	-	**4,40E-05**	1,11E-14	4,09E-14	4,09E-15
1-MCDD	*	2,681E-04	5,21E-07	1,86E-09	5,21E-04	1,69E-05	3,01E-07	-	**1,24E-06**	5,93E-13	9,08E-12	9,08E-13
2-MCDD	*	2,707E-04	3,30E-07	2,09E-09	3,30E-04	1,68E-05	2,83E-07	-	**1,18E-06**	4,63E-13	1,02E-11	1,02E-12
27-DCDD	*	2,989E-04	9,01E-08	3,10E-10	9,01E-05	1,80E-05	3,04E-07	-	**2,40E-05**	9,91E-14	1,51E-12	1,51E-13
28-DCDD	*	2,991E-04	1,19E-07	1,08E-10	1,19E-04	1,81E-05	3,37E-07	-	**7,14E-06**	1,04E-13	5,27E-13	5,27E-14
124-TrCDD	*	3,065E-04	3,02E-08	4,92E-11	3,02E-05	1,82E-05	3,12E-07	-	**3,59E-06**	2,80E-14	2,39E-13	2,39E-14
1368-TeCDD	*	3,122E-04	7,59E-09	2,29E-12	7,59E-06	1,82E-05	3,11E-07	-	**2,37E-05**	6,16E-15	1,11E-14	1,11E-15
PeCDD	*	3,142E-04	4,36E-09	4,89E-13	4,36E-06	1,82E-05	3,11E-07	-	**3,64E-05**	3,47E-15	2,37E-15	2,37E-16
HxCDD	*	3,168E-04	2,09E-09	4,00E-12	2,09E-06	1,81E-05	3,12E-07	-	**4,74E-04**	1,93E-15	1,94E-14	1,94E-15
HpCDD	*	3,182E-04	1,44E-09	8,15E-14	1,44E-06	1,81E-05	3,13E-07	-	**6,01E-04**	1,14E-15	3,96E-16	3,96E-17
OCDD	*	3,195E-04	9,98E-10	2,89E-13	9,98E-07	1,81E-05	3,14E-07	-	**2,49E-03**	8,01E-16	1,40E-15	1,40E-16
2,3,7,8-TetraCDF	*	3,083E-04	2,17E-08	5,38E-11	2,17E-05	1,82E-05	3,10E-07	-	**5,24E-05**	2,15E-14	2,61E-13	2,61E-14
1,2,3,7,8-PentaCDF	*	3,106E-04	1,20E-08	9,16E-11	1,20E-05	1,81E-05	3,08E-07	-	**1,37E-05**	1,65E-14	4,45E-13	4,45E-14
2,3,4,7,8,-PentaCDF	*	3,099E-04	1,20E-08	1,59E-10	1,20E-05	1,81E-05	3,06E-07	-	**5,07E-05**	2,17E-14	7,73E-13	7,73E-14
1,2,3,4,7,8-HexaCDF	*	3,159E-04	2,02E-09	3,16E-10	2,02E-06	1,79E-05	3,10E-07	-	**2,45E-04**	2,48E-14	1,54E-12	1,54E-13
1,2,3,6,7,8-HexaCDF	*	3,183E-04	1,66E-09	2,22E-10	1,66E-06	1,80E-05	3,12E-07	-	**9,36E-05**	1,76E-14	1,08E-12	1,08E-13
1,2,3,7,8,9-HexaCDF	*	3,151E-04	3,13E-09	4,50E-11	3,13E-06	1,81E-05	3,10E-07	-	**2,74E-05**	5,77E-15	2,18E-13	2,18E-14
2,3,4,6,7,8-HexaCDF	*	3,200E-04	1,67E-09	6,71E-11	1,67E-06	1,81E-05	3,14E-07	-	**2,83E-05**	6,25E-15	3,26E-13	3,26E-14
1,2,3,4,6,7,8-HeptaCDF	*	3,200E-04	1,67E-09	6,61E-11	1,67E-06	1,81E-05	3,14E-07	-	**1,23E-03**	5,96E-15	3,21E-13	3,21E-14
1,2,3,4,7,8,9-HeptaCDF	*	3,194E-04	2,70E-09	5,03E-12	2,70E-06	1,81E-05	3,15E-07	-	**7,51E-05**	2,47E-15	2,44E-14	2,44E-15
OctaCDF	*	3,154E-04	8,62E-10	2,20E-11	8,62E-07	1,81E-05	3,10E-07	-	**4,01E-03**	2,16E-15	1,07E-13	1,07E-14
TetraCDF	*	3,083E-04	2,17E-08	5,38E-11	2,17E-05	1,82E-05	3,10E-07	-	**5,24E-05**	2,15E-14	2,61E-13	2,61E-14
PentaCDF	*	3,099E-04	1,20E-08	1,59E-10	1,20E-05	1,81E-05	3,06E-07	-	**5,07E-05**	2,17E-14	7,73E-13	7,73E-14
HexaCDF	*	3,134E-04	2,04E-09	3,19E-10	2,04E-06	1,79E-05	3,08E-07	-	**2,47E-04**	2,50E-14	1,55E-12	1,55E-13
HeptaCDF	*	3,171E-04	1,65E-09	3,29E-10	1,65E-06	1,79E-05	3,11E-07	-	**1,22E-03**	2,44E-14	1,60E-12	1,60E-13
OctaCDF	*	3,154E-04	8,62E-10	2,20E-11	8,62E-07	1,81E-05	3,10E-07	-	**4,01E-03**	2,16E-15	1,07E-13	1,07E-14

* = Value expressed as Toxicity equivalent (TEQ) of the most toxic dioxin 2,3,7,8 TCDD

Appendix 3C Relevance of human exposure routes in SEDISOIL

CONTAMINANT	SRC$_{human}$ for sediment mg/kg d.m.	ingestion sediment	ingestion surface water	ingestion partic.. matter	dermal abs. sediment	dermal abs. surface water	fish consumption	DOSIS
Metals								
arsenic	3.346	94,3%	1,3%	0,4%	0,0%	0,0%	4,0%	100%
barium	238	0,3%	99,7%	0,0%	0,0%	0,0%	0,0%	100%
cadmium	1.754	98,8%	0,1%	0,4%	0,0%	0,0%	0,7%	100%
chromium (III)	17.559	99,0%	0,0%	0,4%	0,0%	0,0%	0,6%	100%
chromium (VI)	60	0,3%	99,7%	0,0%	0,0%	0,0%	0,0%	100%
cobalt	17	0,3%	99,7%	0,0%	0,0%	0,0%	0,0%	100%
copper	421.709	84,9%	0,2%	0,3%	0,0%	0,0%	14,5%	100%
mercury	6.726	94,8%	0,1%	0,4%	0,0%	0,0%	4,8%	100%
lead	3.210	93,4%	0,0%	0,4%	0,0%	0,0%	6,2%	100%
molybdenum	119	0,3%	99,7%	0,0%	0,0%	0,0%	0,0%	100%
nickel	143.641	81,0%	1,4%	0,3%	0,0%	0,0%	17,3%	100%
zinc	994.808	56,1%	0,1%	0,2%	0,0%	0,0%	43,6%	100%
Anorganic compounds								
cyaniden vrij	596,15	0,3%	99,7%	0,0%	0,0%	0,0%	0,0%	100%
cyaniden complex	2.565.023,48	90,4%	9,6%	0,0%	0,0%	0,0%	0,0%	100%
thiocyanates	131,15	0,3%	99,7%	0,0%	0,0%	0,0%	0,0%	100%
Aromatic compounds								
Benzene	5,48	0,0%	0,9%	0,0%	1,3%	93,8%	3,9%	100%
Ethylbenzene	110,77	0,0%	0,1%	0,0%	0,9%	92,6%	6,3%	100%
Phenol	173,93	0,1%	5,0%	0,0%	3,4%	86,8%	4,6%	100%
p-Cresol	122,35	0,1%	2,2%	0,0%	1,9%	89,7%	6,0%	100%
Toluene	191,29	0,0%	0,3%	0,0%	0,7%	94,0%	5,0%	100%
m-Xylene	113,77	0,0%	0,1%	0,0%	0,6%	92,9%	6,4%	100%
Catechol	1.112,44	0,8%	16,2%	0,0%	22,0%	57,1%	3,8%	100%
Resorcinol	191,41	0,3%	22,2%	0,0%	7,6%	65,6%	4,4%	100%
Hydroquinone	1.125,28	1,3%	21,1%	0,0%	35,6%	39,4%	2,6%	100%
o-Cresol	108,30	0,1%	2,2%	0,0%	1,7%	90,0%	6,1%	100%
m-Cresol	137,74	0,1%	2,1%	0,0%	2,2%	89,6%	6,0%	100%
o-Xylene	81,20	0,0%	0,2%	0,0%	0,4%	93,1%	6,3%	100%
p-Xylene	222,54	0,0%	0,1%	0,0%	1,2%	92,4%	6,3%	100%
Polycyclic aromatic hydrocarbons (PAHs)								
Anthracene	4.168,32	2,9%	0,0%	0,0%	82,5%	10,5%	4,0%	100%
Benzo(a)anthracene	286,43	1,6%	0,0%	0,0%	45,4%	8,4%	44,7%	100%
Benzo(k)fluoranthene	560,08	3,2%	0,0%	0,0%	88,7%	0,4%	7,8%	100%
Benzo(a)pyrene	16,57	0,9%	0,0%	0,0%	26,2%	3,3%	69,5%	100%
Chrysene	5.972,87	3,4%	0,0%	0,0%	94,6%	0,2%	1,9%	100%
Phenanthrene	427,32	0,3%	0,0%	0,0%	8,5%	65,5%	25,7%	100%
_Fluoranthene	1.696,31	1,0%	0,0%	0,0%	26,9%	27,3%	44,9%	100%
Indeno, 1,2,3-cd pyrene	582,99	3,3%	0,0%	0,0%	92,3%	0,1%	4,3%	100%
Benzo(ghy)perylene	3.640,07	3,4%	0,0%	0,0%	96,1%	0,0%	0,5%	100%
Pyrene *)	59.136,54	3,3%	0,0%	0,0%	93,6%	1,4%	1,7%	100%
Naphthalene	121,13	0,1%	0,1%	0,0%	2,4%	88,7%	8,7%	100%
acenaphthene *)	47.000,19	2,6%	0,0%	0,0%	74,4%	19,5%	3,4%	100%
Benzo(b)fluoranthene *)	101,44	0,6%	0,0%	0,0%	16,1%	5,9%	77,5%	100%
Benzo(j)fluoranthene *)	88,85	0,5%	0,0%	0,0%	14,1%	3,8%	81,6%	100%
Dibenz(a,h)anthracene *)	26,93	1,5%	0,0%	0,0%	42,6%	1,7%	54,1%	100%
9H-Fluorene *)	214,31	0,2%	0,0%	0,0%	4,2%	76,5%	19,1%	100%
Acenaphthylene	174,84	0,1%	0,1%	0,0%	2,8%	82,8%	14,3%	100%
Chlorinated hydrocarbons, volatile organic compounds (VOC's)								
1,2-dichloroethane	61,50	0,1%	5,4%	0,0%	3,5%	86,1%	5,0%	100%
dichloromethane (methylenechloride)	210,13	0,1%	7,1%	0,0%	2,8%	86,1%	3,9%	100%
tetrachloromethane (carbontetrachloride)	3,23	0,0%	0,6%	0,0%	0,6%	86,5%	12,3%	100%
tetrachloroethene	18,79	0,0%	0,2%	0,0%	0,9%	83,6%	15,2%	100%
trichloromethane(chloroform)	84,04	0,1%	2,4%	0,0%	2,2%	88,2%	7,1%	100%
trichloroethene	93,49	0,1%	0,7%	0,0%	1,5%	89,0%	8,8%	100%
vinylchloride	1,61	0,1%	2,9%	0,0%	2,1%	92,0%	3,0%	100%
1,1-dichloroethane	195,39	0,1%	2,7%	0,0%	1,9%	90,1%	5,2%	100%
HCN (organisch)	249,74	0,1%	40,0%	0,0%	4,0%	55,2%	0,7%	100%
Chlorinates hydrocarbons, chlorobenzenes, chlorofenols, others								
Monochlorobenzene	282,65	0,0%	0,3%	0,0%	1,1%	91,8%	6,8%	100%
1,4-Dichlorobenzene	204,85	0,1%	0,1%	0,0%	1,6%	86,4%	11,7%	100%
1,2,4-Trichlorobenzene	21,71	0,1%	0,1%	0,0%	2,1%	75,6%	22,1%	100%
1,2,3,4-Tetrachlorobenzene	2,99	0,2%	0,0%	0,0%	4,7%	50,5%	44,5%	100%
Pentachlorobenzene	1,52	0,1%	0,0%	0,0%	2,4%	20,9%	76,6%	100%
Hexachlorobenzene	0,23	0,0%	0,0%	0,0%	1,1%	4,7%	94,1%	100%
2-Chlorophenol	12,26	0,1%	1,8%	0,0%	3,2%	86,7%	8,1%	100%
2,4-Dichlorophenol	9,24	0,1%	0,4%	0,0%	2,4%	83,2%	13,9%	100%
2,3,4-Trichlorophenol	20,01	0,2%	0,2%	0,0%	5,3%	72,2%	22,1%	100%
2,3,4,5-Tetrachlorophenol	37,44	0,4%	0,1%	0,0%	9,9%	51,9%	37,8%	100%
Pentachlorophenol	0,52	0,0%	0,0%	0,0%	0,1%	19,0%	80,8%	100%
1-chloronaphatalene	215,18	0,1%	0,0%	0,0%	2,1%	79,9%	17,8%	100%
PCB 28	0,06	0,2%	0,0%	0,0%	4,8%	8,6%	86,4%	100%
PCB 52	0,03	0,1%	0,0%	0,0%	2,7%	2,4%	94,8%	100%
PCB101	0,20	0,6%	0,0%	0,0%	15,9%	1,2%	82,3%	100%
PCB118	0,69	1,9%	0,0%	0,0%	54,7%	0,6%	42,8%	100%
PCB138	0,28	0,8%	0,0%	0,0%	22,3%	0,6%	76,2%	100%
PCB153	0,37	1,0%	0,0%	0,0%	29,3%	0,6%	69,1%	100%
PCB180	0,45	1,3%	0,0%	0,0%	35,3%	0,3%	63,2%	100%
1,2-Dichlorobenzene	548,63	0,0%	0,1%	0,0%	1,0%	87,0%	11,8%	100%
1,3-Dichlorobenzene	-							
1,2,3-Trichlorobenzene	16,53	0,1%	0,1%	0,0%	1,6%	75,0%	23,2%	100%
1,3,5-Trichlorobenzene	79,32	0,3%	0,0%	0,0%	7,9%	69,5%	22,3%	100%
1,2,4,5-Tetrachlorobenzene	2,34	0,1%	0,0%	0,0%	3,7%	52,3%	43,8%	100%
1,2,3,5-Tetrachlorobenzene	1,36	0,1%	0,0%	0,0%	2,2%	51,3%	46,4%	100%
3-Chlorophenol	20,31	0,2%	0,8%	0,0%	5,4%	85,6%	8,1%	100%
4-Chlorophenol	6,65	0,1%	1,1%	0,0%	1,8%	88,8%	8,3%	100%
2,3-Dichlorophenol	15,54	0,1%	0,6%	0,0%	4,1%	81,6%	13,5%	100%
2,5-Dichlorophenol	17,48	0,2%	0,4%	0,0%	4,6%	81,2%	13,6%	100%
2,6-Dichlorophenol	21,91	0,2%	0,7%	0,0%	5,8%	80,1%	13,2%	100%
3,4-Dichlorophenol	9,21	0,1%	0,2%	0,0%	2,4%	83,0%	14,3%	100%

