Common Implementation Strategy for the Water Framework Directive

Environmental Quality Standards (EQS)

Substance Data Sheet

Priority Substance No. 6

Cadmium and its Compounds

CAS-No. 7440-43-9

Final version
Brussels, 31 July 2005

Disclaimer

This data sheet provides background information on the setting of the Environmental Quality Standard in accordance with Article 16 of the Water Framework Directive (2000/60/EC). The information was compiled, evaluated and used as outlined in the Manual [4] and has been discussed in a consultative process with the Expert Advisory Forum on Priority Substances and the Expert Group on Quality Standards. Furthermore, it has been peer-reviewed by the SCTEE [12]. The substance data sheet may, however, not necessarily represent the views of the European Commission.

New upcoming information was considered and included up to the date of finalisation of this data sheet. Information becoming available after finalisation of this document will be evaluated in the review process of priority substances according to Art. 16(4) of the Water Framework Directive. If necessary, the Environmental Quality Standard substance data sheets will then be revised in the light of technical and scientific progress.

1 Identity of substance

Priority Substance No: 6	Cadmium and its Compounds
CAS-Number:	7440-43-9
Classification WFD Priority List *:	PHS

* PS: priority substance; PHS: priority hazardous substance; PSR: priority substance under review according to Decision 2455/2001.

2 Proposed quality standards

Notes:

1. This data sheet is based on the November 2001 and July 2003 draft versions of the ongoing EU-RAR (see references [1 & 10], reference [10] was the basis for the SCTEE-opinions on the Cd-RAR [13 & 14]). The final draft of the RAR has been circulated in July 2005 for a last round of written comments to a limited set of open (mainly editorial) issues. Since the draft of July 2003 no amendments with relevance to the quality standards proposed in this data sheet have been included in the updates of the RAR and no aspects that could become relevant for the proposed standards are open for the commenting procedure on the final draft.

   It therefore can be assumed that the quality standards proposed in this data sheet are in line with the conclusions that will finally be published as result of the risk assessment process.

2. Although in this data sheet the use of the Added Risk Approach is suggested for setting quality standards for cadmium and its compounds (see section 8) the Commission may decide to refer to the Total Risk Approach and propose quality standards that already account for and comprise the natural background concentration.

2.1 Overall quality standards

Ecosystem	**Quality Standard**			**Comment**
AA-QS inland waters	**hardness [mg $CaCO_3$ L^{-1}]**	**AA-MPA$_{water}$ [ug Cd L^{-1}]**	**AA-MPA$_{SPM}$ [mg Cd kg^{-1} SPM** (rounded)**]**	QS = $C_{background}$ + MPA Under consideration of the water quality required to prevent secondary poisoning of top predators **the QS (i.e. $C_{background}$ + MPA) should not exceed 0.26 µg Cd/l** (corresponding to 34 mg Cd /kg SPM, see sections 8.3 & 8.6)
	40 - <100	0.08	10	
	100 - <200	0.15	20	
	>200	0.25	30	
AA-QS transitional, coastal and territorial Waters	MPA$_{saltwater}$ = 0.21 µg Cd L^{-1} (corresponding MPA$_{SPM}$ = 27 mg Cd/kg dw)			QS = $C_{background}$ + MPA, see section 8.1
MAC-QS (ECO)	**hardness [mg $CaCO_3$ L^{-1}]**	**MAC-MPA$_{water}$ [ug Cd L^{-1}]**		MAC-QS = $C_{background}$ + MAC-MPA; see section 8.1
	40 - <100	0.45		
	100 - <200	0.9		
	>200	1.5		

2.2 Specific quality standards

Protection Objective [#]	**Quality Standard**	**Comment**
Pelagic community (freshwater)	see table 2.1, AA-QS inland waters	
Pelagic community (saltwater)	see table 2.1, AA-QS transitional, coastal and territorial waters	
Benthic community (freshwater sediment)	MPA: 2.3 mg Cd /kg dry wt corresponding concentration in water: 0.018 µg/l	QS = $C_{background}$ + MPA
Benthic community (marine sediment)	Derivation of a QS/MPA not possible	lack of toxicity data of marine benthic organisms; see 8.2
Predators (second. poisoning) (freshwater)	0.16 mg/kg prey (corresponding conc. in water: 0.26 µg/l; in SPM 33.8 mg/kg)	see section 8.3
Food uptake by man	0.1 – 1.0 mg/kg edible parts of fish, crustaceans or cephalopods	CR No 466/2001, see section 8.4
Abstraction of water intended for human consumption (AWIHC)	5 µg/l (total concentration in unfiltered water sample)	Imperative value in CD 75/440/EEC, see section 8.5
Water intended for human consumption (WIHC)	5 µg/l	Drinking water standard set by CD 98/83/EC

3 Classification

R-Phrases and Labelling	**Reference**
Carc. Cat. 2; R45 - Muta. Cat. 3; R68 - Repr. Cat. 3; R62-63 - T; R48/23/25 - T+; R26 - F; R17 - N; R50-53	[15]

4 Physical and chemical properties

Property	**Value**	**Ref.**	**Comments**
Mol. Weight:			depending on compound
Water Solubility			depending on compound
Vapour Pressure:			depending on compound
Dissociation constant:			depending on compound

5 Environmental fate and partitioning

Table 5.1: Degradation data and partition coefficients

Property	**Value**	**Ref.**	**Comments**
Abiotic degradation Hydrolysis Photolysis	not applicable		
Biodegradation	not applicable		
Partition coefficients			Calculated European mean [1], see also table 5.1
Octanol - Water	not applicable		
Koc (organic carbon-water)			
$K_{susp-water}$ (suspended matter-water)	130,000	[1]	
$K_{sed-water}$ (sediment-water)			

Partition coefficients of suspended particulate matter (SPM) [10]

The value of K_p can be derived from the ratio of dissolved to total Cd concentrations in waterbodies. The dissolved fraction is generally the fraction passing a 0.45 µm membrane filter. The K_p-value varies with environmental conditions. Factors having a large influence on the actual K_p-value are the pH, the total metal concentration, the water hardness and the nature and concentration of complexing agents. A range of measured K_p values is presented in Table 5.1. In the calculations presented here, a European average value of $K_p = 130\ 10^3$ L kg^{-1} is used.

Table 5.2: The solid- water partition coefficient of suspended matter (K_p) in different freshwaters (table 3.1.4 of [10]).

Location	**K_p ($L\ kg^{-1}$) average**	**K_p ($L\ kg^{-1}$) min**	**K_p ($L\ kg^{-1}$) max**	**Source**
Flanders	$17\ 10^3$	$0.28\ 10^3$	$280\ 10^3$	VMM, 1997
the Rhine, Meuse and Schelde rivers in The Netherlands	n.a.	$30\ 10^3$	$300\ 10^3$	Ros&Slooff, 1990
4 locations in the Netherlands 1983-1986	$129\ 10^3$	n.a.	n.a.	Crommentuijn et al., 1997a
7 locations in the Netherlands 1988-1992	$151\ 10^3$	n.a.	n.a.	Crommentuijn et al., 1997a
3 locations in the Netherlands 1992-1994	$224\ 10^3$	n.a.	n.a.	Crommentuijn et al., 1997a
St Lawrence River basin 1991-1992	$100\ 10^3$	$7.9\ 10^3$	$794\ 10^3$	Quemerais and Lum, 1997

n.a.: not available

Bioaccumulation [1]

The restricted survey of BCFs of aquatic organisms conducted in the context of the risk assessment [1] demonstrates that the BCFs are highest in primary producers and lowest in secondary consumers. Factors affecting the BCF are the water hardness, pH, the Cd concentration and the presence of Cd^{2+}complexing agents.

Table 5.2: Comparison of freshwater BCF ($L\ kg^{-1}$) found in the risk assessment with data found by Taylor (1983). (Table 3.2.34a in [1])

	this review		Taylor (1983)*		
	min	max	median	min	max
algae - wet weight *dry weight*	1636 *2222*	23143 *310000*	7535 *115116*	10	10000
invertebrates - wet weight *dry weight*	396 *546*	17560 *33333*	994 *5000*	10	2000
vertebrates - wet weight *dry weight*	0.51 *5*	6484 *33333*	229 *233*		
vertebrates -total body content- wet weight *dry weight*	0.51 *5*	511 *1385*	15 *80*	1	3000

* full reference cited in [1]

6 Effect Data (aquatic environment)

Data validated in the context of the cadmium risk assessment as well as PNECs derived and conclusions drawn in the report served as basis for the quality standards calculated and proposed in this data sheet.

A summary of the lowest reliable toxicity values of cadmium for aquatic species is presented in tables A1 (short-term tests), A2 (long-term tests, freshwater) and A4 (long-term tests saltwater) of Annex 1 to this data sheet.

6.1 Predicted no-effect concentrations as calculated in the risk assessment

Table 6.1: PNECs

Compartment	**Value**	**Reference**
Surface water	0.19 µg Cd /l (dissolved fraction)	[1]
	0.09 $(H/50)^{0.7409}$ µg Cd L^{-1} (dissolved fraction)	for refined risk characterisation if hardness is known [1]
Sediment	2.3 mg Cd /kg	[10]
$PNEC_{oral}$ (secondary poisoning)	0.16 mg Cd / kg food of predator (fresh weight basis)	birds/mammals [1]

6.1.1 Calculation of PNEC surface water [1]

Generic $PNEC_{water}$

There are enough data from all three trophic levels to calculate the $PNEC_{water}$ by the assessment factor method (AFM) using the lowest assessment factor 10 according to TGD. The lowest NOEC value with a RI ≤ 3 is 0.16 µg L^{-1}. This would yield a $PNEC_{water}$ = 0.016µg L^{-1}. The $PNEC_{water}$, derived with the assessment factor method, is in the range of background concentrations of membrane filtered freshwaters. The Cd toxicity has not been tested in that range.

As enough NOEC data are available, the effects assessment is based on statistical extrapolation. Different species sensitivity distributions (SSD's) have been calculated in [1] and the method of Aldenberg and Slob (1993) has been selected for the assessment.. Based on the selected NOEC data (RI 1-3, data rated RI 4 was not used), the fifth percentile (HC_5), with 50% confidence, of a species sensitivity distribution was calculated using the software package ETX 1.3a (RIVM, Bilthoven, The Netherlands).

The HC_5 is calculated for 4 different approaches of data selection. The first approach is by using all the selected data, without calculation of species geometric mean values (either RI 1-3 or RI 1-2 of table A2). The second method is by calculating 'geometric mean' NOEC values for each species, resulting in one NOEC per species. The third approach is by calculating 'geometric mean' NOECs on a case-by-case basis (table A3; according to the recommendations elaborated at the "London-Workshop" in the framework of the EU Existing Substances programme, geometric mean NOECs are calculated for the same species and endpoint, tested in similar media. This approach does not result in one NOEC per species). The fourth approach is by selecting the lowest NOEC for each species, resulting in one NOEC per species.

Table 6.2: Calculation of critical concentrations (µg L^{-1}) using the assessment factor method (AFM) or the statistical extrapolation method (SEM, Aldenberg and Slob, 1993) for various levels of data quality (table 3.2.10 in [1])

data quality group	**AFM: NOEC/AF µg Cd L^{-1}**	
	AF=10	
RI 1-3	0.016	
RI 1-2	0.047	
	SEM: HC_5 at 50% (and 95%) confidence µg Cd L^{-1}	
	logistic distribution	normal distribution
Selection of all data, RI 1-2 (Table A2); n = 21	0.39 (0.15)	0.40 (0.16)
Selection of all data, RI 1-3 (Table A2); n = 49	0.35 (0.19)	0.34 (0.20)
One species, one value: geometric mean NOECs; n = 28	0.59 (0.30)	0.59 (0.32)
Case-by-case geometric mean calculation (Table A3); n = 44	0.38 (0.21)	0.38 (0.22)
One species, one value: lowest NOEC selection; n = 28	0.31 (0.14)	0.31 (0.15)

Selection on data quality does affect the value of HC_5 between groups RI 1-3 and RI 1-2. The NOEC data with RI 1-3 yield a smaller HC_5 than those with RI 1-2. The former group of data is derived based on 28 species whereas the latter is derived on 16 species. Many test results are classified as RI 3 mainly because the source document did not give statistical data analysis or because only nominal concentrations were given. These tests are still considered to be reliable (no critical information is missing). The choice between these two data groups is therefore a trade off between complete background information on tests with fewer species or more species with less complete background information. The latter is preferred here because the statistical extrapolation is based on the modelling of the species sensitivity distribution.

The choice of SSD (log-logistic or log-normal) does not affect the HC_5. The choice of data selection (geometric mean calculation or not, lowest NOEC selection or not) influences the HC_5 by a factor two. The lowest HC_5 (0.31 µg L^{-1}) is calculated when only the lowest NOEC value is selected for each species. The highest HC_5 (0.59 µg L^{-1}) is calculated when the geometric mean NOEC is calculated for each species. However, as best alternative for data selection the case by case calculation of geometric mean NOECs was identified in the RA, where NOEC's are only averaged for the same species tested on the same endpoint in the same or a similar medium. This proposal results in:

HC_5 = 0.38 µg L^{-1}

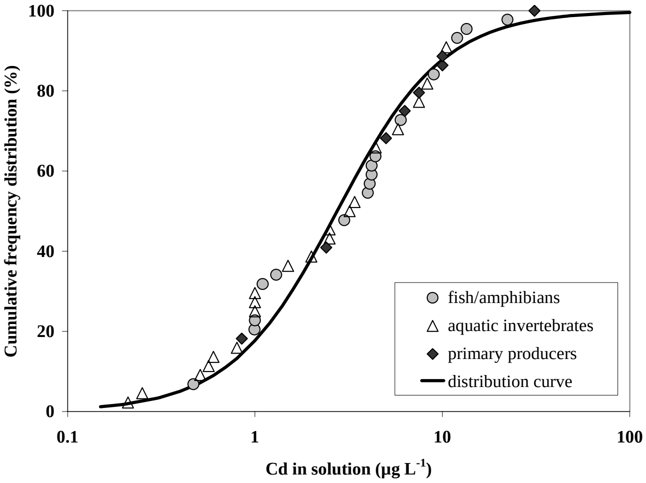

Figure 6.1: Frequency distribution and HC_5. Cumulative frequency distribution of the NOEC values of Cd toxicity tests of data quality group and RI 1-3 used to calculate the HC_5 (case-by-case geometric mean calculation; n = 44)

Estimation of an additional safety factor to calculate the PNEC from the HC_5

The database of the 168 reliable tests on single species contains 3 reliable LOECs below the HC_5 whereas the 9 multi-species studies identified 1 LOEC below the hardness corrected HC_5. Therefore, it is proposed in [1] to include a safety factor of 2 on the HC_5, yielding

$PNEC_{water} = HC_5/2 = 0.19\ \mu g\ L^{-1}$

No LOECs of the reliable single species or multi species studies is found below this $PNEC_{water}$. However, this generic $PNEC_{water}$ might not be protective for water with a very low water hardness (see section 3.2.1.6.4).

$PNEC_{water}$ as a function of water characteristics

Water characteristics appear to affect Cd toxicity. It is generally assumed that toxicity of Cd increases with reducing water hardness, reducing concentrations of dissolved organic matter and increasing solution pH.

However, effects of dissolved organic matter on Cd toxicity could not be described using the tests that are reviewed in [1] since most tests did not report this water characteristic. For the effects of pH on Cd toxicity regressions between the $\log(EC_{x\geq50})$ and pH showed non-significant effects for both the acute as chronic tests (P>0.05 for both regressions).

Considerable regional differences in water hardness of surface waters exist within the EU. Half of the surface waters in the northern European countries have a water hardness below 10 mg $CaCO_3$ L^{-1}, while in the western European countries almost 50% of the surface waters have a hardness above 200 mg $CaCO_3$ L^{-1}. Therefore, it is proposed in [1] that a water hardness correction of the $PNEC_{water}$ for risk characterisation at a local or regional scale might be useful.

In order to quantify the effect of water hardness on Cd toxicity it is proposed in [1] to use the quantification established by the US-EPA (US-EPA, 2001, full reference not given in [1]). For

Daphnia magna, *Pimephales promelas* and *Salmo trutta* an increasing trend of chronic values with increasing water hardness was observed in the EPA-study. The chronic value is the geometric mean of the NOEC and LOEC value for a given endpoint. Regression of the natural logarithm of the chronic value against the natural logarithm of water hardness gave a slope of 0.7712 for *D. magna*, 1.0034 for *P. promelas* and 0.5212 for *S. trutta*. The pooled slope for the three species is 0.7409, with 95% confidence limits of 0.3359 and 1.1459. The slope of 0.7409 was then used to adjust a range of chronic values to a reference hardness of 50 mg $CaCO_3$ L^{-1} following

$$\text{Chronic value}_{H=50} = \text{Chronic value}_{H}\left(\frac{50}{H}\right)^{0.7409} \tag{1}$$

The water hardness correction covers a hardness range of 44-209 mg $CaCO_3$ L^{-1}.

The water hardness correction equation of the U.S. EPA (US EPA, 2001; see above) was used to calculate the HC_5 as a function of water hardness. All NOEC values at hardness H were converted to NOEC values at a reference hardness of 50 mg $CaCO_3$ L^{-1} ($NOEC_{H=50}$) following

$$\text{NOEC}_{H=50} = \text{NOEC}_{H}\left(\frac{50}{H}\right)^{0.7409} \tag{2}$$

Geometric mean values were then calculated on the same data as in table A3 (used for the derivation of the generic HC_5 of 0.38 µg/l) after normalisation of the data. The software package ETX 1.3a (RIVM, Bilthoven, The Netherlands) was used to calculate the HC_5 at the reference hardness of 50 mg $CaCO_3$ L^{-1}, assuming a log-logistic distribution. This HC_5 value was then divided by a safety factor of 2 (as for the generic PNEC above) to yield a $PNEC_{water,\ regional}$ that is valid for waters with hardness of 50 mg $CaCO_3$ L^{-1} (0.09 µg Cd L^{-1}). Finally, equation 2 was used again to recalculate the $PNEC_{water,regional}$ at different values of water hardness as

$$PNEC_{water,regional} = 0.09\ (H/50)^{0.7409} \tag{3}$$

Table 6.3: The $PNEC_{water,regional}$ (µg L^{-1}) for different values of water hardness (H, mg $CaCO_3$/L). The NOEC data were all first normalised to H=50 from which the HC_5 at a reference hardness was found. The PNECwater at that hardness contains a safety factor of 2. The normalisation was then used to calculate the $PNEC_{water,regional}$ values at other values of H. (Table 3.2.15 in [1])

	N	min. NOEC	median NOEC	$PNEC_{water}$
Data normalised to H 50 (method 2)	34	0.07		0.09
retransformed $PNEC_{water} = 0.09\ (H/50)^{0.7409}$				
H 40				0.08
H50				0.09
H100				0.15
H200				0.25

It is proposed in [1] that this equation is not extrapolated below H = 40 mg $CaCO_3$ L^{-1}, i.e. the $PNEC_{water,regional}$ for H<40 mg $CaCO_3$ L^{-1} = 0.08 µg Cd L^{-1}.

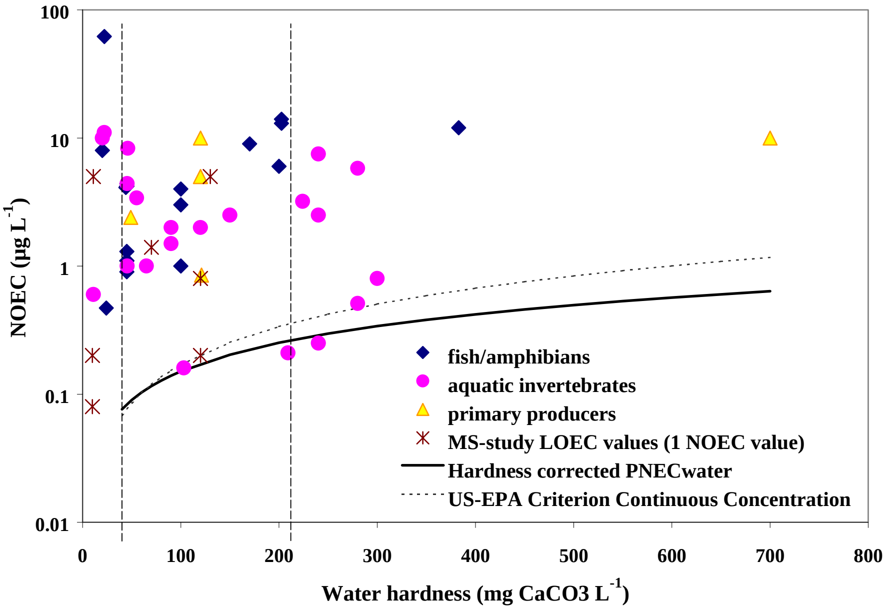

Figure 6.2: NOEC values of the laboratory studies , LOEC of multi-species studies (1 NOEC), water hardness corrected $PNEC_{water}$ and the US-EPA chronic criterion (US-EPA, 2000) as a function of water hardness. The dashed lines indicate the range of water hardness for which the US EPA (2001) hardness correction was derived. (Fig 3.2.3 in [1])

The water hardness correction method yields a $PNEC_{water,regional}$ at H = 50 mg $CaCO_3$/L, of 0.09 µg Cd L^{-1} for the whole data set. The $PNEC_{water,regional}$ that is transformed to other water hardness using the slope of 0.7409, increases more than threefold between H = 40 and H = 200 (Fig. 3.2.3).