CONTAMINANT	SRC$_{human}$ for sediment mg/kg d.m.		ingestion sediment	ingestion surface water	ingestion partic.. matter	dermal abs. sediment	dermal abs. surface water	fish consumption	DOSIS
3,5-Dichlorophenol	2,20		0,0%	0,1%	0,0%	0,6%	84,2%	15,0%	100%
2,3,5-Trichlorophenol	18,70		0,2%	0,2%	0,0%	4,9%	72,1%	22,6%	100%
2,3,6-Trichlorophenol	16,70		0,2%	0,1%	0,0%	4,4%	71,6%	23,7%	100%
3,4,5-Trichlorophenol	1,78		0,0%	0,1%	0,0%	0,5%	72,6%	26,8%	100%
2,4,6-Trichlorophenol	1,88		0,0%	0,2%	0,0%	0,5%	75,1%	24,3%	100%
2,4,5-Trichlorophenol	21,86		0,2%	0,1%	0,0%	5,8%	70,8%	23,1%	100%
2,3,4,6-Tetrachlorophenol	1,06		0,0%	0,1%	0,0%	0,3%	59,1%	40,5%	100%
2,3,5,6-Tetrachlorophenol	22,03		0,2%	0,1%	0,0%	5,8%	58,6%	35,2%	100%
PCB 77 *)	0,0001	*	1,0%	0,0%	0,0%	28,0%	1,8%	69,2%	100%
PCB 169 *)	0,0002	*	1,3%	0,0%	0,0%	36,2%	0,5%	62,0%	100%
2-chloronaphatalene	200,85		0,1%	0,0%	0,0%	2,0%	79,7%	18,2%	100%
3,4,5-Trichlorophenol	18,76		0,2%	0,1%	0,0%	5,0%	69,2%	25,5%	100%
PCB 105 *)	0,0002	*	1,5%	0,0%	0,0%	42,5%	0,8%	55,2%	100%
PCB 126 *)	0,0002	*	1,2%	0,0%	0,0%	32,5%	1,0%	65,4%	100%
PCB 156 *)	0,0003	*	1,9%	0,0%	0,0%	54,3%	0,4%	43,4%	100%
PCB 157 *)	0,0003	*	1,8%	0,0%	0,0%	49,8%	0,4%	48,0%	100%
Pesticides									
DDT	11,11		0,6%	0,0%	0,0%	17,6%	0,8%	81,0%	100%
DDE	7,03		0,4%	0,0%	0,0%	11,1%	1,5%	87,0%	100%
Aldrin	0,06		0,0%	0,0%	0,0%	0,5%	0,8%	98,7%	100%
Dieldrin	1,58		0,4%	0,1%	0,0%	12,5%	7,2%	79,7%	100%
Endrin	2,92		0,4%	0,1%	0,0%	11,6%	7,3%	80,6%	100%
a-HCH	15,21		0,4%	0,3%	0,0%	12,0%	35,6%	51,6%	100%
b-HCH	0,33		0,5%	0,3%	0,0%	13,0%	35,1%	51,0%	100%
g-HCH	0,30		0,2%	0,3%	0,0%	5,9%	38,1%	55,4%	100%
d-HCH	-								
Carbaryl	36,42		0,3%	2,8%	0,0%	9,6%	67,1%	20,1%	100%
Carbofuran	33,99		0,5%	15,4%	0,0%	13,5%	50,1%	20,5%	100%
Propoxur	16,83		0,5%	16,9%	0,0%	13,3%	51,9%	17,5%	100%
Maneb	6.089,45		3,4%	0,0%	0,0%	96,4%	0,0%	0,1%	100%
Atrazine	36,77		0,2%	2,0%	0,0%	5,8%	66,6%	25,4%	100%
DDD	4,94		0,3%	0,0%	0,0%	7,8%	1,5%	90,4%	100%
Other compounds									
Cyclohexanone	271.689,91		1,7%	10,6%	0,0%	46,8%	38,8%	2,1%	100%
Butylbenzylphthalate	21.879,05		1,2%	0,0%	0,0%	34,6%	8,9%	55,1%	100%
Di(2-ethylhexyl)phthalate	59,13		0,4%	0,0%	0,0%	11,7%	0,5%	87,4%	100%
Pyridine	32,38		0,9%	15,9%	0,0%	25,6%	55,4%	2,2%	100%
Styrene	223,98		0,1%	0,2%	0,0%	1,5%	92,3%	6,0%	100%
Tetrahydrofuran	47,86		0,1%	25,7%	0,0%	3,8%	68,0%	2,4%	100%
Tetrahydrothiophene	425,68		0,1%	3,4%	0,0%	1,9%	90,2%	4,4%	100%
dihexyl phthalate (DHP) *)	12,40		0,1%	0,0%	0,0%	2,5%	1,2%	96,2%	100%
disodecyl phthalate (DIDP) *)	487,64		3,4%	0,0%	0,0%	96,5%	0,0%	0,0%	100%
dimethyl phthalate (DMP) *)	168,51		1,2%	10,2%	0,0%	33,4%	43,7%	11,6%	100%
dibuthyl phthalate (DBP) *)	49,53		0,0%	0,0%	0,0%	0,8%	27,0%	72,2%	100%
diethyl phthalate (DEP) *)	4.943,61		0,7%	2,5%	0,0%	19,6%	54,4%	22,9%	100%
aliphatic >EC5-EC6	46.512,92		0,7%	0,0%	0,0%	18,4%	77,2%	3,7%	100%
aliphatic >EC6-EC8	217.498,40		3,1%	0,0%	0,0%	86,1%	10,2%	0,7%	100%
aliphatic >EC8-EC10	10.619,91		3,0%	0,0%	0,0%	84,1%	11,6%	1,3%	100%
aliphatic >EC10-EC12	12.100,07		3,4%	0,0%	0,0%	95,8%	0,7%	0,1%	100%
aliphatic >EC12-EC16	12.195,09		3,4%	0,0%	0,0%	96,6%	0,0%	0,0%	100%
aliphatic >EC16-EC21	243.933,90		3,4%	0,0%	0,0%	96,6%	0,0%	0,0%	100%
aromatic >EC5-EC7	186,26		0,0%	0,0%	0,0%	0,7%	94,8%	4,3%	100%
aromatic >EC7-EC8	281,15		0,0%	0,0%	0,0%	1,1%	93,4%	5,4%	100%
aromatic >EC8-EC10	103,62		0,1%	0,1%	0,0%	2,1%	89,7%	8,1%	100%
aromatic >EC10-EC12	177,80		0,1%	0,1%	0,0%	3,5%	87,0%	9,3%	100%
aromatic >EC12-EC16	417,04		0,3%	0,1%	0,0%	8,3%	79,6%	11,8%	100%
aromatic >EC16-EC21	2.553,01		2,4%	0,0%	0,0%	67,4%	23,5%	6,7%	100%
aromatic >EC21-EC35	3.649,94		3,4%	0,0%	0,0%	96,3%	0,1%	0,1%	100%
diisobutylphthalate(DIBP) *)	11,21		0,1%	0,1%	0,0%	2,2%	33,3%	64,3%	100%
Dioxins									
2,3,7,8-TCDD	0,0001	*	0,7%	0,0%	0,0%	18,4%	1,3%	79,6%	100%
1368-TeCDD	0,0001	*	1,0%	0,0%	0,0%	28,2%	1,1%	69,7%	100%
PCDD	0,0002	*	1,4%	0,0%	0,0%	40,7%	0,5%	57,3%	100%
HxCDD	0,0003	*	2,1%	0,0%	0,0%	58,5%	0,2%	39,2%	100%
HpCDD	0,0003	*	2,4%	0,0%	0,0%	66,8%	0,1%	30,8%	100%
OCDD	0,0004	*	2,6%	0,0%	0,0%	73,9%	0,0%	23,4%	100%
2,3,7,8-TetraCDF	0,0001	*	0,4%	0,0%	0,0%	12,0%	1,7%	85,8%	100%
1,2,3,7,8-PentaCDF	0,0001	*	0,7%	0,0%	0,0%	20,0%	0,9%	78,4%	100%
2,3,4,7,8,-PentaCDF	0,0001	*	0,7%	0,0%	0,0%	20,0%	0,9%	78,4%	100%
1,2,3,4,7,8-HexaCDF	0,0003	*	2,1%	0,0%	0,0%	59,1%	0,3%	38,5%	100%
1,2,3,6,7,8-HexaCDF	0,0003	*	2,3%	0,0%	0,0%	63,8%	0,2%	33,7%	100%
1,2,3,7,8,9-HexaCDF	0,0002	*	1,7%	0,0%	0,0%	48,8%	0,3%	49,1%	100%
2,3,4,6,7,8-HexaCDF	0,0003	*	2,3%	0,0%	0,0%	63,8%	0,2%	33,7%	100%
1,2,3,4,6,7,8-HeptaCDF	0,0003	*	2,3%	0,0%	0,0%	63,8%	0,1%	33,8%	100%
1,2,3,4,7,8,9-HeptaCDF	0,0003	*	1,9%	0,0%	0,0%	52,7%	0,2%	45,2%	100%
OctaCDF	0,0004	*	2,7%	0,0%	0,0%	76,1%	0,0%	21,1%	100%
TetraCDF	0,0001	*	0,4%	0,0%	0,0%	12,0%	1,7%	85,8%	100%
PentaCDF	0,0001	*	0,7%	0,0%	0,0%	20,0%	0,9%	78,4%	100%
HexaCDF	0,0003	*	2,1%	0,0%	0,0%	58,8%	0,3%	38,9%	100%
HeptaCDF	0,0003	*	2,3%	0,0%	0,0%	63,8%	0,1%	33,8%	100%
OctaCDF	0,0004	*	2,7%	0,0%	0,0%	76,1%	0,0%	21,1%	100%

* = Value expressed as Toxicity equivalent (TEQ) of the most toxic dioxin 2,3,7,8 TCDD

*) = These compounds were added at the end of the evaluation process; therefore not the complete data evaluation was performed.

Appendix 3D Concentrations in environmental compartments in SEDISOIL

CONTAMINANT	C sediment mg/kg d.m.	C surface water mg/dm3	C particulate matter mg/kg d.m.	C fish mg/kg fresh weight	max. water solubility mg/dm3
Metals					
arsenic	3,35E+03	5,02E-01	5,02E+03	2,51E+00	3,00E+03
barium	2,38E+02	7,75E+02	2,38E+02	0,00E+00	3,00E+03
cadmium	1,75E+03	2,02E-02	2,63E+03	2,02E-01	3,00E+03
chromium (III)	1,76E+04	9,08E-02	2,63E+04	1,82E+00	3,00E+03
chromium (VI)	5,96E+01	1,94E+02	5,96E+01	0,00E+00	3,00E+03
cobalt	1,67E+01	5,42E+01	1,67E+01	0,00E+00	3,00E+03
copper	4,22E+05	1,27E+01	6,33E+05	1,27E+03	3,00E+03
mercury	6,73E+03	5,93E-02	1,01E+04	5,93E+00	3,00E+03
lead	1,19E+04	2,80E-02	1,79E+04	1,40E+01	3,00E+03
molybdenum	1,19E+02	3,87E+02	1,19E+02	0,00E+00	3,00E+03
nickel	1,44E+05	2,69E+01	2,15E+05	5,39E+02	3,00E+03
zinc	9,95E+05	1,36E+01	1,49E+06	1,36E+04	3,00E+03
Anorganic compounds					
cyaniden vrij	5,96E+02	1,94E+03	5,96E+02	0,00E+00	3,00E+03
cyaniden complex	2,57E+06	3,00E+03	9,23E+02	0,00E+00	3,00E+03
thiocyanates	1,31E+02	4,26E+02	1,31E+02	0,00E+00	3,00E+03
Aromatic compounds					
Benzene	5,48E+00	1,19E+00	1,06E+01	8,03E+00	1,99E+03
Ethylbenzene	1,11E+02	5,55E+00	2,20E+02	3,92E+02	1,59E+02
Phenol	1,74E+02	7,81E+01	3,24E+02	1,15E+02	6,56E+04
p-Cresol	1,22E+02	4,31E+01	2,31E+02	1,88E+02	2,86E+04
Toluene	1,91E+02	2,57E+01	3,75E+02	6,90E+02	6,11E+02
m-Xylene	1,14E+02	7,48E+00	2,25E+02	5,93E+02	1,97E+02
Catechol	1,11E+03	2,52E+02	2,15E+03	9,56E+01	1,24E+05
Resorcinol	1,91E+02	1,73E+02	3,30E+02	5,45E+01	2,42E+05
Hydroquinone	1,13E+03	2,05E+02	2,19E+03	4,00E+01	3,92E+04
o-Cresol	1,08E+02	4,22E+01	2,04E+02	1,88E+02	1,49E+04
m-Cresol	1,38E+02	4,11E+01	2,63E+02	1,87E+02	6,32E+03
o-Xylene	8,12E+01	8,94E+00	1,60E+02	5,89E+02	2,19E+02
p-Xylene	2,23E+02	8,30E+00	4,43E+02	5,86E+02	2,11E+02
Polycyclic aromatic hydrocarbons (PAHs)					
Anthracene	4,17E+03	7,13E-02	1,65E+02	1,01E+02	7,13E-02
Benzo(a)anthracene	2,86E+02	8,01E-03	5,73E+02	1,39E+02	1,16E-02
Benzo(k)fluoranthene	5,60E+02	4,84E-04	9,76E+01	2,42E+01	4,84E-04
Benzo(a)pyrene	1,66E+01	4,32E-04	3,31E+01	2,16E+01	8,42E-04
Chrysene	5,97E+03	1,79E-03	1,09E+02	5,78E+01	1,79E-03
Phenanthrene	4,27E+02	4,34E-01	8,54E+02	6,40E+02	8,50E-01
_Fluoranthene	1,70E+03	1,93E-01	3,39E+03	1,40E+03	2,01E-01
Indeno, 1,2,3-cd pyrene	5,83E+02	2,65E-04	3,22E+01	1,33E+01	2,65E-04
Benzo(ghy)perylene	3,64E+03	1,86E-04	5,82E+01	9,32E+00	1,86E-04
Pyrene **	5,91E+04	1,06E-01	8,27E+02	5,15E+02	1,06E-01
Naphthalene	1,21E+02	2,17E+00	2,42E+02	2,17E+02	3,18E+01
acenaphthene **	4,70E+04	2,57E+00	1,01E+03	1,07E+03	2,57E+00
Benzo(b)fluoranthene **	1,01E+02	7,99E-03	2,03E+02	2,41E+02	1,68E-02
Benzo(j)fluoranthene **	8,89E+01	5,07E-03	1,78E+02	2,54E+02	8,81E-03
Dibenz(a,h)anthracene **	2,69E+01	3,36E-04	5,39E+01	1,68E+01	8,28E-04
9H-Fluorene **	2,14E+02	6,27E-01	4,28E+02	4,74E+02	1,32E+00
Acenaphthylene	1,75E+02	1,02E+00	3,49E+02	4,44E+02	4,01E+00
Chlorinated hydrocarbons, volatile organic compounds (VOC's)					
1,2-dichloroethane	6,15E+01	2,93E+01	1,14E+02	4,32E+01	1,02E+04
dichloromethane (methylenechloride)	2,10E+02	1,65E+02	3,69E+02	1,47E+02	1,80E+04
tetrachloromethane (carbontetrachloride)	3,23E+00	9,05E-01	6,18E+00	3,06E+01	9,38E+02
tetrachloroethene	1,88E+01	1,21E+00	3,72E+01	1,52E+02	1,19E+02
trichloromethane(chloroform)	8,40E+01	2,84E+01	1,59E+02	1,33E+02	9,39E+03
trichloroethene	9,35E+01	1,34E+01	1,83E+02	2,73E+02	1,16E+03
vinylchloride	1,61E+00	6,66E-01	3,01E+00	1,11E+00	4,28E+02
1,1-dichloroethane	1,95E+02	8,43E+01	3,65E+02	2,60E+02	5,22E+03
HCN (organisch)	2,50E+02	7,78E+02	2,60E+02	2,19E+01	3,12E+03
Chlorinates hydrocarbons, chlorobenzenes, chlorofenols, others					
Monochlorobenzene	2,83E+02	2,17E+01	5,59E+02	8,44E+02	5,07E+02
1,4-Dichlorobenzene	2,05E+02	5,30E+00	4,08E+02	7,30E+02	6,05E+01
1,2,4-Trichlorobenzene	2,17E+01	1,96E-01	4,34E+01	1,10E+02	2,88E+01
1,2,3,4-Tetrachlorobenzene	2,99E+00	6,34E-03	5,98E+00	1,38E+01	3,40E+00
Pentachlorobenzene	1,52E+00	3,15E-03	3,04E+00	2,38E+01	3,23E-01
Hexachlorobenzene	2,32E-01	3,49E-04	4,64E-01	9,36E+00	1,17E-02
2-Chlorophenol	1,23E+01	2,14E+00	2,39E+01	1,51E+01	8,71E+03
2,4-Dichlorophenol	9,24E+00	4,53E-01	1,83E+01	2,60E+01	1,91E+03
2,3,4-Trichlorophenol	2,00E+01	2,86E-01	3,99E+01	4,12E+01	7,11E+01
2,3,4,5-Tetrachlorophenol	3,74E+01	8,70E-02	7,49E+01	7,06E+01	3,61E+00
Pentachlorophenol	5,23E-01	2,29E-02	1,04E+00	1,51E+02	4,28E+00
1-chloronaphatalene	2,15E+02	1,41E+00	4,30E+02	8,86E+02	1,68E+01
PCB 28	6,09E-02	2,58E-05	1,22E-01	5,38E-01	1,21E-01
PCB 52	3,43E-02	1,18E-05	6,85E-02	5,89E-01	2,65E-02
PCB101	2,01E-01	1,02E-05	4,02E-01	5,12E-01	1,32E-02
PCB118	6,90E-01	5,32E-06	1,38E+00	2,66E-01	6,54E-03
PCB138	2,82E-01	9,48E-06	5,64E-01	4,74E-01	6,96E-04
PCB153	3,70E-01	8,59E-06	7,39E-01	4,30E-01	2,74E-03
PCB180	4,45E-01	7,86E-06	8,91E-01	3,93E-01	7,69E-04
1,2-Dichlorobenzene	5,49E+02	2,34E+01	1,09E+03	3,16E+03	1,40E+02
1,3-Dichlorobenzene	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,13E+02
1,2,3-Trichlorobenzene	1,65E+01	1,67E-01	3,30E+01	1,15E+02	1,36E+01
1,3,5-Trichlorobenzene	7,93E+01	1,43E-01	1,59E+02	1,11E+02	4,71E+00
1,2,4,5-Tetrachlorobenzene	2,34E+00	6,84E-03	4,68E+00	1,36E+01	6,82E-01
1,2,3,5-Tetrachlorobenzene	1,36E+00	6,32E-03	2,72E+00	1,44E+01	2,61E+00
3-Chlorophenol	2,03E+01	9,51E-01	4,03E+01	1,50E+01	7,97E+03
4-Chlorophenol	6,65E+00	1,27E+00	1,29E+01	1,56E+01	7,67E+03
2,3-Dichlorophenol	1,55E+01	7,28E-01	3,09E+01	2,52E+01	9,05E+02
2,5-Dichlorophenol	1,75E+01	4,42E-01	3,48E+01	2,54E+01	4,21E+02
2,6-Dichlorophenol	2,19E+01	8,74E-01	4,35E+01	2,46E+01	5,34E+02