Sorption of Cd^{2+} on suspended particles is higher in soft water than in hard water. As a result, the difference in HC_5 values between soft and hard water becomes smaller if the concentrations are based on total concentrations (dissolved + sorbed) [1].

6.1.2 Calculation of PNEC sediment [10]

Since the first draft of this substance data sheet has been set up on the basis of the draft risk assessment report available by that time [1], the PNEC derived for sediment has been changed following discussions at the Technical Meeting. In the actual final draft of the RAR (July 2003) [10] it was lowered by a factor of approximately 11 to 2.3 mg Cd/ kg $_{dw}$. In the following, the rationale behind the derivation of the $PNEC_{sediment}$ as laid down in the final draft of the RAR [10] is given in abridged form.

According to the TGD, the $PNEC_{sediment}$ may be calculated using the equilibrium partitioning (EP) method in the absence of ecotoxicological data for sediment-dwelling organisms. Based on the equilibrium partitioning, the following formula is applied to calculate $PNEC_{sediment}$ (mg $kg^{-1}{}_{dw}$):

$$PNEC_{sediment} = K_p \cdot PNEC_{water} \cdot 10^{-3}$$

in which K_p equals the solid-water partition coefficient of suspended matter, expressed in L kg^{-1}, and $PNEC_{water}$ expressed in µg L^{-1}. This transformation has assumed that the fraction Cd in the pore water can be neglected compared to the total amount of Cd in the sediment. Even at the lowest Kp assumed in the Table below, this fraction is less than 0.01%. The $PNEC_{water}$ equals 0.19

µg L^{-1}. The K_p ranges 17 10^3 L kg^{-1}- 224 10^3 L kg^{-1} (typical value , 130 10^3 L kg^{-1} see tables 5.0 & 5.1). The TGD stipulates an upper limit of Kp beyond which an additional safety factor of 10 should be included (either in PNEC or in PEC) to take the risk of direct ingestion into account. This upper limit is at Kp of about 2000 L kg^{-1}. This situation is certainly the case for Cd, therefore the PNEC should be lowered by a factor of 10 in all cases, i.e. the $PNEC_{sediment}$ should be calculated in this case as

$$\mathrm{PNEC}_{\mathrm{sediment}} = \mathrm{K}_{\mathrm{p}} \cdot \mathrm{PNEC}_{\mathrm{water}} \cdot 10^{-4}$$

This results in:

K_p (L kg^{-1})	$PNEC_{sediment}$ (mg Cd kg^{-1}_{dw})
17000	0.32
130000	2.5
224000	4.3

The ‘generic’ PNECsediment derived with the EP method using the typical Kp values of suspended matter is, therefore, 2.5 mg Cd kg^{-1}_{dw}.

Another approach to calculate the $PNEC_{sediment}$ is using the assessment factor (AF) method. There is only one sediment toxicity test available within the data set that can be considered as a real chronic test (14 month field test with a midge species of the genus *Chironomus*, NOEC 115 mg/kg sediment). The test duration of other tests are 4-10 days and use mortality as endpoint (see table A6).

The NOEC of the *Chironomus* test (115 mg/kg) is divided by an AF of 50. The choice of an AF of 50 instead of 100 is justified by the number of acute toxicity data, showing no differences between species. This results in

$PNEC_{sediment}$ = 115 mg kg^{-1}/50 = 2.3 mg Cd kg^{-1}dw

The AF method yields a PNEC that is almost identical as the ‘generic’ $PNEC_{sediment}$ derived with the EP method. The AF method however predicts a PNEC which is even below the background value of the sediment in which the lowest chronic NOEC was found (2.8 mg Cd kg^{-1}dw). The separation between the PNEC and effect concentrations (n=15) is higher than 100-fold, and this is large for natural elements. Additional chronic toxicity data (currently not found) could remove this concern by reducing the AF to 10 or below. However, it should be recalled that sediment toxicity tests spiked with Cd have little field relevance because Cd availability can remain low as long as the capacity of free sulphides (AVS) in the sediment is not exceeded. Mixed metal pollution is the rule rather than the exception in the field and the Cd availability in a metal polluted sediment is larger than in a clean sediment.

In conclusion, the $PNEC_{sediment}$ is derived by the assessment factor method, i.e.

$PNEC_{sediment}$ = 2.3 mg Cd kg^{-1}_{dw}

6.1.3 Calculation of the PNEC for non compartment specific effects relevant for the food chain (secondary poisoning) [1]

The risk of secondary poisoning is focussed on mammals and birds and not on lower organisms. No or little data were found to calculate the $PNEC_{oral}$ for fish or aquatic invertebrates, benthic organisms or lower terrestrial organisms [1].

Bioaccumulation factor in water

Several field studies and one laboratory experiment were found in which the BAF ($L\ kg_{ww}^{-1}$) was calculated for organisms, mainly invertebrates, exposed by both water and food. Bioaccumulation factors range from 4 to 170000 $L\ kg^{-1}{}_{dw}$. Comparison of bioaccumulation factors and bioconcentration factors of aquatic invertebrates reveals the latter to be significantly lower.

Table 6.4: BAF values of vertebrates - whole body ($L\ kg^{-1}$). (Table 3.2.34b in [1])

	min	max	median
Vertebrates - total body content- *dry weight*	4	2492	167
Vertebrates - total body content- *wet weight**	1	623	42

* calculated assuming a mean dry weight : wet weight ratio of 0.25 for whole fish

Secondary poisoning within the aquatic compartment

No $PNEC_{oral}$ can be calculated for secondary or primary consumers in the aquatic compartment since no NOEC’s were found from feeding studies. Cd uptake through food intake may be more important than uptake from water for some organisms, such as amphipods and insects (Stephenson and Turner 1993, Munger and Hare 1997; full reference in [1]).

Secondary poisoning of top predators

The $PNEC_{oral}$ is calculated from the lowest NOEC using an assessment factor [1]. The assessment factors for the feeding test are based on the TGD (TGD, 1996, p.350) and are 10 for the 90 day feeding test with mallard ducks (reproduction as endpoint).

Test substance	**Organism**	**Medium**	**Duration (d)**	**Endpoint**	**NOEC (mg Cd/kg)**	**Reference ***
$CdCl_2$	first-year adult mallard duck *Anas platyrhynchos*	commercial duck breeder mash coated with Cd dissolved in propylene glycol	90	spermatogenesis	**1.6**	White et al., 1978

* full reference in [1]

The suggested $\mathbf{PNEC_{oral}}$ is therefore **= 0.16 mg/kg fresh weight**

Expressed as the fresh-weight based Cd concentration in the food of the predator.

The risk of secondary poisoning of fish eating birds by Cd is predicted to be smaller than the direct effects of Cd in the aquatic environment [1]. This is readily demonstrated using BCFs of fish. Cadmium concentrations in whole fish at the proposed $\text{PNEC}_{\text{water}}$ = 0.19 µg Cd/l is predicted to range between 0.0001 and 0.12 mg Cd/kg fresh weight using the *whole* range of BCFs (0.5-623 l/kg fresh weight). These Cd concentrations are below the $\text{PNEC}_{\text{oral}}$. This assessment is made for freshwater systems and *not* for marine environments. Nephrotoxic lesions ascribed to Cd have been found in sea birds from areas that are relatively uncontaminated and where natural Cd may be the source (Nicholson et al., 1983; IPCS, 1992b; full references in [1]). It is therefore proposed in [1] that the PNEC oral should not be used for the marine environment where the bioaccumulation of Cd differs from that in freshwater dominated systems.

Bioaccumulation in sediment

Most of the BAFs of benthic organism are lower than 1 (either fresh weight based or dry weight based)). The BAFs are smaller for vertebrates than for invertebrates. [1]

	min	**max**	**Median**
invertebrates, wet weight (kg_{dw}/kg_{ww})	0.38	0.44	0.43
invertebrates, dry weight (kg_{dw}/kg_{dw})	0.01	1.15	0.28
vertebrates, wet weight (kg_{dw}/kg_{ww})	0.006	0.18	0.07

6.2 Summary on Endocrine Disrupting Potential

Cd or its compounds are apparently not suspected or known to exert endocrine disrupting potential. A possible ED potential of the substances is not addressed in [1] or [2].

7 Effect data (human health)

The human health part of the RARs for cadmium and compounds (R302/303) is in many parts and in many different stages of discussion. The critical effects on kidney and bone are not yet included in the documents. No conclusive effect data regarding the oral uptake of cadmium compounds could be retrieved from the so far available draft RARs.

It is therefore proposed to use the maximum levels set in Commission Regulation (EC) No 466/2001 [3] for cadmium in food as relevant quality standards for biota with regard to human health.

Table 7.1: Maximum levels of Cd in food from aquatic sources as set in Commission Regulation (EC) No 466/2001 [3]

Product	**maximum level (mg/kg wet weight)**
3.2.5 Muscle meat of fish, excluding fish species listed in 3.2.5.1	0.05
3.2.5.1 Muscle meat of *Dicologoglossa cunneata, Anguilla anguilla, Engraulis encrasicholus, Luvarus imperialis, Trachurus trachurus, Mugil labrosus labrosus, Diplodus vulgaris, Sardina pilchardus*	0.1
3.2.6 Crustaceans, excluding brown meat of crab	0.5
3.2.7 Bivalve molluscs	1.0
3.2.8 Cephalopods (without viscera)	1.0

8. Calculation of quality standards

8.1 Quality standards for water

In accordance with section 4.4 of the Manual [4] the use of the added risk approach is suggested to derive the water quality standards for cadmium.

$QS_{water} = C_{background} + MPA$

Freshwater

The $PNEC_{water}$ of 0.19 µg/l as identified in [1] (see table 6.12 of this data sheet) is equivalent to the maximum permissible addition in freshwater (MPA_{fw}).

As natural background concentration the Cd-concentration in the river Rhine is used as an example in order to illustrate the calculation of the quality standard. The natural background concentration of cadmium in the Rhine is 0.3 mg Cd/ kg suspended particulate matter (SPM) [5] and 0.003 µg/l "dissolved" Cd in water.

Hence, the quality standard for freshwater without consideration of the possible influence of water hardness on Cd toxicity as identified in [1] is:

$QS_{freshwater}$ = 0.003 µg Cd /l + 0.19 µg Cd /l = 0.193 µg Cd /l

As the log $Kp_{Water\text{-}SPM}$ is >3, the QS for water is additionally given as concentration in SPM (see section 8.4.1 of the draft report [4]). The $Kp_{SPM\text{-}water}$ as derived in the risk assessment (130,000 l/kg) is used for the calculation:

$MPA_{SPM.fw}$ = $MPAf_{water}$ (0.19 µg Cd /l) * Kp (130,000 l/kg) = **24.7 mg Cd / kg SPM** (dry wt)

For the Rhine as example, the QS for cadmium in SPM is therefore calculated as follows:

$QS_{SPM.fw}$ = $C_{background}$ (0.3 mg/kg) + $MPA_{SPM.fw}$ (24.7 mg/kg) = 25 mg Cd / kg SPM (dry wt)

Hardness correction of Cd toxicity

As proposed in the Cd risk assessment report ([1] and section 6.1 of this data sheet), it may be considered to correct Cd toxicity for hardness of water. Examples of respective water quality standards at different values of hardness are given in table 8.1.

Table 8.1: Quality standards for Cd at different levels of hardness

			Example with Rhine background levels $C_{background.water}$ **= 0.003 µg/l** $C_{background.sediment}$ **= 0.3 mg/kg**	
Hardness [mg $CaCO_3$ / l]	**MPA_{water} (= PNEC) [µg Cd /l]**	**MPA_{SPM} [mg Cd /kg]**	**QS_{water} [µg Cd /l]**	**QS_{SPM} [mg Cd / kg SPM]**
H40	0.08	10.4	0.083	10.7
H50	0.09	11.7	0.093	12.0
H100	0.15	19.5	0.153	19.8
H200	0.25	32.5	0.253	32.8

If it is decided to take the influence of hardness on the toxicity of cadmium into account for the setting of quality standards for freshwater, it is proposed to define no more than 3 hardness classes (table 8.2), in order to keep the use of the standards rather simple in practice.

Table 8.2: Proposed hardness classes for the quality standards of Cd referring to freshwater

Hardness Class	**Hardness [mg $CaCO_3$ / l]**	**MPA_{water} (= $PNEC_{water}$) [µg Cd /l]**	**$MPA_{SPM.wat}$ [mg Cd / kg SPM]**
I	H 40 # - <100	**0.08**	10.4
II	H 100 - <200	**0.15**	19.5
III	H >200	**0.25**	32.5

The hardness regression was only established in the range of 40-200 mg/l $CaCO_3$. Thus, care should be taken in relating QS derived on this basis to waters with lower hardness than 40 mg/l $CaCO_3$. However, even for tests conducted in softer waters no lower NOECs than the MPA (PNEC) of 0.08 µg Cd/l were identified in the risk assessment [1]

A further option to set the quality standard for Cd in freshwater is to exclusively use the MPA derived for the lowest hardness class I plus the relevant background concentration. This might be justified as cadmium is identified as priority hazardous substance. Emissions and losses of PHS shall cease or be phased out no longer than 20 years after the adoption of a quality standard for the substance concerned by the European Parliament and the Council.

Transitional, coastal and territorial waters

Marine waters are not yet addressed in the risk assessment for cadmium and no toxicity data for marine organisms are presented in the RAR [1, 10].

Following the conclusions of the Expert Group on Quality Standards (meeting of 12-16 May in Brussels), the Netherlands provided marine effects data of cadmium. These data (see table A4 in

Annex 1) come from Appendix 2 of the report of Crommentuijn et al. (1997) [7] and serve in this data sheet as basis for the derivation of a Maximum Permissible Addition (MPA) referring to the pelagic communities in transitional, coastal and territorial waters.

Long-term NOECs for marine organisms are available for marine fish, crustaceans, several groups of algae (chlorophyceae, bacillariophyceae, dinophyceae, coccolithophora), shellfish, annelids, nematoda, and cyanobacteria (table A4).

The species requirements for using the SSD approach as given in the TGD [8] is not entirely fulfilled as NOECs of insects and higher plants are not included in the database. However, the recommendation of the TGD is focused on freshwater environments and insects and higher plants are taxonomic groups that are normally not of particular relevance in saltwater or transitional waters (with the exception of higher plants in mangrove or seagrass ecosystems).

The 16 long-term NOECs given in bold in table A4 were used as input-data. The approach followed is in line with the approach used to derive the HC5 for freshwater (see section 6.1.1) The different taxonomic groups have been given similar weight (i.e. nearly the same number of toxicity tests per taxonomic group were included in the SSD if enough data were available, only one endpoint - the most sensitive - per species). If more than one test result for the same species, endpoint and exposure time was available the geometric mean of the individual NOECs was calculated.

The software package ETX 1.407 (RIVM, Bilthoven, The Netherlands [11]; based on the method of Aldenberg & Jaworska [9]) was used to calculate the 5-percentile cut-off value of the species sensitivity distribution.

The selected log-transformed data fit well to the expected distribution curve (see figure 8.1), and all tests for normal distribution of the input data (Kolmogorov-Smirnov, Anderson-Darling and Cramer van Mises) were passed on the highest level of significance (p = 0.1). The result of the SSD calculation is presented in table 8.3.

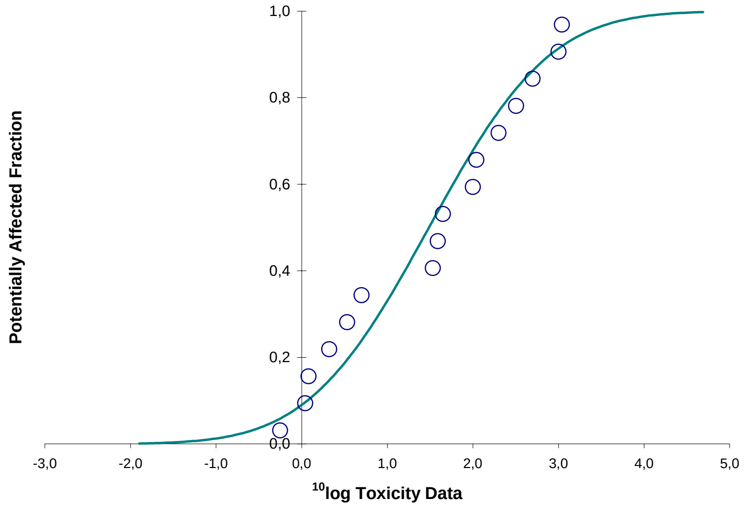

Figure 8.1: Cumulative frequency distribution of the saltwater data set used for the derivation of the 5P-COV with the method of Aldenberg and Jaworska [9]

Table 8.3: Results of the SSD calculation (saltwater NOEC data; n=16)

		90 % Confidence Interval	
Data set	**5-Percentile Cut-Off Value (50% confidence)**	5P-COV (95% conf.)	5P-COV (5% conf.)
Saltwater NOECs as given in table A4	0.42 µg/l	0.048 µg/l	1.716 µg/l

In order to account for further uncertainties it is foreseen in the TGD to divide the 5P-COV by an appropriate assessment factor between 1 and 5. Lowering the AF below 5 on the basis of increased confidence needs to be fully justified. The exact value of the AF must depend on an evaluation of the uncertainties around the derivation of the 5th percentile.

The data base used for the calculation of the 5P-COV covers less than the 8 normally recommended different taxonomic groups. Toxicity data on relevant marine taxonomic groups such as echinodermata, coelenterata and porifera are lacking. Further the ratio between the 50% and 95% confidence levels of the 5%-cut-off-value is quite high (8.75). However, on the other hand the lowest reported NOECs for saltwater organisms are in the same range as for freshwater organisms and none of the NOECs of the saltwater database is below the calculated 5P-COV. It is therefore proposed to use the same assessment factor as agreed by the Technical Meeting and used in the risk assessment report for the result of the SSD with freshwater data (AF = 2).

$MPA_{saltwater}$ = 5P-COV (0.42 µg/l) / AF (2) = 0.21 µg Cadmium /l

As the log $Kp_{Water\text{-}SPM}$ is >3, the QS for water is additionally given as concentration in SPM (see section 4.3.1 of the Manual [4]). The $Kp_{SPM\text{-}water}$ as derived in the risk assessment (130,000 l/kg) is used for the calculation:

$MPA_{SPM.sw}$ = MPA_{sw} (0.21 µg Cd /l) * Kp (130,000 l/kg) = **27.3 mg Cd / kg SPM**

The natural background concentration estimated in the report of Crommentuijn et al. [7] for marine waters (0.025 µg/l)[1] is used as an example in order to illustrate the calculation of the quality standard. Hence, the quality standard for transitional, coastal and territorial waters is:

$QS_{saltwater}$ = 0.025 µg Cd /l + 0.21 µg Cd /l = 0.235 µg Cd /l

Maximum permissible addition for transient concentration peaks (MAC-MPA)

The MAC-QS is calculated as $C_{background}$ + MAC-MPA (where MAC-MPA is the maximum permissible addition based on acute toxicity data).

There is a wealth of acute toxicity data available for freshwater organisms (fish, crustaceans, algae, molluscs, annelid worms, insects). As it is generally assumed that toxicity of Cd increases with reduced water hardness and because there exist considerable regional differences in water hardness of surface waters within the EU, this water quality parameter needs to be taken into account for the derivation of the MAC-MPA. The approach followed is in principle the same as

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[1] A natural background concentration of Cd in SPM of marine waters is not reported. Therefore an example QS referring to the concentration in SPM was not calculated.

used in the Cd-RAR for the calculation of the $PNEC_{water,regional}$ [10] and the hardness-corrected (annual average) MPA in section 8.1 of this data sheet.

In order to quantify the effect of water hardness on Cd toxicity the quantification established by the US-EPA (see section 6.1.1 and references [1,10] is used. This regression equation is validated for a hardness range of 44-209 mg $CaCO_3$/l.

All relevant short-term tests conducted in the hardness-range of 40-210 mg/$CaCO_3$/l were selected from tables 3.2.2, 3.2.4 and 3.2.6 of the RAR [10] and the test results normalised to a hardness of 50 mg $CaCO_3$/l:

$$ELC50_{H=50} = ELC50_{Hx} * (50/Hx)^{0.7409}$$

with:

$ELC50_{H=50}$	acute test result normalised to a hardness of 50 mg $CaCO_3$/l
$ELC50_{Hx}$	acute test result at hardness of the test solution ($40 \leq Hx \leq 210$ mg $CaCo_3$/l)

Geometric mean values were then calculated with the normalised acute data for the same species, endpoint and test duration. The resulting 27 ELC50s (see table A5 in Annex 1) were used to calculate the 5-percentile cut-off value of a species sensitivity distribution (SSD) with the software package ETX 1.407 (RIVM, Bilthoven, The Netherlands [11]; based on the method of Aldenberg & Jaworska [9]). The species requirements of the TGD for setting up a SSD are fulfilled with the exception of the availability of higher plant data.

The selected log-transformed data fit well to the expected distribution curve (see figure 8.2)), and all tests for normal distribution of the input data (Kolmogorov-Smirnov, Anderson-Darling and Cramer van Mises) were passed on the highest level of significance (p = 0.1). The result of the SSD calculation is given in table 8.4.