CONTAMINANT		C sediment mg/kg d.m.	C surface water mg/dm3	C particulate matter mg/kg d.m.	C fish mg/kg fresh weight	max. water solubility mg/dm3
3,4-Dichlorophenol		9,21E+00	2,50E-01	1,84E+01	2,67E+01	3,02E+01
3,5-Dichlorophenol		2,20E+00	1,69E-01	4,35E+00	2,80E+01	3,99E+01
2,3,5-Trichlorophenol		1,87E+01	2,22E-01	3,73E+01	4,22E+01	1,52E+02
2,3,6-Trichlorophenol		1,67E+01	1,50E-01	3,34E+01	4,43E+01	1,26E+02
3,4,5-Trichlorophenol		1,78E+00	9,77E-02	3,53E+00	5,00E+01	3,46E+01
2,4,6-Trichlorophenol		1,88E+00	1,85E-01	3,70E+00	4,52E+01	2,43E+02
2,4,5-Trichlorophenol		2,19E+01	1,64E-01	4,37E+01	4,31E+01	3,80E+02
2,3,4,6-Tetrachlorophenol		1,06E+00	1,15E-01	2,09E+00	7,55E+01	1,47E+01
2,3,5,6-Tetrachlorophenol		2,20E+01	1,73E-01	4,40E+01	6,57E+01	4,79E+00
PCB 77 **	*	1,41E-04	3,44E-09	2,83E-04	1,72E-04	1,91E-03
PCB 169 **	*	1,83E-04	3,08E-09	3,66E-04	1,54E-04	5,58E-04
2-chloronaphatalene		2,01E+02	1,31E+00	4,01E+02	9,07E+02	9,71E+00
3,4,5-Trichlorophenol		1,88E+01	9,31E-02	3,75E+01	4,77E+01	3,46E+01
PCB 105 **	*	2,15E-04	2,74E-09	4,29E-04	1,37E-04	7,15E-03
PCB 126 **	*	1,64E-04	3,25E-09	3,29E-04	1,63E-04	7,00E-03
PCB 156 **	*	2,74E-04	2,16E-09	5,48E-04	1,08E-04	1,22E-03
PCB 157 **	*	2,52E-04	2,39E-09	5,04E-04	1,19E-04	1,22E-03
Pesticides						
DDT		1,11E+01	5,04E-04	2,22E+01	2,52E+01	6,48E-03
DDE		7,03E+00	5,41E-04	1,41E+01	2,71E+01	4,09E-02
Aldrin		6,21E-02	1,23E-04	1,24E-01	6,14E+00	2,46E-02
Dieldrin		1,58E+00	2,79E-03	3,17E+00	4,96E+00	2,99E-01
Endrin		2,92E+00	5,65E-03	5,85E+00	1,00E+01	4,66E-01
a-HCH		1,52E+01	1,22E-01	3,04E+01	3,21E+01	1,63E+00
b-HCH		3,30E-01	2,42E-03	6,58E-01	6,35E-01	9,38E-01
g-HCH		2,99E-01	5,25E-03	5,97E-01	1,38E+00	5,81E+00
d-HCH		0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,01E+01
Carbaryl		3,64E+01	3,28E+00	7,18E+01	3,76E+01	8,16E+01
Carbofuran		3,40E+01	1,20E+01	6,43E+01	2,55E+01	3,76E+02
Propoxur		1,68E+01	6,56E+00	3,16E+01	1,09E+01	1,82E+03
Maneb		6,09E+03	8,50E-05	9,86E+02	4,25E+00	8,50E-05
Atrazine		3,68E+01	3,87E+00	7,23E+01	7,88E+01	3,81E+01
DDD		4,94E+00	5,62E-04	9,87E+00	2,81E+01	6,23E-02
Other compounds						
Cyclohexanone		2,72E+05	1,90E+04	2,74E+04	6,13E+03	1,90E+04
Butylbenzylphthalate		2,19E+04	4,22E+00	3,98E+03	1,71E+04	4,22E+00
Di(2-ethylhexyl)phthalate		5,91E+01	4,35E-03	1,18E+02	2,17E+02	4,57E-02
Pyridine		3,24E+01	6,17E+00	6,29E+01	1,38E+00	6,65E+05
Styrene		2,24E+02	1,00E+01	4,45E+02	4,46E+02	3,20E+02
Tetrahydrofuran		4,79E+01	9,99E+01	6,50E+01	1,47E+01	4,06E+05
Tetrahydrothiophene		4,26E+02	2,41E+02	7,77E+02	4,91E+02	1,29E+04
dihexyl phthalate (DHP) **		1,24E+01	4,79E-03	2,48E+01	2,39E+02	1,15E-02
disodecyl phthalate (DIDP) **		4,88E+02	2,24E-06	9,22E-02	1,12E-01	2,24E-06
dimethyl phthalate (DMP) **		1,69E+02	1,59E+01	3,32E+02	2,88E+01	2,01E+03
dibuthyl phthalate (DBP) **		4,95E+01	8,89E-01	9,88E+01	2,33E+03	2,35E+00
diethyl phthalate (DEP) **		4,94E+03	1,93E+02	9,83E+03	2,85E+03	2,87E+02
aliphatic >EC5-EC6		4,65E+04	2,80E+01	2,59E+03	4,60E+03	2,80E+01
aliphatic >EC6-EC8		2,17E+05	4,20E+00	1,94E+03	8,37E+02	4,20E+00
aliphatic >EC8-EC10		1,06E+04	3,25E-01	1,19E+03	7,94E+01	3,25E-01
aliphatic >EC10-EC12		1,21E+04	2,61E-02	7,60E+02	7,54E+00	2,61E-02
aliphatic >EC12-EC16		1,22E+04	5,90E-04	3,43E+02	2,09E-01	5,90E-04
aliphatic >EC16-EC21		2,44E+05	9,99E-07	1,16E+02	4,69E-04	9,99E-07
aromatic >EC5-EC7		1,86E+02	3,19E+00	3,72E+02	5,41E+02	2,20E+02
aromatic >EC7-EC8		2,81E+02	3,83E+00	5,61E+02	6,68E+02	1,30E+02
aromatic >EC8-EC10		1,04E+02	1,12E+00	2,07E+02	2,01E+02	6,50E+01
aromatic >EC10-EC12		1,78E+02	1,22E+00	3,55E+02	2,31E+02	2,48E+01
aromatic >EC12-EC16		4,17E+02	1,43E+00	8,34E+02	2,93E+02	5,81E+00
aromatic >EC16-EC21		2,55E+03	5,43E-01	9,99E+02	1,25E+02	5,43E-01
aromatic >EC21-EC35		3,65E+03	6,60E-03	9,64E+01	1,81E+00	6,60E-03
diisobutylphthalate(DIBP) **		1,12E+01	1,11E-01	2,24E+01	1,60E+02	9,60E+00
Dioxins						
2,3,7,8-TCDD	*	9,32E-05	3,96E-09	1,86E-04	1,98E-04	3,00E-04
1368-TeCDD	*	1,43E-04	3,47E-09	2,85E-04	1,73E-04	3,20E-04
PCDD	*	2,05E-04	2,85E-09	4,11E-04	1,43E-04	1,20E-04
HxCDD	*	2,96E-04	1,95E-09	5,92E-04	9,74E-05	4,40E-06
HpCDD	*	3,37E-04	1,53E-09	6,75E-04	7,65E-05	2,40E-06
OCDD	*	3,73E-04	1,17E-09	7,47E-04	5,83E-05	4,00E-07
2,3,7,8-TetraCDF	*	6,08E-05	4,27E-09	1,22E-04	2,13E-04	4,13E-04
1,2,3,7,8-PentaCDF	*	1,01E-04	3,90E-09	2,02E-04	1,95E-04	8,73E-04
2,3,4,7,8,-PentaCDF	*	1,01E-04	3,90E-09	2,02E-04	1,95E-04	2,36E-04
1,2,3,4,7,8-HexaCDF	*	2,99E-04	1,91E-09	5,98E-04	9,57E-05	8,25E-06
1,2,3,6,7,8-HexaCDF	*	3,22E-04	1,68E-09	6,44E-04	8,39E-05	1,77E-05
1,2,3,7,8,9-HexaCDF	*	2,46E-04	2,44E-09	4,93E-04	1,22E-04	1,14E-04
2,3,4,6,7,8-HexaCDF	*	3,22E-04	1,68E-09	6,44E-04	8,39E-05	5,89E-05
1,2,3,4,6,7,8-HeptaCDF	*	3,22E-04	1,68E-09	6,45E-04	8,40E-05	1,35E-06
1,2,3,4,7,8,9-HeptaCDF	*	2,66E-04	2,25E-09	5,33E-04	1,12E-04	3,59E-05
OctaCDF	*	3,85E-04	1,05E-09	7,69E-04	5,25E-05	2,15E-07
TetraCDF	*	6,08E-05	4,27E-09	1,22E-04	2,13E-04	4,13E-04
PentaCDF	*	1,01E-04	3,90E-09	2,02E-04	1,95E-04	2,36E-04
HexaCDF	*	2,97E-04	1,93E-09	5,94E-04	9,66E-05	8,25E-06
HeptaCDF	*	3,22E-04	1,68E-09	6,45E-04	8,40E-05	1,35E-06
OctaCDF	*	3,85E-04	1,05E-09	7,69E-04	5,25E-05	2,15E-07

* = Value expressed as Toxicity equivalent (TEQ) of the most toxic dioxin 2,3,7,8 TCDD

** = These compounds were added at the end of the evaluation process; therefore not the complete data evaluation was performed.

Appendix 4 Reliability Score for human exposure and MPR

Explanation

The Reliability Score (RS) of the derived SRC$_{human}$ is based on the reliability of its three basic components: 1) the physicochemical data, 2) the CSOIL model concepts and 3) the human toxicological risk limits (MPR).

1. Based on available data, the physicochemical data was evaluated afterwards a classification based on the reliability could be made. The Reliability Score of the S, Vp and Kow data is based on the work of Jager, Rikken and van der Poel (1997), the RS for Koc data was based on this report and the RS for BCF on the work of Versluijs and Otte (in prep.). Table 1 shows the classification and the corresponding reliability score. For some frequent investigated contaminants the reliability could be higher than the RS according the mentioned table. The physicochemical data as a whole was scored based on the classification of table 1 and the relevant exposure routes involved. It is important to realise that the route "ingestion of soil" is independent of physicochemical parameters. In other words, when the route "ingestion of soil" is dominant the reliability of the physicochemical parameters will be of no concern. The route "inhalation of indoor air" is influenced by S, Vp and Koc. The route "crop consumption" is influenced by Koc and Kow and for metals by BCF.

Table 1: Reliability scores of the physicochemical parameters

High reliability	Medium reliability	Low reliability
S > 1 mg/dm3	S < 1 mg/dm3	
Vp > 1 Pa	Vp < 1 Pa	
log Kow < 4	log Kow 4 – 5.5	log Kow > 5
log Koc < 3.5	log Koc 3.5 – 4.5	log Koc > 4.5
BCF: Cd, Pb,	BCF: As, Cu, Hg, Zn	BCF: Ba, Cr, Co, Mo, Ni

2. The RS of the CSOIL concept is "high" when the dominant exposure route is "ingestion of soil". When a major contribution of the exposure routes "inhalation of indoor air" and/or "crop consumption" is given a RS of "medium". A relevant contribution of the route "consumption of contaminated drinking water after permeation" leads to a score of low reliability (3).
3. The RS of the human toxicological risk limits (the TDI or CRI and the TCA or CRA) is according to Baars et al. (2001).

The overall RS of the SRC$_{human}$ for soil is determined by the component with the lowest RS. It is stressed that the RS only can serve as a relative earmark.

used codes: *"1" : high reliability*
"2" : medium reliability
"3" : low reliability

	Contribution (%) of the most relevant exposure routes to the total exposure			Reliability Score (RS) of the different model components and risk limits				
	ingestion soil	inhalation air inside	consump. of crops	phys-chem data	CSOIL concept	**human exposure**	**TDI/TCA**	RS SRC$_{human}$
Metals and trace elements								
arsenic	71%	< 1%	28%	1	1	**1**	**1**	high
barium	57%	< 1%	42%	2	1	**2**	**1**	medium
cadmium	7%	< 1%	93%	1	1	**1**	**1**	high
chromium (III)	67%	< 1%	32%	1	1	**1**	**2**	medium
chromium (VI)	67%	< 1%	32%	1	1	**1**	**3**	low
cobalt	4%	< 1%	96%	3	1	**3**	**2**	low
copper	10%	< 1%	90%	2	1	**2**	**2**	medium
mercury	13%	< 1%	87%	2	1	**2**	**1**	medium
lead	57%	< 1%	42%	1	1	**1**	**1**	high
molybdenum	16%	< 1%	84%	3	1	**3**	**1**	low
nickel	45%	< 1%	55%	2	1	**2**	**1**	medium
zinc	11%	< 1%	89%	2	1	**2**	**1**	medium
Aromatic compounds								
Benzene	< 1%	97%	1%	1	2	**2**	**1**	medium
Ethylbenzene	< 1%	96%	1%	1	2	**2**	**1**	medium
Phenol	1%	1%	97%	1	2	**2**	**1**	medium
o-Cresol	1%	2%	54%	1	2	**2**	**2**	medium
m-Cresol	1%	3%	53%	1	2	**2**	**2**	medium