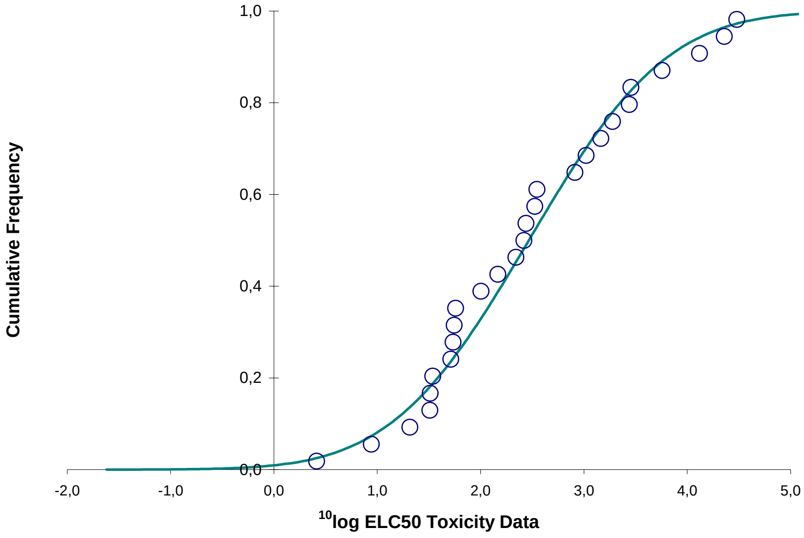

Figure 8.2: Cumulative frequency distribution of the combined freshwater and saltwater data set used for the derivation of the 5P-COV by the method of Aldenberg and Jaworska [9]

Table 8.4: Results of the SSD calculation (normalised$_{H=50}$ freshwater ELC50 data, n=27)

		90 % Confidence Interval	
Data set	**5-Percentile Cut-Off Value (50% confidence)**	5P-COV (95% conf.)	5P-COV (5% conf.)
Normalized and averaged ELC50s as given in table A5	5.27 µg/l	1.25 µg/l	14.98 µg/l

It is suggested to derive the MAC-MPA on the basis of the 5-Percentile Cut-Off Value (5P-COV = 5.3 µg/l) and the guidance given in the TGD on the effects assessment for intermittent releases (section 4.4.7 of the Manual [4]). As the 5P-COV is derived with the SSD-method, covering a wide range of different species and taxonomic groups, a reduced assessment factor of 10 (instead of 100) is deemed protective enough to establish the MAC-MPA (i.e. MAC-MPA$_{H=50}$ = 0.53 µg Cd/l).

Hardness-dependency of the MAC-MPA may be taken into account as suggested for the annual average MPA, i.e. by defining 3 hardness classes, covering the hardness range of ≥ 40 mg CaCO$_3$/l (see table 8.5).

$$\mathbf{MAC\text{-}MPA_{H40\text{-}100;\ H100\text{-}200;\ H>200} = MAC\text{-}MPA_{H=50}\ (0.53\ \mu g/l) * (H_{40;\ 100;\ 200}/50)^{0.7409}}$$

Table 8.5: Proposed MAC-MPAs for 3 different hardness classes

Hardness Class	**Hardness [mg CaCO$_3$ / l]**	**MAC-MPA$_{water}$ [µg Cd /l]**
I	H 40 # - <100	**0.45**
II	H 100 - <200	**0.89**
III	H >200	**1.48**

The hardness regression was only established in the range of 40-200 mg/l CaCO$_3$. Thus, care should be taken in relating MAC-MPAs derived on this basis to waters with lower hardness than 40 mg/l CaCO$_3$. The lowest LC50 observed in water with a hardness <40 mg CaCO3/l is 1 µg/l for swim-up of *Oncorhynchus tsahwytscha* alevins (see table 3.2.2 of [10]). Hence, for soft waters <40 mg CaCO$_3$/l setting a MAC-MPA of 0.1 µg/l may be appropriate.

8.2 Quality standard for sediment

Since the partition coefficient water – SPM is >1000 (trigger value) the calculation of sediment quality standards is required.

Freshwater ecosystems

In the final draft of the risk assessment report [10] it is proposed to use a PNEC of 2.3 mg Cd/kg (dry wt) to assess the risk of sediment dwelling organisms (see section 6.1.2 of this data sheet). Hence, this PNEC is suggested as MPA$_{sediment.fw}$ for cadmium.

MPA$_{sediment.fw}$ = 2.3 mg Cd/ kg sediment (dry wt)

As for water, the added risk approach is proposed to calculate the QS$_{sediment.fw}$. Again, the natural background concentration of cadmium in SPM of the river Rhine (0.3 mg Cd /kg SPM [5]) is taken as an example to derive QS$_{sediment.fw}$.

$\mathbf{QS_{sed.rhine}}$ = $C_{background}$ [0.3 mg/kg SPM] + MPA [2.3 mg/kg SPM] = **2.6 mg Cd/kg SPM** (dry wt)

In account of the range of Kp values for Cd in the risk assessment report [10] (i.e. 17,000 – 224,000 l/kg with a typical value of 130,000 l/kg), the $PNEC_{sediment}$ ($\approx MPA_{sediment.fw}$) of 2.3 mg Cd/kg will result in a lower corresponding water concentration than the aquatic PNECs derived in the RAR (generic PNEC 0.19 µg/l, or if hardness dependence of the PNEC is considered: $\approx$ 0.08 – 0.25 µg/l). This is illustrated by the following scenario calculations (table 8.6). The water concentration corresponding to the $PNEC_{sediment}$ ($\approx MPA_{sediment.fw}$) is:

$MPA_{sediment.freshwater}$ [µg Cd/l] = $MPA_{sediment.fw}$ (2300 µg/kg) / Kp (l/kg)

Table 8.6: Scenario calculations for the MPA_{water} corresponding to the $MPA_{sediment}$

$MPA_{sediment.freshwater}$ [µg Cd/l]	$MPA_{sediment.fw}$ [µg Cd/kg]	Kp [l/kg]
0.135	2300	17,000
0.018	2300	130,000
0.010	2300	224,000

Consequently, accounting for the typical Kp of 130,000 and the PNECsediment of 2.3 mg/kg, the resulting $MPA_{freshwater}$ would be 0.018 µg/l. This is four to twelve times lower than the PNECs derived in the RAR for the protection of pelagic organisms in waters with a hardness of ≥40 - >200 mg $CaCO_3$/l.

However, there is some uncertainty associated with the $PNEC_{sediment}$ derived in the RAR (see section 6.1.2 of this data sheet and reference [10]). Taking account of the uncertainties associated with the $PNEC_{sediment}$, the EAF decided at its 6th meeting that the overall quality standard (respectively the MPA) should be based on the aquatic MPA derived for the protection of the pelagic community.

8.3 Secondary poisoning of top predators

The relevant $PNEC_{oral}$ identified in the risk assessment [1] is 0.16 mg Cd /kg food (wet weight) of the predator (section 6.1.3 of this data sheet). The $PNEC_{oral}$ is the quality standard for tissue of prey organisms with respect to secondary poisoning of top predators as objective of protection.

Based on this quality standard referring to biota tissue, a corresponding quality standard referring to the cadmium concentration in water is calculated with the bioconcentration factors (BCF) of fish. These BCFs range from 0.51 to 6484, with a median of 229 (table 5.2 of this data sheet). However, field derived bioaccumulation factors (BAF = BCF+BMF) for whole fish (wet weight) range from minimally 1 to maximally 623 (table 3.2.34 in [1]). It is therefore proposed to calculate the biota quality standard referring to the water concentration with the maximum BAF. The biota QS referring to the Cd concentration in SPM is calculated using the generic partition coefficient water-SPM calculated in [1]. Following the reasons given in the risk assessment (see section 6.1.3 of this data sheet) the biota quality standards derived are only applicable to freshwater ecosystems.

$QS_{secpois.biota}$ = 160 µg Cd /kg food (wet weight)

$QS_{secpois.water}$ = 160 [µg/kg] * 623^{-1} [kg/l] = 0.26 µg Cd /l

$QS_{secpois.SPM}$ = $QS_{secpois.water}$ (0.26 µg Cd /l) * Kp (130,000 l/kg) = 33.8 mg Cd / kg SPM

The quality standards required to protect the pelagic communities in freshwater and in coastal and territorial waters are lower than the specific QS derived for the protection of predators from secondary poisoning.

8.4 Quality standards referring to food uptake by humans

The maximum levels of Cd in food from aquatic sources as set in Commission Regulation (EC) No 466/2001 [3] (see table 7.1 of this data sheet) are proposed as quality standards referring to levels in biota with regard to human health ($QS_{biota.hh}$).

Only one dry weight based BCF for edible parts of seafood (fish muscle) is available in the risk assessment report [1]. This BCF is 29.4. With the lowest maximum level for fish (0.5 mg Cd /kg fillet, fresh weight) set by CR 466/2001, the corresponding Cd concentration in water is 17 µg/l (without consideration of the water content in the fillet - if the water content was considered the BCF would drop to approximately 7-8). In any case, the calculated acceptable levels in water are by far higher than the levels acceptable for the protection of the aquatic community. Therefore, it is not necessary to calculate concentrations in water that correspond to the maximum acceptable Cd levels in fishery products.

8.5 Quality standards for drinking water abstraction

The imperative A1 value of Council Directive 75/440/EEC referring to drinking water abstraction by simple treatment is 5 µg Cd/l, the drinking water standard set by CD 98/83/EC is 5 µg CD/l as well.

The DWS is a limit value never to be exceeded at the tap. The MAC-QS (ECO) derived for the protection of the freshwater community is therefore sufficient to allow for compliance with the DWS standard even if only simple purification techniques (category A1 of CD 75/440/EEC, i.e. filtration and disinfection) are used for the abstraction of drinking water from surface water bodies according to Art. 7 of the WFD.

This can be demonstrated with an example. The highest MAC-MPA (ECO) for hard waters > 200 mg $CaCO_3$/l is 1.5 µg Cd/l. The natural background concentration of Cd is normally negligible (e.g. 0.003 µg/l for the river Rhine). If 15 mg suspended particulate matter were present in 1 l water, this amount of SPM would contain further 2,93 µg Cd (1.5 µg/l * Kp 130,000 l/kg * 15 mg / 10^6 mg). Hence, the total concentration in the unfiltered water sample would be 4.433 µg/l. A higher SPM concentration may however result in an exceedance of the 5 µg Cd /l limit value of the drinking water directive. But as the raw water is filtered in the course of drinking water processing, SPM will be significantly removed and consequently the Cd concentration as well.

8.6 Overall quality standard

The hardness corrected annual average maximum permissible additions for the protection of aquatic life in addition with the local background reference concentrations are proposed as overall quality standard. However, in order to be protective for top predators, the QS_{water} (i.e. $C_{background}$ + MPA) should in no case exceed 0.26 µg Cd/l.

In its opinion on the proposed quality standards [12], the SCTEE has criticised several aspects of the EU-RAR [13, 14] on that this data sheet is based, e.g. it expressed concerns about the procedures and assumptions used to derive the PNEC for the aquatic environment and about the validity of the model used to assess the secondary poisoning. The SCTEE suggested that the QS proposed in this data sheet are re-assessed in the light of these comments.