	Contribution (%) of the most relevant exposure routes to the total exposure			Reliability Score (RS) of the different model components and risk limits				
	ingestion soil	inhalation air inside	consump. of crops	phys-chem data	CSOIL concept	**human exposure**	**TDI/TCA**	RS SRC_{human}
p-Cresol	1%	1%	56%	1	2	**2**	**2**	medium
Toluene	< 1%	97%	1%	1	2	**2**	**1**	medium
o-Xylene	< 1%	94%	3%	1	2	**2**	**1**	medium
p-Xylene	< 1%	95%	2%	1	2	**2**	**1**	medium
m-Xylene	< 1%	95%	2%	1	2	**2**	**1**	medium
Catechol	1%	< 1%	95%	1	2	**2**	**2**	medium
Resorcinol	< 1%	< 1%	98%	1	2	**2**	**2**	medium
Hydroquinone	< 1%	< 1%	98%	1	2	**2**	**2**	medium
Styrene	< 1%	89%	4%	1	2	**2**	**1**	medium
Polycyclic aromatic hydrocarbons								
Naphthalene	3%	61%	26%	1	2	**2**	**1**	medium
Anthracene	78%	< 1%	14%	1	1	**1**	**1**	high
Phenanthrene	71%	< 1%	20%	1	1	**1**	**1**	high
Fluoranthene	74%	< 1%	18%	1	1	**1**	**1**	high
Benzo(a)anthracene	74%	< 1%	19%	1	1	**1**	**1**	high
Chrysene	78%	< 1%	14%	1	1	**1**	**1**	high
Benzo(a)pyrene	68%	< 1%	25%	1	1	**1**	**1**	high
Benzo(ghy)perylene	79%	< 1%	14%	1	1	**1**	**1**	high
Benzo(k)fluoranthene	78%	< 1%	14%	1	1	**1**	**1**	high
Indeno, 1,2,3-cd pyrene	77%	< 1%	15%	1	1	**1**	**1**	high
Pyrene	78%	< 1%	14%	1	1	**1**	**1**	high
acenaphthene	77%	1%	14%	1	1	**1**	**1**	high
Benzo(b)fluoranthene	68%	< 1%	25%	1	1	**1**	**1**	high
Benzo(j)fluoranthene	68%	< 1%	25%	1	1	**1**	**1**	high
Dibenz(a,h)anthracene	17%	< 1%	81%	3	2	**3**	**1**	low
9H-Fluorene	69%	2%	20%	1	1	**1**	**1**	high
Acenaphthylene	64%	3%	23%	1	1	**1**	**1**	high
Chlorinated hydrocarbons								
1,2-dichloroethane	< 1%	94%	4%	1	2	**2**	**3**	low
dichloromethane	< 1%	98%	2%	1	2	**2**	**1**	medium
tetrachloromethane	< 1%	99%	< 1%	1	2	**2**	**1**	medium
tetrachloroethene	< 1%	99%	1%	1	2	**2**	**2**	medium
trichloromethane	< 1%	97%	1%	1	2	**2**	**1**	medium
trichloroethene	< 1%	98%	1%	1	2	**2**	**3**	low
vinylchloride	< 1%	100%	< 1%	1	2	**2**	**1**	medium
Monochlorobenzene	< 1%	90%	2%	1	2	**2**	**2**	medium
1,2-Dichlorobenzene	< 1%	81%	8%	1	2	**2**	**3**	low
1,3-Dichlorobenzene	n.a.							
1,4-Dichlorobenzene	< 1%	87%	6%	1	2	**2**	**1**	medium
1,2,3-Trichlorobenzene	1%	84%	11%	2	2	**2**	**3**	low
1,2,4-Trichlorobenzene	1%	83%	12%	2	2	**2**	**3**	low
1,3,5-Trichlorobenzene	< 1%	99%	< 1%	2	2	**2**	**3**	low
1,2,3,4-Tetrachlorobenzene	6%	24%	59%	2	2	**2**	**3**	low
1,2,3,5-Tetrachlorobenzene	2%	45%	45%	2	2	**2**	**3**	low
1,2,4,5-Tetrachlorobenzene	1%	91%	7%	2	2	**2**	**3**	low
Pentachlorobenzene	2%	54%	42%	2	2	**2**	**3**	low
Hexachlorobenzene	2%	2%	94%	2	2	**2**	**2**	medium
2-Chlorophenol	2%	43%	54%	1	2	**2**	**3**	low
3-Chlorophenol	8%	5%	86%	1	2	**2**	**3**	low
4-Chlorophenol	2%	4%	94%	1	2	**2**	**3**	low
2,3-Dichlorophenol	5%	23%	68%	1	2	**2**	**3**	low
2,4-Dichlorophenol	5%	3%	87%	1	2	**2**	**3**	low
2,5-Dichlorophenol	7%	28%	61%	1	2	**2**	**3**	low
2,6-Dichlorophenol	6%	23%	66%	1	2	**2**	**3**	low
3,4-Dichlorophenol	7%	14%	74%	2	2	**2**	**3**	low
3,5-Dichlorophenol	1%	37%	58%	1	2	**2**	**3**	low
2,3,4-Trichlorophenol	8%	10%	68%	1	2	**2**	**2**	medium
2,3,5-Trichlorophenol	8%	1%	76%	1	2	**2**	**2**	medium
2,3,6-Trichlorophenol	8%	1%	77%	1	2	**2**	**2**	medium
2,4,5-Trichlorophenol	10%	2%	74%	1	2	**2**	**2**	medium
2,4,6-Trichlorophenol	13%	3%	70%	1	2	**2**	**2**	medium
3,4,5-Trichlorophenol	10%	2%	74%	2	2	**2**	**2**	medium
2,3,4,5-Tetrachlorophenol	14%	3%	68%	2	2	**2**	**2**	medium
2,3,4,6-Tetrachlorophenol	3%	2%	78%	2	2	**2**	**2**	medium
2,3,5,6-Tetrachlorophenol	8%	5%	70%	1	2	**2**	**2**	medium
Pentachlorophenol	1%	< 1%	89%	2	2	**2**	**2**	medium
1-chloronaphatalene	4%	43%	42%	2	2	**2**	**3**	low
2-chloronaphatalene	5%	23%	58%	2	2	**2**	**3**	low
PCB 28	8%	5%	86%	3	2	**3**	**1**	low
PCB 52	3%	3%	93%	3	2	**3**	**1**	low
PCB101	7%	3%	89%	3	2	**3**	**1**	low

	Contribution (%) of the most relevant exposure routes to the total exposure			Reliability Score (RS) of the different model components and risk limits				
	ingestion soil	inhalation air inside	consump. of crops	phys-chem data	CSOIL concept	**human exposure**	**TDI/TCA**	RS $\text{SRC}_{\text{human}}$
PCB118	23%	< 1%	74%	3	2	**3**	**1**	low
PCB138	4%	< 1%	96%	3	2	**3**	**1**	low
PCB153	6%	< 1%	94%	3	2	**3**	**1**	low
PCB180	2%	< 1%	98%	3	2	**3**	**1**	low
1-MCDD	8%	6%	84%	2	2	**2**	**1**	medium
2-MCDD	8%	6%	84%	2	2	**2**	**1**	medium
27-DCDD	9%	1%	89%	3	2	**3**	**1**	low
28-DCDD	9%	< 1%	89%	3	2	**3**	**1**	low
124-TrCDD	9%	< 1%	89%	3	2	**3**	**1**	low
2,3,7,8-TCDD	9%	< 1%	90%	3	2	**3**	**1**	low
PCDD	10%	< 1%	89%	3	2	**3**	**1**	low
HxCDD	10%	< 1%	89%	3	2	**3**	**1**	low
HpCDD	10%	< 1%	89%	3	2	**3**	**1**	low
OCDD	10%	< 1%	89%	3	2	**3**	**1**	low
PCB 77	19%	< 1%	78%	3	2	**3**	**1**	low
PCB 105	19%	< 1%	79%	3	2	**3**	**1**	low
PCB 126	9%	< 1%	90%	3	2	**3**	**1**	low
PCB 156	10%	< 1%	89%	3	2	**3**	**1**	low
PCB 157	10%	< 1%	89%	3	2	**3**	**1**	low
PCB 169	8%	< 1%	91%	3	2	**3**	**1**	low
TetraCDF	9%	< 1%	89%	3	2	**3**	**1**	low
PentaCDF	9%	< 1%	89%	3	2	**3**	**1**	low
HexaCDF	10%	1%	88%	3	2	**3**	**1**	low
HeptaCDF	10%	1%	88%	3	2	**3**	**1**	low
OctaCDF	10%	< 1%	89%	3	2	**3**	**1**	low
Pesticides								
DDT	7%	< 1%	92%	2	2	**2**	**1**	medium
DDE	4%	< 1%	95%	2	2	**2**	**1**	medium
DDD	10%	< 1%	89%	2	2	**2**	**1**	medium
Aldrin	< 1%	1%	98%	2	2	**2**	**1**	medium
Dieldrin	11%	< 1%	86%	2	2	**2**	**1**	medium
Endrin	10%	< 1%	88%	2	2	**2**	**1**	medium
a-HCH	9%	18%	66%	2	2	**2**	**1**	medium
b-HCH	10%	18%	65%	2	2	**2**	**1**	medium
g-HCH	4%	< 1%	89%	1	2	**2**	**1**	medium
d-HCH	7%	3%	82%	1	2	**2**	**-**	-
Carbaryl	4%	6%	79%	1	2	**2**	**1**	medium
Carbofuran	< 1%	< 1%	97%	1	2	**2**	**1**	medium
Maneb	-	-	-	-	-	**-**	**1**	-
Atrazine	< 1%	< 1%	98%	1	2	**2**	**1**	medium
Other pollutants								
Mineral oil								
aliphatic >EC5-EC6	< 1%	100%	< 1%	1	2	**2**	**2**	medium
aliphatic >EC6-EC8	< 1%	100%	< 1%	2	2	**2**	**2**	medium
aliphatic >EC8-EC10	< 1%	100%	< 1%	2	2	**2**	**2**	medium
aliphatic >EC10-EC12	< 1%	100%	< 1%	3	2	**3**	**2**	low
aliphatic >EC12-EC16	56%	29%	10%	2	1	**2**	**2**	medium
aliphatic >EC16-EC21	78%	< 1%	13%	1	1	**1**	**2**	medium
aromatic >EC5-EC7	< 1%	99%	< 1%	1	2	**2**	**2**	medium
aromatic >EC7-EC8	< 1%	98%	1%	1	2	**2**	**2**	medium
aromatic >EC8-EC10	< 1%	98%	1%	1	2	**2**	**2**	medium
aromatic >EC10-EC12	1%	91%	4%	1	2	**2**	**2**	medium
aromatic >EC12-EC16	20%	55%	14%	2	2	**2**	**2**	medium
aromatic >EC16-EC21	72%	5%	14%	1	1	**1**	**2**	medium
aromatic >EC21-EC35	79%	< 1%	14%	1	1	**1**	**2**	medium
phthalates								
dimethyl phthalate (DMP) *)	3%	4%	36%	2	3	**3**	**2**	low
diethyl phthalate (DEP) *)	11%	4%	39%	2	3	**3**	**2**	low
diisobutylphthalate (DIBP) *)	3%	< 1%	81%	3	2	**3**	**2**	low
dibuthyl phthalate (DBP) *)	1%	3%	83%	2	2	**2**	**3**	low
Butylbenzylphthalate	71%	< 1%	21%	1	1	**1**	**2**	medium
dihexyl phthalate (DHP) *)	5%	1%	93%	3	2	**3**	**2**	low
Di(2-ethylhexyl)phthalate	2%	< 1%	98%	3	2	**3**	**2**	low
Others								
Cyclohexanone	< 1%	42%	53%	1	2	**2**	**1**	medium
Pyridine	1%	3%	35%	1	3	**3**	**2**	low
Tetrahydrofuran	< 1%	23%	27%	1	3	**3**	**3**	low
Tetrahydrothiophene	< 1%	58%	14%	1	2	**2**	**2**	medium

Appendix 5 Overview of derived risk limits for soil, groundwater and sediment

Appendix 5A Ecotoxicological and human-toxicological SRC and integrated SRC soil and SRC sediment (10% organic matter, 25% clay)

Contaminant	**MPRhuman TDI old [ug.kg-1.d-1]**	**TCL old**	**TDI/CRoral new [ug.kg-1.d-1]**	**TCA/CRin new [ug/m3]**	**Detection limit in soil [mg.kg-1]**	**TV soil current [mg.kg-1]**	**ECOTOX current [mg.kg-1]**	**HUMAN current [mg.kg-1]**	**IV soil current [mg.kg-1]**	**SRCeco soil new [mg.kg-1]**	**SRChumar soil new [mg.kg-1]**	***Integrated SRC soil* [mg.kg-1]**	**SRCeco sediment new [mg.kg-1]**	**SRChumar sediment new [mg.kg-1]**	***Integrated SRC sediment* [mg.kg-1]**
Reference			Baars et al., 2001		VROM, 2000	VROM, 2000	Swartjes, 1999	Swartjes, 1999	VROM, 2000	Verbrugge e.a., 2001	This report		Verbrugge e.a., 2001	this report Otte et al, 200oa	
I Metals and trace elements															
Arsenic	2,1		1	1		29	40	678	55	85	576	**85**	5900	3300	**3300**
Barium	20		20	n.a.	105	160	625	4260	625	890	9342	**890**	7200	-	**7200**
Cadmium	1		0,5	n.a.	1,2	0,8	12	34,9	12	13	28	**13**	820	1800	**820**
Chromium*2										220			43000	17600	**17600**
ChromiumIII (soluble)	5		5	60		100	230	2250	380	220	2756	**220**	43000	17600	**17600**
CromiumVI			5	2,50E-03						220	78	**78**	-	-	
Cobalt	1,4		1,4	0,5		9	240	452	240	180	43	**43**	3200	-	**3200**
Copper	140		140	1		36	190	15700	190	96	8600	**96**	660	>100000	**660**
Mercury											210				
Mercury (inorganic)	0,61		2	0,2		0,3	10	197	10	36	210	**36**	1500	6700	**1500**
Mercury (organic)			0,1	n.a.						4	-	**4**	-	-	-
Lead*3	3,6		3,6	n.a.		85	290	300*3	530	580	622	**580**	63000	3210	**3210**
Molybdenum	10		10	12		3	480	911	200	190	1307	**190**	23000	-	**23000**
Nickel	50		50	0,05		35	210	6580	210	100	1470	**100**	2600	>100000	**2600**
Zinc	1000		500	n.a.	60	140	720	56500	720	350	46100	**350**	6600	>100000	**6600**
II Inorganic compounds															
Cyanides (free)	50	200	50	25		1	-	16,8	20	-	-*6	**-**	-	-	-
Cyanides (complex, pH<5)	13		800	n.a.		5	-	4,36	650	-	-*6	**-**	-	-	-
Cyanides (complex, pH>5)	13		800	n.a.		5	-	4,36	50	-	-*6	**-**	-	-	-
Thiocyanates (sum)	11		11	n.a.		1	-	3,69	20	620	-*6	**620**	-	-	-
III Aromatic compounds															
Benzene	4,3	30	3,3	20	0,06	0,01	25	1,09	1	130	1,1	**1,1**	130	5,5	**5,5**
Ethyl benzene	136	77	100	770	0,09	0,03	-	50	50	110	111	**110**	110	110	**110**
Phenol	60	100	40	20	0,03	0,05	40	74,1	40	14	390	**14**	14	174	**14**
Cresoles (sum)	50	170	50	170	0,03	0,05	50	117	5	13	365	**13**	27	122	**27**
o-Cresol										50	324	50	66	108	66
m-Cresol										16	423	16	110	137	110
p-Cresol										2,6	354	2,6	2,6	122	2,6
Toluene	430	3000	223	400	0,18	0,01	130	339	130	47	32	**32**	79	191	**79**
Xylenes (sum)	10	54	150	870	0,12	0,1	-	25,6	25	17	156	**17**	17	127	**17**
o-Xylene										9,3	109	9,3	9,3	81	9,3
m-Xylene										18	248	18	18	223	18
p-Xylene										30	140	30	30	114	30
Dihydroxybenzenes (sum)			25	n.a.						8	no sum	**8**	8	no sum	**8**
Catechol	40		40	n.a.	0,03	0,05	-	22,9	20	2,6	457	**2,6**	2,6	1100	2,6
Resorcinol	20		20	n.a.	0,03	0,05	-	10,4	10	4,6	20	**4,6**	4,6	190	4,6
Hydroquinone	25		25	n.a.	0,03	0,05	-	10,8	10	43	96	**43**	43	1100	43
Styrene	77	800	120	900	0,15	0,3	-	249	100	86	472	**86**	86	224	**86**