During the development of the methodological framework for the derivation of the quality standards, it was however decided to use the data validated in the EU risk assessments as well for quality standard derivation and to remain consistent with the conclusions drawn in the reports [4]. As such, it can only be stated that the data sheet in its current form is in line with the latest draft of the EU cadmium risk assessment.

9 References

[1] Revised Draft RAR Cadmium metal and Cadmium oxide, section 3.2 and 3.3, November 2001 (file: R302+303_0111_env_effectcharact_ch3.2+3.3.doc)

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[8] Technical Guidance Document on Risk Assessment in Support of Commission Directive 93/67/EEC on Risk Assessment for New Notified Substances and Commission Regulation (EC) No 1488/94 on Risk Assessment for Existing Substances and Directive 98/8/EC of the European Parliament and the Council Concerning the placing of biocidal products on the market. Part II. European Commission Joint Research Centre, EUR 20418 EN/2, © European Communities 2003. Available at the internet-site of the European Chemicals Bureau: http://ecb.jrc.it/existing-chemicals/

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[10] Risk Assessment Report, Cadmium Oxide & Cadmium Metal, CAS-Nos.: 1306-19-0 & 7440-43-9. Final Draft, sections 0 to 3, July 2003. File R302+303_0307_env_hh_ch0-3.doc. The most recent (draft) report is available at the internet site of the European Chemicals Bureau: http://ecb.jrc.it/existing-chemicals/ ⇒ tick ESIS button, then enter CAS or EINECS number of substance.

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[12] Opinion of the Scientific Committee on Toxicity, Ecotoxicity and the Environment (SCTEE) on “The Setting of Environmental Quality Standards for the Priority Substances included in Annex X of Directive 2000/60/EC in Accordance with Article 16 thereof”, adopted by the CSTEE during the 43rd plenary meeting of 28 May 2004, European Commission Health & Consumer Protection Directorate General, Brussels. http://europa.eu.int/comm/health/ph_risk/committees/sct/documents/out230_en.pdf

[13] Scientific Committee on Toxicity, Ecotoxicity and the Environment (CSTEE): Opinion on the results of the Risk Assessment of: Cadmium Metal and Cadmium Oxide, Environmental Part, CAS-No.: 7440-43-9 and 1306-19-0, EINECS-n°: 231-152-8 and 215-146-2. Carried out in the framework of Council Regulation (EEC) 793/93 on the evaluation and control of the risks of existing substances. Adopted by the CSTEE during the 431d plenary meeting of 28 May 2004. C7/GF/csteeop/Cdmet-ox/env/280504 D(04)

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ANNEX 1:

Table A1: Summary of acute Tests [1]

		min	median	max	n
Fish/Amphibians	$E(L)C_{x\geq 50}$ ($\mu g\ L^{-1}$)	0.9	1500	40200	31
Invertebrates	$E(L)C_{x\geq 50}$ ($\mu g\ L^{-1}$)	7	166	74000	61
Primary Producers	$E(L)C_{x\geq 50}$ ($\mu g\ L^{-1}$)	6.1	59	1000	12

Table A2: Selected NOEC data on effects of Cd in freshwater as used in the risk assessment. (Table 3.2.9A in [1])

Organism	**phylum/class**	**order**	**family**	**medium**	**H**	**Nominal/ Measured**	**Duration (d)**	**endpoint**	**NOEC ($\mu g\ L^{-1}$)**	**references ***	**R.I.**
Salmo gairdneri	*Chordata*	*Salmoniformes*	*Salmonidae*	aerated well water; T 10; O_2 7.5; pH 8-8.6	375-390	M	84	mortality	12	Lowe-Jinde and Niimi, 1984	2
Salmo gairdneri	*Chordata*	*Salmoniformes*	*Salmonidae*	synthetic water (ISO 1977) ; T 25; pH 8.3	100	N	50	median survival time	4	Dave et al., 1981	3
Oncorhynchus kisutch	*Chordata*	*Salmoniformes*	*Salmonidae*	sand filtered Lake Superior Water; continuous flow; DO 10.3; Al 41; Ac 3; pH 7.6	45	M	27	biomass	1.3	Eaton et al., 1978	2
Salvelinus fontinalis	*Chordata*	*Salmoniformes*	*Salmonidae*	sand filtered Lake Superior Water; continuous flow; DO 10.3; Al 41; Ac 3; pH 7.6	45	M	126	biomass	1.1	Eaton et al., 1978	2
Salvelinus fontinalis	*Chordata*	*Salmoniformes*	*Salmonidae*	sterilised Lake Superior water; pH 7-8; Al 38-46; Ac 1-10; DO 4-12; T 9-15	42-47	M	3 years	total weight of young /female of the 2nd generation	0.9	Benoit et al, 1976	2
Salvelinus fontinalis	*Chordata*	*Salmoniformes*	*Salmonidae*	reconstituted soft water: T 14-16°C; DO 9.3-11.4 mg/L; Cd(BG) <0.2 µg/L; pH 6.3-7.6; H 20	20	M	10	survival	8	Jop et al., 1995	2
Salvelinus fontinalis	*Chordata*	*Salmoniformes*	*Salmonidae*	river water: T 14-16°C; DO 8.7-12.2 mg/L; Cd(BG) <4 µg/L; pH 6.6-7.4; H 16-28	16-28	M	10	survival	62	Jop et al., 1995	2
Salmo salar	*Chordata*	*Salmoniformes*	*Salmonidae*	municipal water charcoal filtered and UV sterilised; BC 0.13 µg Cd/L; pH 6.5-7.3; T 5-10; DO 11.1-12.5; Al 14-17	19-28	M	46	total biomass	0.47	Rombough and Garside, 1982	2
Catostomus commersoni *Esox lucius*	*Chordata* *Chordata*	*Cypriniformes* *Esociformes*	*Catostomidae* *Esocidae*	sand filtered Lake Superior Water; continuous flow; DO 10.3; Al 41;	45	M	30 28	standing crop (biomass)	4.2 4.2	Eaton et al., 1978	2 2

Organism	**phylum/class**	**order**	**family**	**medium**	**H**	**Nominal/ Measured**	**Dura tion (d)**	**endpoint**	**NOEC (µg L^{-1})**	**references ***	**R.I.**
Salvelinus namaycush	*Chordata*	*Salmoniformes*	*Salmonidae*	Ac 3; pH 7.6			31	biomass	4.4		2
Salmo trutta (late eyed eggs)	*Chordata*	*Salmoniformes*	*Salmonidae*				61		1.1		2
Jordanella floridae	*Chordata*	*Cyprinodontiformes*	*Cyprinodontidae*	untreated Lake Superior water; T 25; DO 8.3; Al 42; Ac 2.4; pH 7.1-7.8	44	M	100	reproduction	4.1	Spehar, 1976	2
Brachydanio rerio	*Chordata*	*Cypriniformes*	*Cyprinidae*	synthetic water (changed ISO) ; T 24; DO >80%; pH 7.2	100	N	36	reproduction	1	Bresch ., 1982	3
Oryzias latipes	*Chordata*	*Beloniformes*	*Adrianichthyidae*	tap water; continuous flow; T 20	200 100	M	18	mortality and abn. behaviour	6 3	Canton and Slooff, 1982	3
Xenopus laevis	*Chordata*	*Anura*	*Pipidae*	tap water; continuous flow; T 20	170		100	inhibition of larvae development	9		3
Pimephaless promelas	*Chordata*	*Cypriniformes*	*Cyprinidae*	pond water diluted with carbon filtered demineralised tap water; DO 6.5-6.6; pH 7.6-7.7; Al 145-161; Ac 8-12; T 16-27	201-204	M	60	reproduction (pond fish)	13	Pickering and Gast, 1972	3
							60	reproduction (laboratory fry)	14		3
Daphnia magna	*Arthropoda*	*Cladocera*	*Daphnidae*	50 µm filtered and sterilised Lake IJssel water; pH 8.1; T 20; H 224	224	N	21	intrinsic rate of natural increase	3.2	Van Leeuwen et al., 1985	3
Daphnia magna	*Arthropoda*	*Cladocera*	*Daphnidae*	NPR synthetic water; pH 8.4; T 20	200	N	21	mortality	1	Van Leeuwen et al., 1985	3
Daphnia magna	*Arthropoda*	*Cladocera*	*Daphnidae*	synthetic water; T 25; pH 8; DO 69%	11	M	21	reproduction	0.6	Kühn et al., 1989	2
Daphnia magna	*Arthropoda*	*Cladocera*	*Daphnidae*	Synthetic water; Al 65; T 25	90	N	7	reproduction	2	Winner, 1988	3
Daphnia magna	*Arthropoda*	*Cladocera*	*Daphnidae*	well water: T 20±2°C; DO 4.9-7.9; Cd(BG) 0.08; pH 7.9	103	M	21	reproduction	0.16	Chapman et al., manuscript	3
Daphnia magna	*Arthropoda*	*Cladocera*	*Daphnidae*	well water: T 20±2°C; DO 4.9-7.9; Cd(BG) 0.08; pH 8.2	209	M	21	reproduction	0.21	Chapman et al., manuscript	3
Daphnia magna	*Arthropoda*	*Cladocera*	*Daphnidae*	unchlorinated, carbon filtered well water, aerated to saturation; Al 230; pH 8; DO >5; T 23; Cd < 0.01 µg Cd/L	240	N	14	reproductive impairment	2.5	Elnabarawy et al., 1986	3
Daphnia magna	*Arthropoda*	*Cladocera*	*Daphnidae*	aerated well water; DO >70%; pH 8; T 22; Al 250	300	M	21	reproduction	0.8	Knowles and McKee, 1987	2
Daphnia magna	*Arthropoda*	*Cladocera*	*Daphnidae*	culture medium; pH8.4; T 20	150	N	25	biomass production/female	2.5	Bodar et al., 1988a	3
Daphnia magna	*Arthropoda*	*Cladocera*	*Daphnidae*	20 µm cloth filtered Lake Superior water; pH 7.7; Al 42.3; DO 9; T 18	45.3	N	21	weight/animal	1	Biesinger and Christensen, 1972	3
Daphnia pulex	*Arthropoda*	*Cladocera*	*Daphnidae*	Whatman N° 1 filtered Lake Champlain water; pH 7.7; Al 42.4; Cd < 1µg L^{-1}	65	N	104	longevity	1	Bertram and Hart, 1979	3
Daphnia pulex	*Arthropoda*	*Cladocera*	*Daphnidae*	unchlorinated, carbon filtered well water, aerated to saturation; Al 230; pH 8; DO >5; T 23; Cd < 0.01 µg	240	N	14	reproductive impairment	7.5	Elnabarawy et al., 1986	3

Organism	**phylum/class**	**order**	**family**	**medium**	**H**	**Nominal/ Measured**	**Duration (d)**	**endpoint**	**NOEC ($\mu g\ L^{-1}$)**	**references ***	**R.I.**
				Cd/L							
Aplexa hypnorum: immature	*Mollusca*	*Basommotophora*	*Physidae*	Lake Superior water; DO 7.5; T 24		M	26	growth	4.41	Holcombe et al., 1984	2
Physa integra	*Mollusca*	*Basommotophora*	*Physidae*	untreated Lake Superior water; pH 7.1-7.7; T 15; DO 10-11; Al 40-44; Ac 1.9-3	44-48	M	21	mortality	8.3	Spehar et al., 1978	2
Daphnia galeata mendotae	*Arthropoda*	*Cladocera*	*Daphnidae*	10 µm filtered Lake Michigan water; T 18.5	120	N	154	number of individuals	2	Marshall, 1978	3
Ceriodaphnia reticulata	*Arthropoda*	*Cladocera*	*Daphnidae*	unfiltered river water; static; Ac 2-4.2; Al 41-65; pH 7.2-7.8	55-79	M	9	reproduction	3.4	Spehar and Carlson, 1984	3
Ceriodaphnia reticulata	*Arthropoda*	*Cladocera*	*Daphnidae*	unchlorinated, carbon filtered well water, aerated to saturation; Al 230; pH 8; DO >5; T 23; Cd < 0.01 µg/L	240	N	7	reproductive impairment	0.25	Elnabarawy et al., 1986	3
Ceriodaphnia dubia	*Arthropoda*	*Cladocera*	*Daphnidae*	Synthetic water; Al 65; T 25	90	N	7	mortality	1.5	Winner, 1988	3
Ceriodaphnia dubia	*Arthropoda*	*Cladocera*	*Daphnidae*	reconstituted soft water: T 14-16°C; DO 9.3-11.4 mg/L; Cd(BG) <0.2 µg/L; pH 6.3-7.6; H 20	20	M	7	reproduction	10	Jop et al., 1995	2
Ceriodaphnia dubia	*Arthropoda*	*Cladocera*	*Daphnidae*	river water: T 14-16°C; DO 8.7-12.2 mg/L; Cd(BG) <4 µg/L; pH 6.6-7.4; H 16-28	16-28	M	7	reproduction	11	Jop et al., 1995	2
Hyalella azteca	*Arthropoda*	*Amphipoda*	*Hyalellidae*	well water: T 23; pH 7.8	280	M	42	Survival	0.51	Ingersoll and Kemble, 2000	3
Chironomus tentans	*Arthropoda*	*Diptera*	*Chironomidae*	well water: T 23; pH 7.8	280	M	20	weight	5.8	Ingersoll and Kemble, 2000	3
Selenastrum capricornutum	*Chlorophyceae*	*Chlorococcales*	*Scenedesmaceae*	modified ISO 6341 medium; 0.2 µm filtered; T 20.3-25.6; pH 7.7-10.4	49	M	3	cell number	2.4	LISEC, 1998a	1
Coelastrum proboscideum	*Chlorophyceae*	*Chlorococcales*	*Coelastraceae*	AM;T 31;pH 5.3;	32	M	1	biomass	6.3	Müller and Payer 1979	2
Asterionella formosa	*Bacillariophyceae*	*Pennales*	*Diatomaceae*	AM; pH 8	121	M	1	growth rate	0.85	Conway and Williams 1979	2
Chlamydomonas reinhardii	*Chlorophyceae*	*Volvocales*	*Chlamydomonaceae*	AM; pH 6.7; T 20	42	N	7	steady state cell number	7.5	Lawrence et al. 1989	3
Scenedesmus quadricauda	*Chlorophyceae*	*Chlorococcales*	*Scenedesmaceae*	AM; pH 7		N	7	biomass (OD)	31	Bringmann and Kühn, 1980	3
Lemna paucicostata	*Liliopsida*	*Arales*	*Lemnaceae*	AM; T 25		N	7	number of fronds		Nasu and Kugimoto, 1981	
				pH>6	120				5		3
				pH 5.1	120				10		3
				pH 5.1	700				10		3

T = temperature (°C); H = hardness (as mg $CaCO_3$/L); DO = dissolved oxygen (mg O_2/L); Al = alkalinity (mg $CaCO_3$/L); Ac = acidity (mg $CaCO_3$/L); AM, artificial medium.

* full reference given in [1]

Table A3: Selected NOEC data on effects of Cd in freshwater and case-by-case calculation of “geometric mean NOECs”(table 3.2.9C in [1]). Bold underlined data are used for the calculation of the 5th-percentile cut-off value of the species sensitivity distribution.

organism	medium	H	endpoint	NOEC ($\mu g\ L^{-1}$)		references
Salmo gairdneri	aerated well water; T 10; O_2 7.5; pH 8-8.6	375-390	mortality	**12**	*S. gairdneri*: no geometric mean calculation: different test medium	Lowe-Jinde and Niimi, 1984
Salmo gairdneri	synthetic water (ISO 1977) ; T 25; pH 8.3	100	median survival time	**4**		Dave et al., 1981
Oncorhynchus kisutch	sand filtered Lake Superior Water; continuous flow; DO 10.3; Al 41; Ac 3; pH 7.6	45	biomass	**1.3**		Eaton et al., 1978
Salvelinus fontinalis	sand filtered Lake Superior Water; continuous flow; DO 10.3; Al 41; Ac 3; pH 7.6	45	biomass	1.1	*S. fontinalis*: geometric mean calculation: same test medium, same endpoint (biomass) geometric mean = **1.0**	Eaton et al., 1978
Salvelinus fontinalis	sterilised Lake Superior water; pH 7-8; Al 38-46; Ac 1-10; DO 4-12; T 9-15	42-47	total weight of young /female of the 2nd generation	0.9		Benoit et al, 1976
Salvelinus fontinalis	reconstituted soft water: T 14-16°C; DO 9.3-11.4 mg/L; Cd(BG) <0.2 µg/L; pH 6.3-7.6; H 20	20	survival	8	*S. fontinalis*: geometric mean calculation: similar test medium, same endpoint (survival) geometric mean = **22**	Jop et al., 1995
Salvelinus fontinalis	river water: T 14-16°C; DO 8.7-12.2 mg/L; Cd(BG) <4 µg/L; pH 6.6-7.4; H 16-28	16-28	survival	62		Jop et al., 1995
Salmo salar	municipal water charcoal filtered and UV sterilised; BC 0.13 µg Cd/L; pH 6.5-7.3; T 5-10; DO 11.1-12.5; Al 14-17	19-28	total biomass	**0.47**		Rombough and Garside, 1982
Catostomus commersoni	sand filtered Lake Superior Water; continuous flow; DO 10.3; Al 41; Ac 3; pH 7.6	45	standing crop	**4.2**		Eaton et al., 1978
Esox lucius			(biomass)	**4.2**		
Salvelinus namaycush			biomass	**4.4**		
Salmo trutta (late eyed eggs)				**1.1**		
Jordanella floridae	untreated Lake Superior water; T 25; DO 8.3; Al 42; Ac 2.4; pH 7.1-7.8	44	reproduction	**4.1**		Spehar, 1976
Brachydanio rerio	synthetic water (changed ISO) ; T 24; DO >80%; pH 7.2	100	reproduction	**1**		Bresch ., 1982
Oryzias latipes	tap water; continuous flow; T 20	200 100	mortality and abn. behaviour	**6** **3**	*O. latipes*: no geometric mean calculation: different test medium	Canton and Slooff, 1982
Xenopus laevis	tap water; continuous flow; T 20	170	inhibition of larvae development	**9**		Canton and Slooff, 1982
Pimephaless promelas	pond water diluted with carbon filtered demineralised tap water; DO 6.5-6.6; pH 7.6-7.7; Al 145-161; Ac 8-12; T 16-27	201-204	reproduction (pond fish)	13	*P. promelas*: geometric mean calculation: same test medium, same endpoint (reproduction) geometric mean = **13.5**	Pickering and Gast, 1972
			reproduction (laboratory fry)	14		
Daphnia magna	50 µm filtered and sterilised Lake IJssel water; pH 8.1; T 20; H 224	224	intrinsic rate of natural increase	**3.2**	*D. magna*: no geometric mean calculation: different endpoints	Van Leeuwen et al., 1985
Daphnia magna	NPR synthetic water; pH 8.4; T 20	200	mortality	**1**		Van Leeuwen et al., 1985
Daphnia magna	synthetic water; T 25; pH 8; DO 69%	11	reproduction	**0.6**	*D. magna*: no geometric mean calculation: different medium	Kühn et al., 1989
Daphnia magna	Synthetic water; Al 65; T 25	90	reproduction	2	*D. magna*: geometric mean calculation: similar medium, same endpoint (reproduction) geometric mean = **0.6**	Winner, 1988
Daphnia magna	well water: T 20±2°C; DO 4.9-7.9; Cd(BG) 0.08; pH 7.9	103	reproduction	0.16		Chapman et al., manuscript
Daphnia magna	well water: T 20±2°C; DO 4.9-7.9; Cd(BG) 0.08; pH 8.2	209	reproduction	**0.21**	*D. magna*: no geometric mean calculation: different medium	Chapman et al., manuscript