Contaminant	**MPRhuman TDI old [ug.kg-1.d-1]**	**TCL old**	**TDI/CRoral new [ug.kg-1.d-1]**	**TCA/CRin new [ug/m3]**	**Detection limit in soil [mg.kg-1]**	**TV soil current [mg.kg-1]**	**ECOTOX current [mg.kg-1]**	**HUMAN current [mg.kg-1]**	**IV soil current [mg.kg-1]**	**SRCeco soil new [mg.kg-1]**	**SRChumar soil new [mg.kg-1]**	***Integrated SRC soil* [mg.kg-1]**	**SRCeco sediment new [mg.kg-1]**	**SRChumar sediment new [mg.kg-1]**	***Integrated SRC sediment* [mg.kg-1]**
Reference			Baars et al., 2001		VROM, 2000	VROM, 2000	Swartjes, 1999	Swartjes, 1999	VROM, 2000	Verbrugge e.a., 2001	This report		Verbrugge e.a., 2001	this report Otte et al, 200oa	
IV Polycyclic aromatic hydrocarbons															
Total PAHs (17)						-	40	-	40	no sum	sum*7	**no sum**	no sum	sum*7	**no sum**
Naphthalene	50		40	?		-	-	603	-	17	870	**17**	17	120	**17**
Anthracene	50		40	n.a.		-	-	29000	-	1,6	25500	**1,6**	1,6	4200	**1,6**
Phenanthrene	20		40	n.a.		-	-	661	-	31	23000	**31**	31	440	**31**
Fluoranthene	20		50 *4	n.a.		-	-	1070	-	260	30300	**260**	260	1600	**260**
Benzo(a)anthracene	20		5 *4	n.a.		-	-	11200	-	2,5	3000	**2,5**	49	290	**49**
Chrysene	2		50 *4	n.a.		-	-	420	-	35	32000	**35**	42	6000	**42**
Benzo(a)pyrene	2		0,5	n.a.		-	-	1110	-	7	280	**7,0**	28	17	**17**
Benzo(ghi)perylene	20		30 *4	n.a.		-	-	12000	-	33	19200	**33**	33	3600	**33**
Benzo(k)fluoranthene	20		5 *4	n.a.		-	-	11600	-	38	3200	**38**	38	560	**38**
Indeno(1,2,3-cd)pyrene	20		5 *4	n.a.		-	-	11800	-	1,9	3200	**1,9**	1,9	580	**1,9**
Pyrene *)			500 *4	n.a.							320000			60000	
acenaphthene (1,2-dihydroacenaphthylene) *)			500 *4	n.a.							315000			47000	
acenaphthylene *)			50 *4	n.a.							26000			170	
Benzo(b)fluoranthene *)			5 *4	n.a.							2800			100	
Benzo(j)fluoranthene *)			5 *4	n.a.							2800			90	
Dibenz(a,h)anthracene *)			0,5 *4	n.a.							70			27	
9H-Fluorene *)			40	n.a.							23000			210	
V Chlorinated hydrocarbons															
1,2-dichloroethane	14	48	14	48		0,02	60	3,86	4	240	6,4	**6,4**	240	62	**62**
Dichloromethane	60	1700	60	3000	1,5	0,4	60	18,9	10	3,9	68	**3,9**	40	210	**40**
Tetrachloromethane	4	60	4	60		0,4	60	0,92	1	29	0,7	**0,7**	29	3,2	**3,2**
Tetrachloroethene	16	2500	16	250		0,002	60	3,89	4	16	8,8	**9**	16	19	**16**
Trichloromethane	30	100	30	100		0,02	60	8,86	10	170	5,6	**5,6**	170	84	**84**
Trichloroethene	540	1900	50	200		0,1	60	303	60	2,5	10	**2,5**	130	93	**93**
Vinylchloride	3,5	100	0,6	3,6	0,03	0,01	60	0,077	0,1	17	0,0022	**0,002**	17	1,6	**1,6**
Total chlorobenzenes	-					-	30	-	30	sum*7	no sum	**no sum**	sum*7	no sum	**no sum**
Monochlorobenzene	300	1000	200	500	0,5	0,08	-	520	-	15	114	**15**	15	280	**15**
Dichlorobenzenes (sum)	190	600	-	-		0,004	-	1154	-	19	476	**19**	19	332	**19**
1,2-Dichlorobenzene			430	600		0,004	-	1154	-	17	477	17	17	550	17
1,3-Dichlorobenzene			-	-						24	-	24	24	-	24
1,4-Dichlorobenzene			100	670						18	475	18	18	200	18
Trichlorobenzenes (sum)	0,5	600				0,002	-	9,04	-	11	40	**11,0**	25	31,0	**25**
1,2,3-Trichlorobenzene			8	50						5	59	5,0	10	17	10
1,2,4-Trichlorobenzene			8	50						5,1	82	5,1	5,1	22	5,1
1,3,5-Trichlorobenzene			8	50						50	13	13	310	80	80
Tetrachlorobenzenes (sum)	0,5	600	0,5	n.a.		0,0007	-	18	-	2,2	7,5	**2,2**	39	2,1	**2,1**
1,2,3,4-Tetrachlorobenzene										16	25	16	40	3	3
1,2,3,5-Tetrachlorobenzene										0,65	8	0,65	47	1,4	1,4
1,2,4,5-Tetrachlorobenzene										1	2,1	1,0	31	2,3	2,3
Pentachlorobenzene	0,5	600	0,5	n.a.		0,001	-	23,7	-	16	6,7	**6,7**	16	1,5	**1,5**
Hexachlorobenzene	0,5	600	0,16	0,75		0,00005	-	26,8	-	2	2,7	**2,0**	2	0,23	**0,23**
Total chlorophenols	-		-	-		-	10	-	10	no sum	sum*8	**no sum**	no sum	sum*8	**no sum**
Monochlorophenols (sum)	3		3	n.a.	0,03	0,002	10	14	-	5,4	77	**5,4**	8,5	11,7	**9**
o-Monochlorophenol										7,8	40	7,8	7,8	12	7,8
m-Monochlorophenol										14	200	14	54	20	20
p-Monochlorophenol										1,4	57	1,4	1,4	7	1,4
Dichlorophenols (sum)	3		3	n.a.		0,003	10	32,5	-	22	105	**22**	22	10,2	**10**

Contaminant	MPRhuman TDI old [ug.kg-1.d-1]	TCL old	TDI/CRoral new [ug.kg-1.d-1]	TCA/CRin new [ug/m3]	Detection limit in soil [mg.kg-1]	TV soil current [mg.kg-1]	ECOTOX current [mg.kg-1]	HUMAN current [mg.kg-1]	IV soil current [mg.kg-1]	SRCeco soil new [mg.kg-1]	SRChumar soil new [mg.kg-1]	*Integrated SRC soil* [mg.kg-1]	SRCeco sediment new [mg.kg-1]	SRChumar sediment new [mg.kg-1]	*Integrated SRC sediment* [mg.kg-1]
Reference			Baars et al., 2001		VROM, 2000	VROM, 2000	Swartjes, 1999	Swartjes, 1999	VROM, 2000	Verbrugge e.a., 2001	This report		Verbrugge e.a., 2001	this report Otte et al, 200oa	
2,3-Dichlorophenol										31	117	31	31	16	16
2,4-Dichlorophenol										8,4	114	8,4	8,4	9	8,4
2,5-Dichlorophenol										53	155	53	53	17	17
2,6-Dichlorophenol										57	148	57	57	22	22
3,4-Dichlorophenol										27	161	27	27	9,2	9,2
3,5-Dichlorophenol										5,4	27	5,4	5,4	2,2	2,2
Trichlorophenols (sum)	3		3	n.a.	0,0015	0,001	10	56,3	-	22	231	**22**	41	8,8	**8,8**
2,3,4-Trichlorophenol										30	186	30	30	20	20
2,3,5-Trichlorophenol										4,5	199	4,5	22	18,7	18,7
2,3,6-Trichlorophenol										110	198	110	110	17	17
2,4,5-Trichlorophenol										22	254	22	22	22	22
2,4,6-Trichlorophenol										8,1	327	8,1	80	1,9	1,9
3,4,5-Trichlorophenol										39	247	39	39	1,8	1,8
Tetrachlorophenols (sum)	3		3	n.a.	0,0015	0,001	10	18,3	-	21	172	**21**	22	9,6	**9,6**
2,3,4,5-Tetrachlorophenol										64	343	64	67	37	37
2,3,4,6-Tetrachlorophenol										13	80	13	13	1,1	1,1
2,3,5,6-Tetrachlorophenol										12	184	12	12	22	12
Pentachlorophenol	30		3	n.a.	0,0015	0,002	5	79,8	-	12	20	**12**	8	0,5	**0,5**
Chloronaphthalenes (sum)	0,5	600	80	1		-	-	9,12	10	23	29	**23**	23	207	**23**
1-Chloronaphthalene										18	19	18	18	215	18
2-Chloronaphthalene										30	45	30	30	200	30
Total polychlorobiphenyls	0,09		0,01	0,5	0.003-0,006	0,02	1	-	1	3,4	sum*7	**sum*7**	3,4	sum*7	**sum*7**
PCB28											0,69	**0,69**		0,06	**0,06**
PCB52											0,28	**0,28**		0,03	**0,03**
PCB101											0,61	**0,61**		0,20	**0,20**
PCB118											1,9	**1,9**		0,69	**0,69**
PCB138											0,32	**0,32**		0,28	**0,28**
PCB153											0,46	**0,46**		0,37	**0,37**
PCB180											0,17	**0,17**		0,45	**0,45**
Trichlorobiphenyl (PCB18)	0,09		-	-		-	-	5,52	-					-	
Hexachlorobiphenyl (PCB128	0,09		-	-		-	-	8,72	-						
Dioxins (+PCDF and PCB) *5	0,00001		0,000004	n.a.		-	0,046	0,001	(0.001)*1		**0,00036**	**0,00036**	-	**0,00021**	**0,00021**
2,3,7,8-TeCDD *5; TEF=1			0,000004	n.a.							0,00031			9,3E-05	
PCDD *5; TEF=1			0,000004	n.a.							0,00031			2,1E-04	
HxCDD *5; TEF 0.1			0,000004	n.a.							0,00032			3,0E-04	
HpCDD *5; TEF=0.01			0,000004	n.a.							0,00032			3,4E-04	
OCDD *5; TEF=0.0001			0,000004	n.a.							0,00032			3,7E-04	
PCB77 *5; TEF=0.0001			0,000004	n.a.						4,2	0,00063		4,2	1,4E-04	
PCB105 *5; TEF=0.0001			0,000004	n.a.						10	0,00063		10	2,1E-04	
PCB118 *5; TEF=0.0001			0,000004	n.a.							0,00076				
PCB126 *5; TEF=0.1			0,000004	n.a.						0,92	0,00030		0,92	1,6E-04	
PCB156 *5; TEF=0.0005			0,000004	n.a.							0,00032			2,7E-04	
PCB157 *5; TEF=0.0005			0,000004	n.a.							0,00032			2,5E-04	
PCB169 *5; TEF=0.01			0,000004	n.a.							0,00026			1,8E-04	
TetraCDF *5; TEF=0.1			0,000004	n.a.							0,00031			6,1E-05	
PentaCDF *5; TEF=0.5/0.05			0,000004	n.a.							0,00031			1,0E-04	
HexaCDF *5; TEF=0.1			0,000004	n.a.							0,00031			3,0E-04	
HeptaCDF *5; TEF=0.01			0,000004	n.a.							0,00032			3,2E-04	
OctaCDF *5; TEF=0.0001			0,000004	n.a.							0,00032			3,8E-04	

Contaminant	**MPRhuman TDI old [ug.kg-1.d-1]**	**TCL old**	**TDI/CRoral new [ug.kg-1.d-1]**	**TCA/CRin new [ug/m3]**	**Detection limit in soil [mg.kg-1]**	**TV soil current [mg.kg-1]**	**ECOTOX current [mg.kg-1]**	**HUMAN current [mg.kg-1]**	**IV soil current [mg.kg-1]**	**SRCeco soil new [mg.kg-1]**	**SRChumar soil new [mg.kg-1]**	***Integrated SRC soil* [mg.kg-1]**	**SRCeco sediment new [mg.kg-1]**	**SRChumar sediment new [mg.kg-1]**	***Integrated SRC sediment* [mg.kg-1]**
Reference			Baars et al., 2001		VROM, 2000	VROM, 2000	Swartjes, 1999	Swartjes, 1999	VROM, 2000	Verbrugge e.a., 2001	This report		Verbrugge e.a., 2001	this report Otte et al, 200oa	
VI Pesticides															
Organochlorine pesticides:															
Total DDT/DDE	-		0,5	n.a.	0,003	-	4	-	4	no sum	23	**no sum**	no sum	7,3	**no sum**
DDT	20		0,5	n.a.		0,09	-	11300	-	1	31	**1**	9,5	11	**9,5**
DDE	20		0,5	n.a.		0,01	-	7830	-	1,3	17	**1,3**	1,3	7	**1,3**
DDD			0,5	n.a.						34	42	**34**	34	5	**5**
Total drins	0,1					-	4	-	4	0,14	no sum	**0,14**	1,2	no sum	**no sum**
Aldrin and dieldrin					0,003					0,22	sum*7	**0,22**		sum*7	
Aldrin	0,1		0,1	0,35	0,003	0,06	0,35	13,8	-	-	0,32	**0,32**	1,7	0,06	**0,06**
Dieldrin	0,1		0,1	0,35	0,003	0,5	4	5,45	-	-	9,1	**9,1**	1,9	1,6	**1,6**
Endrin	0,1		0,2	0,7	0,003	0,04	0,06	4,36	-	0,095	16	**0,095**	0,48	2,9	**0,48**
Total HCHs	1	0,25			0,003	-	2	-	2	6,4	no sum	**no sum**	10	no sum	**no sum**
a-HCH	1		1	0,25	0,003	3	2	21,1	-	17	20	**17**	17	15	**15**
b-HCH	0,02	0,25	0,02	n.a.	0,003	9	-	0,42	-	13	1,6	**1,6**	13	0,33	**0,33**
g-HCH	1	0,25	0,04	0,14	0,003	0,05	2	21,1	-	1,2	1,3	**1,2**	5	0,30	**0,3**
d-HCH	1	0,25	-	-					-	-	-	**no IV**	-	-	**no IV**
Carbamates:															**0**
Carbaryl	10		3	10	0,03	0,00003	5	461	5	0,45	107	**0,45**	0,45	36	**0,45**
Carbofuran	10		2	n.a.	0,03	0,00002	1,5	435	2	0,017	5,7	**0,017**	0,017	34	**0,017**
Other pesticides:															
Maneb	50		50	18	0,03	0,0002	35	29800	35	22	no SRC	**22**	-	no SRC	**no IV**
Atrazine (triazines)	2		5	n.a.	0,006	0,0002	6	21	6	0,71	18	**0,71**	0,71	37	**0,71**
VII Other pollutants															
Mineral oil	25000		-	-		50	-	-	5000	-	sum*7		-	sum*7	
alifaten EC 5-6			2000	18400						-	35		-	47000	
alifaten EC >6-8			2000	18400						-	109		-	>100000	
alifaten EC >8-10			100	1000						-	28		-	10600	
alifaten EC >10-12			100	1000						-	152		-	12100	
alifaten EC >12-16			100	1000						-	55000		-	12200	
alifaten EC >16-21			2000	-						-	1280000		-	>100000	
aromaten EC 5-7			200	400						-	29		-	190	
aromaten EC >7-8			200	400						-	62		-	280	
aromaten EC >8-10			40	200						-	59		-	100	
aromaten EC >10-12			40	200						-	317		-	180	
aromaten EC >12-16			40	200						-	5900		-	420	
aromaten EC >16-21			30	-						-	17500		-	2600	
aromaten EC >21-35			30	-						-	19200		-	3600	
Cyclohexanone	4600	136	4600	136	0,03	0,1	-	270*4	45	150	214	**150**	150	>100000	**150**
Total phthalates	25		4		0,03	0,1	60	-	60	no sum	no sum	**no sum**	no sum	no sum	**no sum**
Dimethyl phthalate			value of total phthalate							84	82	**82**	84	170	**84**
Diethyl phthalate			200							53	17000	**53**	580	2500	**580**
Di-isobutylphthalate			value of total phthalate							17	83	**17**	17	11	**11**
Dibutyl phthalate			52							36	22600	**36**	36	50	**36**
Butyl benzylphthalate	25		500			-	-	776	-	48	294000	**48**	48	9700	**48**
Dihexyl phthalate			value of total phthalate							220	381	**220**	220	12	**12**
Di(2-ethylhexyl)phthalate	25		4			-	-	4628	-	69	60	**60**	10	60	**10**
Pyridine	1	120	1	120	0,3	0,1	150	1,06	0,5	50	11	**11**	280	32	**32**
Tetrahydrofuran	10	35	10	35		0,1	-	0,4	2	120	7	**7,0**	120	48	**48**
Tetrahydrothiophene	180	650	180	650	0,15	0,1	-	94	90	8,8	234	**8,8**	8,8	426	**8,8**

Contaminant	**MPRhuman TDI old [ug.kg-1.d-1]**	**TCL old**	**TDI/CRoral new [ug.kg-1.d-1]**	**TCA/CRin new [ug/m3]**	**Detection limit in soil [mg.kg-1]**	**TV soil current [mg.kg-1]**	**ECOTOX current [mg.kg-1]**	**HUMAN current [mg.kg-1]**	**IV soil current [mg.kg-1]**	**SRCeco soil new [mg.kg-1]**	**SRChumar soil new [mg.kg-1]**	***Integrated SRC soil* [mg.kg-1]**	**SRCeco sediment new [mg.kg-1]**	**SRChumar sediment new [mg.kg-1]**	***Integrated SRC sediment* [mg.kg-1]**
Reference			Baars et al., 2001		VROM, 2000	VROM, 2000	Swartjes, 1999	Swartjes, 1999	VROM, 2000	Verbrugge e.a., 2001	This report		Verbrugge e.a., 2001	this report Otte et al, 200oa	

-	not available
Dl	detection limit
*)	because substances have been added later, less physicochemical data are used for deriving the SRChuman (Otte et al, 2000a)
*1	no reliable value could be derived. In the Ministerial Circulars this value (between brackets) is called a Indicative Level for serious soil contamination
*2	based on chromium (III) only
*3	based on exposure and Maximal Permissible Risk for intake for a child and relative bioavailability for lead in soil in the body of 0.6
*4	based on additional carcinogenic risk of 1:10-4 for lifetime exposure
*5	human values are expressed as toxicity equivalents (TEQ), based on the most toxic compound, 2,3,7,8 TCDD (Van den Berg et al., 1998)
*6	see report on the evaluation of the Intervention Value of cyanides (Koster et al, 2000)
*7	sum or group value should be applied using the "Toxic Unit" approach (or 'fraction approach'), because compounds within this group (probably) have the same mode of actio
*8	sum or group value should be applied using the "Toxic Unit" approach (or 'fraction approach'), because mono to tetrachlorophenols (probably) have the same mode of action

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Appendix 5B Integrated SRCs for groundwater (GW), human and ecotoxicological SRCs and other relevant quality standards

Bold values are used to derive the integrated value; coordination with the Target Value and detection limit still has to be performed

Contaminant	Detection limit in groundw.	Current Target Value GW		Current IV GW	***Integrated SRC GW***	**Max. conc. in GW as drinkingw**	**SRC human GW**	**SRCeco GW**	WHO guideline value		WLB 2000	EC Drinkingw. Directive	Signal Value drinkingw. ruminants	**Equilibrium Partitioning with** SRC for soil	**SRC human for soil**
Reference	VROM, 2000	VROM,2000 deep	<10 m	Swartjes, 1999	***(lowest)***			**Verbrugg 2000**	(WHO, 1993,199		Versteegh 1999	1998	(IKC,1996)		
	[ug.l-1]	[ug.l-1]	[ug.l-1]	[ug.l-1]	***[ug.l-1]***	**[ug.l-1]**	**[ug.l-1]**	**[ug.l-1]**	[ug.l-1]		[ug.l-1]	[ug.l-1]	[ug.l-1]	[ug.l-1]	**[ug.l-1]**
I Metals and trace elements															
Arsenic	0,6	7,2	10	60	***33***	**33**	**-**	**890**	10	P	50	50	-	47	**320**
Barium	4	200	50	625	***666***	**666**	**-**	**7100**	700		*500*	*500*	-	356	**3736**
Cadmium	0,1	0,06	0,4	6	***10***	**17**	**-**	**9,7**	3		5	5	10	5	**11**
Chromium*2	0,5	2,5	1	30	***166***	**166**	**-**	**220**			50	50		-	**-**
ChromiumIII		2,5	1	30	***166***	**166**	**-**	**220**	50	P	-	-	1000	46	**574**
CromiumVI		2,5	1		***166***	**166**	**-**	**260**			-	-			**-**
Cobalt	1	0,7	20	100	***47***	**47**	**-**	**810**	-		-	-	1000	358	**361**
Copper	1	1,3	15	75	***19***	**4660**	**-**	**19**	2000	P	*2000*	*2000*	500	45	**4056**
Mercury	0,01	0,01	0,05	0,3	***0,36***		**-**	**0,36**	1		1	1	10		
Mercury (inorganic)					***14***	**67**	**-**	**14**			-	-		5	**28,0**
Mercury (organic)					***0,36***	**3**	**-**	**0,36**			-	-			**-**
Lead*3	3	1,7	15	75	***17***	**54**	**-**	**150**	10	ATO	10	10	100	16	**17**
Molybdenum	24	3,6	5	300	***333***	**333**	**-**	**27000**	70		-	-	100	4720	**32472**
Nickel	2	2,1	15	75	***500***	**1664**	**-**	**500**	20		20	20	100	50	**735**
Zinc	5	24	65	800	***91***	**16643**	**-**	**91**	-		*3000*	-	24	135	**17729**
II Inorganic contaminants															
Cyanides total (as CN)		-		-		**164**	**-**	**-**	-				-	0	
Cyanides, free (as CN)	2	5		1500	***31***	**1600**	**-**	**31**	70	as CN-	50	50	-	0	
Cyanides, complex (as CN)		10		1500	***29***	**26629**	**-**	**29**	-				-	0	
Thiocyanates (as SCN)	100	-		1500	***366***	**366**	**-**	**10000**	-				-	0	
III Aromatic contaminants															
Benzene	0,002	0,2		30	***110***	**110**	**251**	**30000**	10	10^-5	1	1	-	242	
Ethyl benzene	0,001	4		150	***3329***	**3329**	**5570**	**5500**	300	ATO	1		-	5527	
Phenol	0,5	0,2		2000	***1331***	**1331**	**180000**	**7000**	-		1		-	6450	
Cresoles (sum)	0,1	0,2		200	***1664***	**1664**	**127997**	**10000**	-		1		-		
o-Cresol					***1664***	**1664**	**129000**	**29000**			1			19948	
m-Cresol					***1664***	**1664**	**128000**	**36000**			1			4857	
p-Cresol					***1000***	**1664**	**127000**	**1000**			1			935	
Toluene	0,007	7		1000	***4360***	**7423**	**4360**	**11000**	700	ATO	1		-	4333	
Xylenes (sum)	0,002	0,2		70	***1100***	**4993**	**10074**	**1100**	500	ATO	1		-		
o-Xylene					***1000***	**4993**	**12000**	**1000**			1			1030	
m-Xylene					***1200***	**4993**	**9210**	**1200**			1			673	
p-Xylene					***1100***	**4993**	**9250**	**1100**			1			1979	
Dihydroxybenzenes (sum)					***3100***	**-**	**-**	**3100**			1				
Catechol		0,2		1250	***630***	**1331**	**105000**	**630**	-		1		-	597	
Resorcinol		0,2		600	***666***	**666**	**18500**	**5700**	-		1		-	4378	
Hydroquinone		0,2		800	***832***	**832**	**17800**	**8200**	-		1		-	7935	
Styrene	0,001	6		300	***3800***	**3994**	**21200**	**3800**	20	ATO	1		-	3856	

Contaminant	Detection limit in groundw.	Current Target Value GW		Current IV GW	***Integrated SRC GW***	**Max. conc. in GW as drinkingw**	**SRC human GW**	**SRCeco GW**	WHO guideline value	WLB 2000	EC Drinkingw. Directive	Signal Value drinkingw. ruminants	**Equilibrium Partitioning with** SRC for soil	**SRC human for soil**
Reference	VROM, 2000	VROM,2000 deep	<10 m	Swartjes, 1999	***(lowest)***			**Verbrugg 2000**	(WHO, 1993,199	Versteegh 1999	1998	(IKC,1996)		
	[ug.l-1]	[ug.l-1]	[ug.l-1]	[ug.l-1]	***[ug.l-1]***	**[ug.l-1]**	**[ug.l-1]**	**[ug.l-1]**	[ug.l-1]	[ug.l-1]	[ug.l-1]	[ug.l-1]	[ug.l-1]	**[ug.l-1]**
IV Polycyclic aromatic hydrocarbons														
Total PAHs (17)	0.001-0.01	-		-	***no sum***	**-**	**sum*6**	**no sum**	-					
Naphthalene		0,01		70	***290***	**1331**	**15600**	**290**	-			-	306	
Anthracene		0,0007		5	***1,4***	**1331**	**71**	**1,4**	-	0,05		-	1,38	
Phenanthrene		0,003		5	***30***	**1331**	**850**	**30**	-	0,05		-	31,46	
Fluoranthene		0,003		1	***30***	**1664**	**201**	**30**	-	0,05		-	29,62	
Benzo(a)anthracene		0,0001		0,5	***1,0***	**166**	**12**	**1**	-	0,05		-	0,07	
Chrysene		0,003		0,2	***1,2***	**1664**	**1,8**	**1,2**	-	0,05		-	1,15	
Benzo(a)pyrene		0,0005		0,05	***0,72***	**17**	**0,84**	**0,72**	0,7 10^-5	0,01	0,01	-	0,18	
Benzo(ghi)perylene		0,0003		0,05	***0,18***	**999**	**0,19**	**0,18**	-	0,05	0,1	-	0,21	
Benzo(k)fluoranthene		0,0004		0,05	***0,36***	**166**	**0,48**	**0,36**	-	0,05	0,1	-	0,38	
Indeno(1,2,3-cd)pyrene		0,0004		0,05	***0,04***	**166**	**0,27**	**0,036**	-	0,05	0,1	-	0,03	
Pyrene *)					***106***	**16643**	**106**							
acenaphthene (1,2-dihydroacenaphthylene) *)					***2570***	**16643**	**2570**							
acenaphthylene *)					***1664***	**1664**	**4010**							
Benzo(b)fluoranthene *)					***17***	**166**	**17**							
Benzo(j)fluoranthene *)					***8,8***	**166**	**8,8**							
Dibenz(a,h)anthracene *)					***0,83***	**17**	**0,83**							
9H-Fluorene *)					***1320***	**1331**	**1320**							
V Chlorinated hydrocarbons														
1,2-dichloroethane	0,1	7		400	***466***	**466**	**3140**	**130000**	30 10^-5	*3*	3	-	3134	
Dichloromethane	0,005	0.01(dl)		1000	***1997***	**1997**	**55800**	**40000**	20	*1*		-	3216	
Tetrachloromethane	0.001-0.01	0.01(dl)		10	***133***	**133**	**190**	**8700**	2	*1*		-	199	
Tetrachloroethene	0,005	0.01(dl)		40	***533***	**533**	**560**	**1000**	40	*10*	10	-	568	
Trichloromethane	0,008	6		400	***999***	**999**	**1910**	**63000**	-	*50*	100	-	1930	
Trichloroethene	0,004	24		500	***1500***	**1664**	**1500**	**20000**	70 P	*10*	10	-	362	
Vinylchloride	0.001-0.01	0.01(dl)		5	***0,40***	**20**	**0,4**	**8000**	5 10^-5	*0,5*	0,5	-	1	
Total chlorobenzenes		-		-	***no sum***	**-**	**no sum**	**sum*6**	-	*1*		-		
Monochlorobenzene	0,001	7		180	***1100***	**6657**	**8790**	**1100**	300 ATO	*1*		-	1159	
Dichlorobenzenes (sum)	0,003	3		50	***650***	**-**	**15840**	**650**	1000/NAD/300	*1*		-		
1,2-Dichlorobenzene					*740*	**14313**	**20400**	**740**		*1*			728	
1,3-Dichlorobenzene					*820*	**-**	**-**	**820**		*1*			837	
1,4-Dichlorobenzene					*460*	**3329**	**12300**	**460**		*1*			467	
Trichlorobenzenes (sum)	0.001-0.01	0.01(dl)		10	***140***		**217**	**140**	20 ATO	*1*		-		
1,2,3-Trichlorobenzene					*100*	**266**	**595**	**100**		*1*			51	
1,2,4-Trichlorobenzene					*46*	**266**	**743**	**46**		*1*			46	
1,3,5-Trichlorobenzene					*23*	**266**	**23**	**550**		*1*			23	
Tetrachlorobenzenes (sum)	0.001-0.01	0.01(Dl)		2,5	***17***	**17**	**23**	**120**	-	*1*		-		
1,2,3,4-Tetrachlorobenzene					*17*	**17**	**53,7**	**83**		*1*			34	
1,2,3,5-Tetrachlorobenzene					*17*	**17**	**38,8**	**210**		*1*			3	
1,2,4,5-Tetrachlorobenzene					*6*	**17**	**6,14**	**90**		*1*			3	
Pentachlorobenzene	0.001-0.01	0,003		1	***14***	**17**	**13,9**	**32**	-	*1*		-	14	
Hexachlorobenzene	0.001-0.01	0,00009		0,5	***3***	**5**	**4,05**	**3**	1 10^-5	*1*		-	3	

Contaminant Reference	Detection limit in groundw. VROM, 2000 [ug.l-1]	Current Target Value GW VROM,2000 deep [ug.l-1]	 <10 m [ug.l-1]	Current IV GW Swartjes, 1999 [ug.l-1]	Integrated SRC GW (lowest) [ug.l-1]	Max. conc. in GW as drinkingw [ug.l-1]	SRC human GW [ug.l-1]	SRCeco GW Verbrugg 2000 [ug.l-1]	WHO guideline value (WHO, 1993,199 [ug.l-1]		WLB 2000 Versteegh 1999 [ug.l-1]	EC Drinkingw. Directive 1998 [ug.l-1]	Signal Value drinkingw. ruminants (IKC,1996) [ug.l-1]	Equilibrium Partitioning with SRC for soil [ug.l-1]	 SRC human for soil [ug.l-1]
Total chlorophenols		-		-		-	sum*7	no sum	-		1		-		
Monochlorophenols (sum)	1-10	0,3		100	100	100	8981	1000	-	NAD	1		-		
o-Monochlorophenol					100	100	7100	1400			1			1377	
m-Monochlorophenol					100	100	9360	2500			1			657	
p-Monochlorophenol					100	100	10900	290			1			270	
Dichlorophenols (sum)	1	0,2		30	100	100	4159	870	-	NAD	1		-		
2,3-Dichlorophenol					100	100	5590	1400			1			1455	
2,4-Dichlorophenol					100	100	5580	410			1			413	
2,5-Dichlorophenol					100	100	3930	1300			1			1343	
2,6-Dichlorophenol					100	100	5920	2300			1			2281	
3,4-Dichlorophenol					100	100	3480	590			1			733	
3,5-Dichlorophenol					100	100	2050	420			1			417	
Trichlorophenols (sum)	1	0,03		10	100	100	1922	340	200	10^-5/I	1		-		
2,3,4-Trichlorophenol					100	100	2660	420			1			429	
2,3,5-Trichlorophenol					100	100	2370	260			1			54	
2,3,6-Trichlorophenol					100	100	1790	990			1			993	
2,4,5-Trichlorophenol					100	100	1900	160			1			165	
2,4,6-Trichlorophenol					100	100	1910	480			1			49	
3,4,5-Trichlorophenol					100	100	1230	190			1			194	
Tetrachlorophenols (sum)	0,5	0,01		10	100	100	1080	130	-		1		-		
2,3,4,5-Tetrachlorophenol					100	100	797	150			1			149	
2,3,4,6-Tetrachlorophenol					100	100	1090	160			1			166	
2,3,5,6-Tetrachlorophenol					95	100	1450	95			1			94	
Pentachlorophenol	0,1	0,04		3	85	100	214	85	9	0^-5/P	1		-	61	
Chloronaphthalenes (sum)		-		6	150	2663	190	150	-		1		-		
1-Chloronaphthalene					120	2663	122	120			1			118	
2-Chloronaphthalene					190	2663	295	190			1			196	
Total polychlorobiphenyls	0.001-0.01	0,01		0,01	sum*6	0,33	sum*6	-	-		0,5	0,5	-		
PCB 28					0,291	0,33	0,291	-			0,1	0,1		0,2920	
PCB 52					0,097	0,33	0,097	-			0,1	0,1		0,0963	
PCB 101					0,031	0,33	0,031	-			0,1	0,1		0,0310	
PCB 118					0,015	0,33	0,015	-			0,1	0,1		0,0146	
PCB 138					0,011	0,33	0,011	-			0,1	0,1		0,0108	
PCB 153					0,011	0,33	0,011	-			0,1	0,1		0,0107	
PCB 180					0,003	0,33	0,003	-			0,1	0,1		0,0030	
Trichlorobiphenyl		-		-	-	0,33			-		0,1	0,1	-	0,0000	
Hexachlorobiphenyl		-		-	-	0,33			-		0,1	0,1	-	0,0000	
Dioxins (+PCDF and PCB) *5		-		(0.000001)*1	3,1E-06	0,0001	3,1E-06	-	-		1		-		
2,3,7,8-TeCDD *5; TEF=1						0,0001	1,32E-05	-						0	
PCDD *5; TEF=1						0,0001	4,36E-06	-						0	
HxCDD *5; TEF 0.1						0,0001	2,09E-06	-						0	
HpCDD *5; TEF=0.01						0,0001	1,44E-06	-						0	
OCDD *5; TEF=0.0001						0,0001	9,98E-07	-						0	

Contaminant Reference	Detection limit in groundw. VROM, 2000 [ug.l-1]	Current Target Value GW VROM,2000 deep [ug.l-1]	<10 m [ug.l-1]	Current IV GW Swartjes, 1999 [ug.l-1]	***Integrated SRC GW (lowest) [ug.l-1]***	**Max. conc. in GW as drinkingw [ug.l-1]**	**SRC human GW [ug.l-1]**	**SRCeco GW Verbrugg 2000 [ug.l-1]**	WHO guideline value (WHO, 1993,199 [ug.l-1]	WLB 2000 Versteegh 1999 [ug.l-1]	EC Drinkingw. Directive 1998 [ug.l-1]	Signal Value drinkingw. ruminants (IKC,1996) [ug.l-1]	**Equilibrium Partitioning with** SRC for soil [ug.l-1]	**SRC human for soil [ug.l-1]**
PCB77 *5; TEF=0.0001						0,0001	1,54E-07	0,1					0	
PCB105 *5; TEF=0.0001						0,0001	8,10E-06	0,13					0	
PCB118 *5; TEF=0.0001						0,0001	5,85E-06	-					0	
PCB126 *5; TEF=0.1						0,0001	5,99E-06	0,018					0	
PCB156 *5; TEF=0.0005						0,0001	2,5E-06	-					0	
PCB157 *5; TEF=0.0005						0,0001	3,01E-06	-					0	
PCB169 *5; TEF=0.01						0,0001	4,39E-06	-					0	
TetraCDF *5; TEF=0.1						0,0001	2,17E-05	-					0	
PentaCDF *5; TEF=0.5/0.05						0,0001	1,20E-05	-					0	
HexaCDF *5; TEF=0.1						0,0001	2,04E-06	-					0	
HeptaCDF *5; TEF=0.01						0,0001	1,65E-06	-					0	
OctaCDF *5; TEF=0.0001						0,0001	8,62E-07	-					0	
VI Pesticides										0,5	0,5			
Organochlorine pesticides:														
Total DDT/DDD/DDE	0.001-0.01	-		0,01	*no sum*		sum*6	no sum	-					
DDT		4E-06		-	*0,43*	17	1,39	0,43	2	0,1	0,1	0,1	0,05	
DDE		4E-06		-	*0,10*	17	1,32	0,1	-	0,1	0,1	0,1	0,10	
DDD		4E-06			*3,8*	17	4,73	3,8					3,87	
Total drins	0.001-0.01	-		0,1	*no sum*		no sum	1,8	-			0,1		
Aldrin and dieldrin							sum*6	3,4				0,1		
Aldrin		9E-06		-	*0,6*	3,3	0,64	3,4	0,03	0,03	0,03	0,1	1	
Dieldrin		0,0001		-	*3,3*	3,3	16	3,4	0,03	0,03	0,03	0,1	16	
Endrin		0.00004		-	*0,9*	6,7	31	0,92	-	0,1	0,1	0,1		
Total HCHs	0.001-0.01	-		1	*no sum*	-	no sum	100	-					
a-HCH		0,033		-	*33*	33	159	140	-	0,1	0,1	0,1	137	
b-HCH		0,008		-	*0,7*	0,7	11	93	-	0,1	0,1	0,1	12	
g-HCH		0,009		-	*1,3*	1,3	23	87	2	0,1	0,1	0,1	21	
d-HCH					-	-	-	-						
Carbamates:														
Carbaryl	0,012	0,002		50	*41*	100	9590	41	-	0,1	0,1	-	41	
Carbofuran	0,017	0,009		100	*6,5*	67	2040	6,5	7	0,1	0,1	-	6	
Other pesticides:														
Maneb		0,00005		0,1	*32*	1664	0,085	32	-	0,1	0,1	-		
Atrazine	0,02	0,029		150	*76*	166	1930	76	2	0,1	0,1	-	75	
VII Other pollutants														
Mineral oil		50		600	*sum*6*	-	*sum*6*		-	-	-	-		
alifaten EC 5-6					*613*	66571	613	-					0	
alifaten EC >6-8					*444*	66571	444	-					0	
alifaten EC >8-10					*15*	3329	15	-					0	
alifaten EC >10-12					*10*	3329	10	-					0	
alifaten EC >12-16					*0,59*	3329	0,59	-					0	
alifaten EC >16-21					*0,0010*	66571	0,0010	-					0	
aromaten EC 5-7					*492*	6657	492	-					0	

Contaminant	Detection limit in groundw.	Current Target Value GW		Current IV GW	***Integrated SRC GW***	**Max. conc. in GW as drinkingw**	**SRC human GW**	**SRCeco GW**	WHO guideline value	WLB 2000	EC Drinkingw. Directive	Signal Value drinkingw. ruminants	**Equilibrium Partitioning with** SRC for soil	**SRC human for soil**
Reference	VROM, 2000	VROM,2000 deep	<10 m	Swartjes, 1999	***(lowest)***			**Verbrugg 2000**	(WHO, 1993,199	Versteegh 1999	1998	(IKC,1996)		
	[ug.l-1]	[ug.l-1]	[ug.l-1]	[ug.l-1]	***[ug.l-1]***	**[ug.l-1]**	**[ug.l-1]**	**[ug.l-1]**	[ug.l-1]	[ug.l-1]	[ug.l-1]	[ug.l-1]	[ug.l-1]	**[ug.l-1]**
aromaten EC >7-8					***850***	**6657**	**850**	**-**					0	
aromaten EC >8-10					***640***	**1331**	**640**	**-**					0	
aromaten EC >10-12					***1331***	**1331**	**2170**	**-**					0	
aromaten EC >12-16					***1331***	**1331**	**5810**	**-**					0	
aromaten EC >16-21					***543***	**999**	**543**	**-**					0	
aromaten EC >21-35					***7***	**999**	**6,6**	**-**					0	
Cyclohexanone		0,5		15000	***153114***	**153114**	**262000**	**260000**	-			-	183644	
Total phthalates		0,5		5	***no sum***	**133**	**no sum**	**no sum**	-			-	-	
Dimethyl phthalate					***133***	**133**	**7750**	**8100**					7762	
Diethyl phthalate					***6657***	**6657**	**287000**	**23000**					2073	
Di-isobutylphthalate					***133***	**133**	**818**	**160**					168	
Dibutyl phthalate					***170***	**1731**	**2350**	**170**					647	
Butyl benzylphthalate		-		-	***100***	**16643**	**4220**	**100**	-			-	102	
Dihexyl phthalate					***12***	**133**	**11,5**	**84**					85	
Di(2-ethylhexyl)phthalate		-		-	***4***	**133**	**4,41**	**5**	8			-	4	
Pyridine		0,5		30	***33***	**33**	**2130**	**57000**	-			-	2121	
Tetrahydrofuran		0,5		300	***333***	**333**	**16000**	**800000**	-			-	16620	
Tetrahydrothiophene		0,5		5000	***5991***	**5991**	**137000**	**9400**	-			-	5156	

-	not available
dl	detection limit
*1	no reliable value could be derived. In the Ministerial Circulars this value (between brackets) is called a Indicative Level for serious soil contamination
*2	based on chromium (III) only
*3	based on exposure and Maximal Permissible Risk for intake for a child (instead of averaged lifelong exposure and Maximal Permissible Risk for Intake)
*5	human values are expressed as toxicity equivalents (TEQ), based on the most toxic compound 2,3,7,8 TCDD (Van den Berg et al., 1998)
*6	sum or group value should be applied using the "Toxic Unit" approach (or 'fraction approach'), because compounds within this group (probably) have the same mode of action
*7	sum or group value should be applied using the "Toxic Unit" approach (or 'fraction approach'), because mono to tetrachlorophenols (probably) have the same mode of action

References

'Swartjes, F.A., 1999. Risk-Based Assessment of Soil and Groundwater Quality in the Netherlands: Standards and Remediation Urgency. Risk Analysis, Vol 19, No 6, 1999

WHO. Guidelines for drinking-water quality (second ed., volume 1, recommendations), 1993. Guidelines for drinking-water quality (second ed., addendum to volume 1), 1998.

P	provisional guideline value
NAD	No adequate data to permit recommandation of guideline value
ATO	tions below this concentration may affect the appearance, taste or odour of the water
10^-5	excess lifetime cancer risk of 10^-5
U	unnecessary, concentrations normally found not hazardous to human health

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Verbruggen, E.M.J., T. Crommentuijn, R. Posthumus and A.P. van Wezel, (in prep.) Ecotoxicological Serious Risk Concentrations for soil, sediment and water: 1 updated proposals for first series of compounds RIVM, Bilthoven. RIVM report 711701020.

Appendix 6 Changes of risk limits for soil and groundwater

The sign indicates if the revised risk-limit is assessed lower (<), higher (>) or approximately the same (~) compared with current values.

	TDI/CRI new vs current	TCA/CRA new vs current	exposure (CSOIL) new vs current	SRChuman, new vs current	SRCeco new vs current	*Integrated SRC soil eco or hum determined*	*Integrated SRC soil new vs current*	Integrated SRC soil [mg.kg-1]	IV soil current [mg.kg-1] ROM, 200	GW: Integr. vs current	Integr. SRC GW [ug.l-1]	Current IV GW [ug.l-1]
I Metals and trace elements												
Arsenic	<		~	~	>	ECO	~	85	55	~	33	60
Barium	~		<	>	~	ECO	~	890	625	~	666	625
Cadmium	<		~	~	~	ECO	~	13	12	~	10	6
Chromium									380	>	166	30
ChromiumIII (soluble)	~		~	~	~	ECO	~	220	380	>	166	30
CromiumVI						HUM	<	78		>	166	
Cobalt	~		>	<	~	HUM	<	43	240	<	47	100
Copper	~		~	~	~	ECO	~	96	190	<	19	75
Mercury										~	0,37	0,3
Mercury (inorganic)	>		>	~	>	ECO	>	36	10		14	
Mercury (organic)								4			0,36	
Lead*3	~		<	>	~	BOTH	~	580	530	<	17	75
Molybdenum	~		~	~	<	ECO	~	190	200	~	333	300
Nickel	~		>	<	<	ECO	<	100	210	>	500	75
Zinc	<		~	~	<	ECO	<	350	720	<	91	800
II Inorganic contaminants												
Cyanides (free)	~	<						-	20		29	-
Cyanides (complex, pH<5)	>							-	650	<	31	1500
Cyanides (complex, pH>5)	>							-	50	<	31	1500
Thiocyanates (sum)	~							620	50	<	375	1500
III Aromatic contaminants												
Benzene	~	~	~	~	>	HUM	~	1,3	1	>	110	30
Ethyl benzene	~	>	<	>		BOTH	>	110	50	>	3329	150
Phenol	~	<	<	>	<	ECO	<	14	40	~	1331	2000
Cresoles (sum)	~	~	<	>	<	ECO	>	13	5	>	1664	200
o-Cresol						ECO		50			1664	
m-Cresol						ECO		16			1664	
p-Cresol						ECO		2,6			1000	
Toluene	~	<	>	<	<	HUM	<	38	130	>	5070	1000
Xylenes (sum)	>	>	>	>		ECO	~	17	25	>	1100	70
o-Xylene						ECO		9,3			1000	
m-Xylene						ECO		18			1200	
p-Xylene						ECO		30			1100	
Dihydroxybenzenes (sum)						ECO		8			3100	
Catechol	~		<	>	0	ECO	<	2,6	20	~	630	1250
Resorcinol	~		~	~	0	ECO	<	4,6	10	~	666	600
Hydrochinon	~		<	>	0	ECO	>	43	10	~	832	800
Styrene	~	~	~	~	0	ECO	~	86	100	>	3800	300
IV Polycyclic aromatic hydrocarbons												
Total PAHs (10)					<			no sum	40			
Naphthalene	~		~	~	<	ECO	<	17	-	>	290	70
Anthracene	~		~	~	<	ECO	<	1,6	-	<	1,4	5
Phenantrene	>		<	>	~	ECO	~	31	-	>	30	5
Fluoranthene	>		<	>	>	ECO	>	260	-	>	30	1
Benzo(a)anthracene	<		~	<	<	ECO	<	2,5	-	~	1,0	0,5
Chrysene	>		<	>	~	ECO	~	35	-	>	1,2	0,2
Benzo(a)pyrene	<		~	<	<	ECO	<	7	-	>	0,72	0,05
Benzo(ghi)perylene	~		~	~	~	ECO	~	33	-	>	0,18	0,05
Benzo(k)fluoranthene	<		~	<	~	ECO	~	38	-	>	0,36	0,05
Indeno(1,2,3-cd)pyrene	<		~	<	<	ECO	<	1,9	-	~	0,04	0,05
Pyrene *)											11	
acenaphtene *)											2570	
1,2-dihydroacenaphthalene *)											1664	
Benzo(b)fluoranthene *)											17	
Benzo(j)fluoranthene *)											8,8	
Dibenz(a,h)anthracene *)											0,71	
9H-Fluorene *)											1320	
V Chlorinated hydrocarbons												
1,2-dichloroethane	~	~	~	~	>	HUM	~	7,5	4	~	466	400
Dichloromethane	~	~	<	>	<	ECO	<	3,9	10	~	1997	1000
Tetrachloromethane	~	~	~	~	<	HUM	~	0,81	1	>	133	10
Tetrachloroethene	~	<	<	>	<	HUM	>	10,3	4	>	533	40
Trichloromethane	~	~	~	~	>	HUM	~	6,5	10	>	999	400
Trichloroethene	<	<	>	<	<	ECO	<	2,5	60	>	1664	500
Vinylchloride	<	<	>	<	<	HUM	<	0,0025	0,1	<	0,46	5
Total chlorobenzenes					<			no sum	30		-	-
Monochlorobenzene	~	<	>	<		ECO	~	15	-	>	1100	180
Dichlorobenzenes (sum)				<		ECO	~	19	-	>	650	50
1,2-Dichlorobenzene	>	~	>	<		ECO		17	-		740	
1,3-Dichlorobenzene						ECO		24			820	
1,4-Dichlorobenzene	~	~				ECO		18			460	
Trichlorobenzenes (sum)	<			>		ECO	<	7,3	-	>	40	10
1,2,3-Trichlorobenzene	>	<				ECO		5			71	
1,2,4-Trichlorobenzene	>	<				ECO		5,1			46	
1,3,5-Trichlorobenzene	>	<				HUM		5,6			10	
Tetrachlorobenzenes (sum)	~		>	<		ECO	<	2,2	-	>	17	2,5
1,2,3,4-Tetrachlorobenzene						ECO		16			17	
1,2,3,5-Tetrachlorobenzene						ECO		0,65			17	
1,2,4,5-Tetrachlorobenzene						ECO		1			7	
Pentachlorobenzene	~		>	<		HUM	<	7,4	-	>	15	1
Hexachlorobenzene	<	<	>	<		ECO		2	-	>	3	0,5
Total chlorophenols					<			no sum	10		-	-
Monochlorophenols (sum)	~		<	>	~	ECO	~	5,4	-	~	100	100
o-Monochlorophenol						ECO		7,8			100	
m-Monochlorophenol						ECO		14			100	
p-Monochlorophenol						ECO		1,4			100	
Dichlorophenols (sum)	~		<	>	>	ECO	>	22	-	>	100	30
2,3-Dichlorophenol						ECO		31			100	
2,4-Dichlorophenol						ECO		8,4			100	
2,5-Dichlorophenol						ECO		53			100	
2,6-Dichlorophenol						ECO		57			100	
3,4-Dichlorophenol						ECO		27			100	
3,5-Dichlorophenol						ECO		5,4			100	

	TDI/CRI new vs current	TCA/CRA new vs current	exposure (CSOIL) new vs current	SRChuman, new vs current	SRCeco new vs current	*Integrated SRC soil* eco or hum determined	*Integrated SRC soil* new vs current	Integrated SRC soil [mg.kg-1]	IV soil current [mg.kg-1] ROM, 200	GW: Integr. vs current	Integr. SRC GW [ug.l-1]	Current IV GW [ug.l-1]
Trichlorophenols (sum)	~		<	>	>	**ECO**	**>**	**22**	-	>	**100**	10
2,3,4-Trichlorophenol						ECO		**30**			100	
2,3,5-Trichlorophenol						ECO		**4,5**			100	
2,3,6-Trichlorophenol						ECO		**110**			100	
2,4,5-Trichlorophenol						ECO		**22**			100	
2,4,6-Trichlorophenol						ECO		**8,1**			100	
3,4,5-Trichlorophenol						ECO		**39**			100	
Tetrachlorophenols (sum)	~		<	>	>	**ECO**	**>**	**21**	-	>	**130**	10
2,3,4,5-Tetrachlorophenol						ECO		**64**			150	
2,3,4,6-Tetrachlorophenol						ECO		**13**			160	
2,3,5,6-Tetrachlorophenol						ECO		**12**			95	
Pentachlorophenol	<		<	<	>	**ECO**	**~**	**12**	-	>	**85**	3
Chloronaphthalenes (sum)	>	<	>	>		**ECO**	**>**	**23**	10	>	**150**	6
1-Chloronaphthalene						BOTH		**18**			120	
2-Chloronaphthalene						ECO		**30**			190	
Total polychlorobiphenyls	<				>	**HUM**		**sum**	1	-	**no sum**	0,01
PCB28							**~**	**0,69**			**0,291**	
PCB52							**<**	**0,28**			**0,097**	
PCB101							**~**	**0,61**			**0,031**	
PCB118							**~**	**1,9**			**0,015**	
PCB138							**<**	**0,32**			**0,011**	
PCB153							**<**	**0,46**			**0,011**	
PCB180							**<**	**0,17**			**0,003**	
Trichlorobiphenyl (PCB18)				<					-		**-**	-
Hexachlorobiphenyl (PCB128-169)				<					-		**-**	-
Dioxins (+PCDF and PCB) *5	<				<	**HUM**	**<**	**0,00036**	(0.001)*1	>	**2,6E-06**	
2,3,7,8-TeCDD *5; TEF=1	<		~	<								(0.000001)*1
PCDD *5; TEF=1	<		~	<								
HxCDD *5; TEF 0.1	<		>	<								
HpCDD *5; TEF=0.01	<		>	<								
OCDD *5; TEF=0.0001	<		>	<								
PCB77 *5; TEF=0.0001						HUM						
PCB105 *5; TEF=0.0001						HUM						
PCB118 *5; TEF=0.0001												
PCB126 *5; TEF=0.1						HUM						
PCB156 *5; TEF=0.0005												
PCB157 *5; TEF=0.0005												
PCB169 *5; TEF=0.01												
TetraCDF												
PentaCDF												
HexaCDF												
HeptaCDF												
OctaCDF												
VI Pesticides												
Organochlorine pesticides:												
Total DDT/DDE/DDD					<				4			0,01
DDT	<		>	<		ECO	**<**	**1**	-	>	**0,43**	-
DDE	<		>	<		ECO	**<**	**1,3**	-	>	**0,10**	-
DDD	<					BOTH	**>**	**34**	-	>	**3,8**	
Total drins	<				<	**ECO**	**<**	**0,14**	4			0,1
Aldrin and dieldrin								**0,22**	-			
Aldrin	~		>	<		ECO		**0,32**	-	>	**0,6**	-
Dieldrin	~		~	~		ECO		**9,1**	-	>	**3,3**	-
Endrin	>		~	>	~	ECO		**0,095**	-	>	**0,9**	-
Total HCHs	<	<			>			**no sum**	2			1
a-HCH	~		~	~	>	**BOTH**	**>**	**17**	-	>	**33**	-
b-HCH	~		<	>	>	**HUM**	**~**	**1,6**	-	**~**	**0,7**	-
g-HCH	<	~	~	<	~	**BOTH**	**~**	**1,2**	-	**~**	**1,3**	-
d-HCH								**no IV**	-		-	
Carbamates:												
Carbaryl	<		~	<	<	**ECO**	**<**	**0,45**	5	~	**41,0**	50
Carbofuran	<		>	<	<	**ECO**	**<**	**0,017**	2	<	**6,5**	100
Other pesticides:												
Maneb	~				~	**ECO**		**22**	35	>	**32**	0,1
Atrazin	>		>	~	<	**ECO**	**<**	**0,71**	6	~	**76**	150
VII Other pollutants												
Mineral oil							**?**		5000	<	**only frac**	600
alifaten EC 5-6								**40**			**711**	
alifaten EC >6-8								**128**			**519**	
alifaten EC >8-10								**33**			**18**	
alifaten EC >10-12								**180**			**12**	
alifaten EC >12-16								**56800**			**0,59**	
alifaten EC >16-21								**1280000**			**0,0010**	
aromaten EC 5-7								**33**			**570**	
aromaten EC >7-8								**73**			**989**	
aromaten EC >8-10								**141**			**1331**	
aromaten EC >10-12								**366**			**1331**	
aromaten EC >12-16								**8000**			**1331**	
aromaten EC >16-21								**17700**			**543**	
aromaten EC >21-35								**19200**			**7**	
Cyclohexanone	~	~				**ECO**	**>**	**150**	45	>	**153114**	15000
Total phthalates	<				<				60			5
Dimethyl phthalate						BOTH	**~**	**84**		>	**133**	
Diethyl phthalate						ECO	**~**	**53**		>	**6657**	
Di-isobutylphthalate						ECO	**<**	**17**		>	**133**	
Dibutyl phthalate						ECO	**~**	**36**		>	**170**	
Butyl benzylphthalate	>		<	>		ECO	**~**	**48**	-	>	**100**	-
Dihexyl phthalate						ECO	**>**	**220**		>	**12**	
Di(2-ethylhexyl)phthalate	<		>	<		BOTH	**~**	**69**	-	~	**4**	-
Pyridine	~	~	<	>	<	HUM	**>**	**11**	0,5	~	**33**	30
Tetrahydrofuran	~	~	<	>		HUM	**>**	**7**	2	~	**333**	300
Tetrahydrothiophene	~	~	<	>		ECO	**<**	**8,8**	90	~	**5991**	5000

Appendix 7 Soil type correction for human exposure to metals

Human exposure to metals only depends on the soil type, when crop consumption contributes to the exposure (see also section 5.7). For metals the following relation can be derived:

$$\mathrm{IVsoil}_{act}= \mathrm{IVsoil}_{standard} * (1 + (y/x)*\mathrm{BCF}_{standard})/ (1 + (y/x)*\mathrm{BCF}_{actual}) \qquad (1)$$

With x= factor for exposure via soil ingestion, amount of soil (mg soil $_{dry\ weight}$.kg$^{-1}{}_{bw}$.day^{-1})
y= factor for exposure via crop consumption (mg crop $_{dry\ weight}$.kg$^{-1}{}_{bw}$.day^{-1})

and the following values for x and y (based on the calculatoins in CSOIL):

metal/scenario	y/x	x	y
Pb, residential with garden	**12,7**	8,33	106,2
Pb, allotment garden	6,61	8,33	55,1
other metals, residential with garden	**579**	1,37	793
other metals, allotment garden	301	1,37	412

In the evaluation of the BCF metals (Versluijs and Otte, in prep.; Otte et al., 2001) a relation was derived between the general BCF and soil characteristics (pH, clay and OM-content) and the metal concentration. The following “freundlich” relation was used[6]:

$$\log[\text{C-plant}]= a+b*\log (Q)+ c*pH + d*\log (\%OC) +e* \log (\% clay) \qquad (2)$$

which also could be written as:

$$BCF = 10^{a} * Q^{(b-1)} * 10^{c*pH} * (\%OC)^{d} * (\%clay)^{e} \qquad (3)$$

with the following values for a to e for cadmium, lead, copper and nickel (Versluijs and Otte, in prep.):

Compound	a	b	c	d	e
Pb	-1.51	1	-0.02	-0.13	-0.026
Cd	-0.29	1	-0.03	-0.03	-0.006
Cu	0.016	1	-0.09	-0.24	0.06
Ni	-1.52	1	0	-0.02	-0.006

At the current standard soil (pH=6, %OM=10 and %clay=25) and level of the Intervention Value, this leads to a BCF for Pb, Cd, Cu and Ni of respectively 0.017, 0.32, 0.24 and 0.029. (the BCFs are resp. 0.020, 0.35, 0.33 and 0.029 for the proposed alternative standard soil: pH=5, %OM=5 and %clay=15). Combining equation (1) with (3) and the data leads to the following soil type correction in relation to human exposure (for the current standard soil):

$$\begin{aligned}
IV_{act.Pb} &= IV_{standard,Pb} * (1+ 12.7*0.017)/ (1 + 12.7*BCF_{act})\\
&= IV_{standard,Pb} * 1.30/ (1 + 9.3*(\%OM/1.7)^{-0.13}*(\%clay)^{-0.026})\\
IV_{act.Cd} &= IV_{standard,Cd} * (1+ 579*0.32)/ (1 + 579*BCF_{act})\\
&= IV_{standard,Cd} * 196/(1 + 538*(\%OM/1.7)^{-0.03}*(\%clay)^{-0.006})\\
IV_{act.Cu} &= IV_{standard,Cu} * (1+ 579*0.24)/ (1 + 579*BCF_{act})\\
&= IV_{standard,Cu} * 173/(1 + 459*(\%OM/1.7)^{-0.24}*(\%clay)^{0.06})\\
IV_{act.Ni} &= IV_{standard,Ni} * (1+ 579*0.029)/ (1 + 579*BCF_{act})\\
&= IV_{standard,Ni} * 17.5/(1 + 548*(\%OM/1.7)^{-0.02}*(\%clay)^{-0.006})
\end{aligned}$$

The ranges of %OM and % clay where these relations can be used, based on the 5- and 95-percentile in original data set, are %OM= 1.5-22 and %clay = 2-33 (and pH= 5 - 7.5) (Versluijs and Otte, in prep.). Applying these minimum and maximum value for OM and clay leads to a soil-type correction for Pb of 0.94-1.02, for Cd of 0.93-1.03, for Cu of 0.74-1.19 and for Ni of 0.95-1.02 for the scenario “residential with garden”. When the effect of the pH would be included, these differences would be much larger for Cd and Cu. The use of more data in the future also could lead to larger differences, because more statistical significant relations could be derived.

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[6] these freundlich equations with the corresponding values for a to e should not be used for deriving BCF-values directly, because of little deviations with BCF-values based on individual crops (Versluijs and Otte, in prep.)

Appendix 8 Integrated risk limits soil for alternative standard soil

When the current standard soil would be modified to the alternative standard soil, with: Organic-matter content= 5%; clay content = 15%; pH=5, this would lead to different SRCs$_{human}$ and SRC$_{eco}$ for soil and groundwater. I the following tables the modified input-parameters are given. In Appendix 3A, the SRCs$_{human}$ for soil and for groundwater are given for this alternative standard soil.

Revised BCF values for metals for current and revised standard soil

Metal	**Current BCF (Bockting & Van den Berg, 1992)**	**Revised BCF standard soil**	**Revised BCF Alternative soil**
soil type	***No relation with soil characteristics***	**pH 6 OM 10 % clay 25 %**	**pH 5 OM 5 % clay 15 %**
As	*0.021*	0.009	0.009
Ba $^{*)}$	*0.043*	0.017	0.017
Cd	*0.37*	0.31	**0.35**
Cr $^{*)}$	*0.009*	0.011	0.011
Co $^{*)}$	*0.021*	0.58	0.58
Cu	*0.10*	0.20	**0.33**
Hg	*0.02*	0.15	0.15
Pb	*0.013*	0.017	**0.020**
Mo $^{*)}$	*0.129*	0.12	0.12
Ni	*0.025*	0.028	**0.030**
Zn	*0.22*	0.18	0.18

$^{*)}$ The BCF is based on geometric mean; there is no relation with the standard soil

Current Kp values and revised Kp values for current and proposed standard soil, including references (l/kg)

Metal	**Current Kp (Van den Berg and Roels, 1991)**	**REVISED Kp pH 6, OM% 10, clay% 25**	**REVISED Kp pH 5, OM% 5, clay% 15**	**Reference**
As	980	1800	1800	Sauvé et al., 2000
Ba	60	2500	2500	Sauvé et al., 2000
Cd	190	2560	**720**	Otte et al. 2000b
Cr	14400	4800	4800	Sauvé et al., 2000
Co	120	120	120	Van den Berg and Roels, 1991
Cu	540	2120	2120	Sauvé et al., 2000
Hg	3300	7500	7500	Sauvé et al., 2000
Pb	2380	36000	**11000**	Otte et al. 2000b
Mo	20	40	40	Sauvé et al., 2000
Ni	560	2000	**1000**	Janssen et al., 1997a
Zn	250	2600	**520**	Otte et al. 2000b

Appendix 9 Contribution of estimated background exposure in the Netherlands to the TDI/ CR$_{oral}$

from: Baars et al., 2001

Chemical	**Background exposure in the Netherlands (µg · kg bw^{-1} · day-1)**	**Percentage of TDI/ CR$_{oral}$**	**Main source of background**	**TDI/ CR$_{oral}$ (µg · kg bw^{-1} · day-1)**
I. Metals				
Arsenic (inorganic)	0.3	30%	food	1
Barium (soluble)	9	45%	food	20
Cadmium	0.2 (excl. smoking)	40%	food	0.5
Chromium (III)	1	20%	food	5
Cobalt	0.3	21%	food	1.4
Copper	30	21%	food	140
Lead	2 (1-4 yr) and 0.64	55% and 18%	-	3.6
Mercury (inorganic)	0.1	5%	food, amalgan	2
Mercury (organic)	0.02	20%	food, amalgan	0.1
Molybdenum	4	40%	-	10
Nickel	4	8%	food and inhalation	50
Zinc	300	60%	food	500
II. Other inorganic compounds				
Cyanides, free	-	-		50
Cyanides, complex	0.4	<1%		800
Thiocyanate	74	672%	naturally occuring in food	11
III. Aromatic compounds				
Benzene	-	-	-	3.3
Ethylbenzene	1	1%	inhalation and food	100
Toluene	10	4%	air	223
Xylenes	30	20%	inhalation	150
IV. Polycyclic aromatic hydrocarbons (PAHs)				
Benzo[a]pyrene	0.0027	<1%	food	0.5
V. Chlorinated hydrocarbons				
1,2-Dichloroethane	1	7%	inhalation	14
1,2-cis-Dichloroethene	0.13			6
1,2-trans-Dichloroethene				17
Trichloroethene	2	4%	food and air	50
Tetrachloroethene	2	13%	food and air	16
Dichloromethane	5	8%	inhalation	60
Trichloromethane (chloroform)	3	10%	food, drinking water, air	30
Tetrachloromethane	0.2	5%	food and air	4
Monochlorobenzene	<0.9	<1%		200
1,2-dichlorobenzene	<0.017	<1%		430
1,3-dichlorobenzene				-
1,4-dichlorobenzene				100
1,2,3-trichlorobenzene	<0.04	<1%		8
1,2,4-trichlorobenzene				8
1,3,5-trichlorobenzene				8
Hexachlorobenzene	0.003	<2%		0.16
Pentachlorophenol	0.001	<1%	food	3
Vinylchloride	0.06	10%	air, food and water	0.6
Dioxins (PCDDs, PCDFs, planar PCBs), in TEQ	1.2 10^{-6}	30% (120% of ultimate goal)	food	4 ·10^{-6} (ultimate goal 1· 10^{-6})
Polychlorinated biphenyls, non-planar (7 indicator PCBs)	0.01	100%	food	0.01
VI. Pesticides				
Aldrin	<0.04	<40%	food	0.1
Dieldrin				0.1
Endrin				0.2

Chemical	**Background exposure in the Netherlands ($\mu g \cdot kg\ bw^{-1} \cdot$ day-1)**	**Percentage of TDI/ CR_{oral}**	**Main source of background**	**TDI/ CR_{oral} ($\mu g \cdot kg\ bw^{-1} \cdot$ day-1)**
DDT, DDD, DDE (total)	<0.1	<20%		0.5
α-Hexachloro-cyclohexane	<0.03	<3%	food	1
β- Hexachloro-cyclohexane	<0.01	<50%	food	0.02
γ- Hexachloro-cyclohexane	<0.03	<75%	food	0.04
Triazines (atrazine)	negligible			5
VII. Other organic compounds				
Aliphatic >EC5-EC8	86 (C3-C11)	4%	air	2000
Aliphatic >EC8-EC16	550 (C7-C12)	550%	via air, with painting	100
Phthalates (total)	5-9	<225%		4
bis(2-ethylhexyl)phthalate	3	75%		4
Dibutyl phthalate				52
Diethyl phthalate				200
Butylbenzyl phthalate	2-6	1%		500