organism	medium	H	endpoint	NOEC ($\mu g\ L^{-1}$)		references
Daphnia magna	unchlorinated, carbon filtered well water, aerated to saturation; Al 230; pH 8; DO >5; T 23; Cd < 0.01 µg Cd/L	240	reproductive impairment	**2.5**		Elnabarawy et al., 1986
Daphnia magna	aerated well water; DO >70%; pH 8; T 22; Al 250	300	reproduction	**0.8**		Knowles and McKee, 1987
Daphnia magna	culture medium; pH8.4; T 20	150	biomass production/female weight/animal	**2.5**	*D. magna*: no geometric mean calculation: different medium	Bodar et al., 1988a
Daphnia magna	20 µm cloth filtered Lake Superior water; pH 7.7; Al 42.3; DO 9; T 18	45.3		**1**		Biesinger and Christensen, 1972
Daphnia pulex	Whatman N° 1 filtered Lake Champlain water; pH 7.7; Al 42.4; Cd < 1µg L^{-1}	65	longevity	**1**	*D. pulex*: no geometric mean calculation: different medium	Bertram and Hart, 1979
Daphnia pulex	unchlorinated, carbon filtered well water, aerated to saturation; Al 230; pH 8; DO >5; T 23; Cd < 0.01 µg Cd/L	240	reproductive impairment	**7.5**		Elnabarawy et al., 1986
Aplexa hypnorum: immature	Lake Superior water; DO 7.5; T 24		growth	**4.41**		Holcombe et al., 1984
Physa integra	untreated Lake Superior water; pH 7.1-7.7; T 15; DO 10-11; Al 40-44; Ac 1.9-3	44-48	mortality	**8.3**		Spehar et al., 1978
Daphnia galeata mendotae	10 µm filtered Lake Michigan water; T 18.5	120	number of individuals	**2**		Marshall, 1978
Ceriodaphnia reticulata	unfiltered river water; static; Ac 2-4.2; Al 41-65; pH 7.2-7.8	55-79	reproduction	**3.4**	*C. reticulata*: no geometric mean calculation: different medium	Spehar and Carlson, 1984
Ceriodaphnia reticulata	unchlorinated, carbon filtered well water, aerated to saturation; Al 230; pH 8; DO >5; T 23; Cd < 0.01 µg/L	240	reproductive impairment	**0.25**		Elnabarawy et al., 1986
Ceriodaphnia dubia	Synthetic water; Al 65; T 25	90	mortality	**1.5**	*C. dubia*: no geometric mean calculation: different medium, different endpoint	Winner, 1988
Ceriodaphnia dubia	reconstituted soft water: T 14-16°C; DO 9.3-11.4 mg/L; Cd(BG) <0.2 µg/L; pH 6.3-7.6; H 20	20	reproduction	10	*C. dubia*: geometric mean calculation: similar medium, same endpoint (reproduction)	Jop et al., 1995
Ceriodaphnia dubia	river water: T 14-16°C; DO 8.7-12.2 mg/L; Cd(BG) <4 µg/L; pH 6.6-7.4; H 16-28	16-28	reproduction	11	geometric mean = **10.5**	Jop et al., 1995
Hyalella azteca	well water: T 23; pH 7.8	280	Survival	**0.51**		Ingersoll and Kemble, 2000
Chironomus tentans	well water: T 23; pH 7.8	280	weight	**5.8**		Ingersoll and Kemble, 2000
Selenastrum capricornutum	modified ISO 6341 medium; 0.2 µm filtered; T 20.3-25.6; pH 7.7-10.4	49	cell number	**2.4**		LISEC, 1998a
Coelastrum proboscideum	AM;T 31;pH 5.3;	32	biomass	**6.3**		Müller and Payer 1979
Asterionella formosa	AM; pH 8	121	growth rate	**0.85**		Conway and Williams 1979
Chlamydomonas reinhardii	AM; pH 6.7; T 20	42	steady state cell number	**7.5**		Lawrence et al. 1989
Scenedesmus quadricauda	AM; pH 7		biomass (OD)	**31**		Bringmann and Kühn, 1980
Lemna paucicostata	AM; T 25		number of fronds		*L. paucicostata*: no geometric mean calculation: different medium	Nasu and Kugimoto, 1981
	pH>6	120		**5**		
	pH 5.1	120		**10**		
	pH 5.1	700		**10**		

T = temperature (°C); H = hardness (as mg $CaCO_3$/L); DO = dissolved oxygen (mg O_2/L); Al = alkalinity (mg $CaCO_3$/L); Ac = acidity (mg $CaCO_3$/L); AM, artificial medium.

Table A4: Selected NOEC data on effects of Cd in seawater and case-by-case calculation of “geometric mean NOECs”. Bold underlined data are used for the calculation of the 5^{th} percentile cut-off value of the species sensitivity distribution.

#	Organism	Taxonomic group	Test duration	Endpoint	NOEC µg/l	Reference
1	Allorchestes compressa, first instar juveniles	Crustacea	28 d	mortality or immobility	11	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
2	**Allorchestes compressa, first instar juveniles**	**Crustacea**	**28 d**	**weight**	**2,1**	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
3	Anabaena variabilis	Cyanobacteria	7 d	chlorophyll content	39	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
4	Artemia salina, encysted embryos	Crustacea	48 h	hatchability	1,1	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
5	**Asterionella glacialis**	**Diatomeae**	**4-5w**	**reproduction**	**1,1**	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
6	Bacteriastrum delicatulum	Diatomeae	4-5w	reproduction	11	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
7	Bacteriastrum hyalinum	Diatomeae	4-5w	reproduction	11	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
8	Biddulphia mobiliensis	Diatomeae	4-5w	reproduction	3,4	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
9	Callianassa australiensis	Crustacea	14 d	mortality or immobility	320	Ahsanullah, M., D.S. Negilski and M.C. Mobley (1981) Toxicity of zinc, cadmium and copper to the shrimp Callianassa australiensis. I. Effects of individual metals. Mar. Biol., 64, 299-304.
10	Cancer anthonyi, embryo	Crustacea	7 d	mortality or immobility	5	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
11	Cancer anthonyi, embryo	Crustacea	7 d	reproduction	10	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
12	**Capitella capitata**	**Annelida**	**25-40 d**	**reproduction**	**320**	Reish, 1978
13	**Chlorella vulgaris**	**Chlorophyceae**	**7 d**	**chlorophyll content**	**39**	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
14	**Clupea harengus, ELS**	**Fish**	**15 d**	**reproduction**	**100**	Von Westernhage, H., H. Rosenthal and K.R. Sperling (1974) Combined effects of cadmium and salinity on development and survival of herring eggs. Helgol„nd, wiss. Meeresunters., 26, 416-433.
15	**Crassostrea virginica**	**Mollusca**	**9 m**	**reproduction**	**5**	Zaroogian, G.E. and G. Morrison (1981) Effect of cadmium body burdens in adult Crassostrea virginica on fecundity and viability of larvae. Bull. Environ. Contam. Toxicol., 27, 344-348.
16	Ctenodrilus serratus	Annelida	21 d	reproduction	1000	Reish & Carr, 1978
17	Ctenodrilus serratus	Annelida	28-31 d	reproduction	1000	Reish, 1978
18	Dicrateria zhanjiangenis	Algae	6 d	cell number	110	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
19	Ditylum brightwellii	Diatomeae	4-5w	reproduction	34	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
20	**Dunaliella sp.**	**Chlorophyceae**	**6 d**	**cell number**	**1100**	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
21	Emiliania huxleyi	Algae (Coccolitho-phorae)	4-5w	reproduction	1,1	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
22	Gymnodinium spec.	Dinophyceae	4-5w	reproduction	11	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
23	Heterocapsa triquetra	Dinophyceae	4-5w	reproduction	3,4	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
24	Hymenomonas carterae	Algae (Coccolitho-phorae)	4-5w	reproduction	1,1	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
25	Lithodesmium undulatum	Diatomeae	4-5w	reproduction	3,4	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
26	Monhystera disjuncta, 0.35 mm	Nematoda	11 d	mortality or immobility	5000	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.

#	Organism	Taxonomic group	Test duration	Endpoint	NOEC µg/l	Reference
27	**Monhystera microphthalma, 0.35 mm**	**Nematoda**	**13 d**	**mortality or immobility**	**500**	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
28	Mugil cephalus, fry	Fish	8 w	mortality or immobility	20	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
29	Mugil cephalus, juvenile	Fish	8 w	mortality or immobility	100	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
30	**Mugil cephalus**	**Fish**	**8 w**	**mortality or immobility**	**44,7**	**Geometric mean of Nos. 28 & 29**
31	Mysidopsis bahia	Crustacea	7 w	reproduction	5,1	Gentile, S.M., J.H. Gentile, J. Walker and J.F. Heltshe (1982) Chronic effcts of cadmium on two species of mysid shrimps: Mysidopsis bahia and Mysidopsis bigelowi. Hydrobiologia, 93, 195-204.
32	Mysidopsis bahia, < 24 h	Crustacea	28 d	mortality or immobility	2,5	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
33	Mysidopsis bahia, < 24 h	Crustacea	28 d	mortality or immobility	0,6	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
34	**Mysidopsis bahia, < 24 h**	**Crustacea**	**28 d**	**mortality or immobility**	**1,2**	Geometric mean of Nos. 32 & 33
35	Mysidopsis bahia, < 24 h	Crustacea	28 d	number of young	2,5	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
36	Mysidopsis bahia, < 24 h	Crustacea	28 d	number of young	6,1	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
37	Mysidopsis bahia, < 24 h	Crustacea	28 d	number of young	0,9	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
38	Mysidopsis bahia, < 24 h	Crustacea	28 d	number of young	2,5	Geometric mean of Nos. 35, 36 & 37
39	Mysidopsis bahia, 24 h	Crustacea	7 w	mortality or immobility	5,1	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
40	Mysidopsis bahia, 24 h	Crustacea	7 w	number of young	10	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
41	Mysidopsis bahia, 24-48 h, juvenile	Crustacea	5 w	mortality or immobility	4	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
42	Mysidopsis bahia, 24-48 h, juvenile	Crustacea	5 w	number of young	8	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
43	Mysidopsis bahia, 24-48 h, juvenile	Crustacea	5 w	shell	2	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
44	Mysidopsis bahia, 8 d	Crustacea	7 d	mortality or immobility	5	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
45	Mysidopsis bahia, 8 d	Crustacea	7 d	mortality or immobility	25	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
46	Mysidopsis bahia, 8 d	Crustacea	7 d	mortality or immobility	15	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
47	Mysidopsis bahia, 8 d	Crustacea	7 d	reproduction	5	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
48	Mysidopsis bahia, 8 d	Crustacea	7 d	reproduction	15	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
49	Mysidopsis bahia, 8 d	Crustacea	7 d	reproduction	15	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
50	Mysidopsis bahia, 8 d	Crustacea	7 d	weight	5	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
51	Mysidopsis bahia, 8 d	Crustacea	7 d	weight	5	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
52	Mysidopsis bahia, 8 d	Crustacea	7 d	weight	5	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
53	Mysidopsis bigelowi	Crustacea	7 w	reproduction	5,1	Gentile, S.M., J.H. Gentile, J. Walker and J.F. Heltshe (1982) Chronic effcts of cadmium on two species of mysid shrimps: Mysidopsis bahia and Mysidopsis bigelowi. Hydrobiologia, 93, 195-204.
54	**Mytilus edulis**	**Mollusca**	**17 d**	**growth**	**110**	Poulsen, E. H.U. Riisgard and F. Mohlenberg (1982) Accumulation of cadmium and bioenergetics in the mussel Mytilus edulis. Mar. Biol. 68, 25-29.
55	Nereis arenaceodentata	Annelida	4 m	reproduction	560	Reish, 1978
56	Ophryotrocha diadema	Annelida	28 d	reproduction	500	Reish, 1978

#	Organism	Taxonomic group	Test duration	Endpoint	NOEC µg/l	Reference
57	Ophryotrocha diadema	Annelida	28 d	reproduction	500	Reish & Carr, 1978
58	**Ophryotrocha labronica**	**Annelida**	**30 d**	**growth**	**200**	Roed, K.H. (1980) Effects of salinity and cadmium interaction on reproduction and growth during three successive generations of Ophryotrocha labronica (Polychaeta). Helgol. Wiss. Meeresunters., 33. 1/4, 47-58.
59	Pellioditis marina, 0.42 mm	Nematoda	8 d	mortality or immobility	25000	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
60	**Peridinium spec.**	**Dinophyceae**	**4-5w**	**reproduction**	**0,56**	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
61	**Pleuronectes flesus, ELS**	**Fish**	**21 d**	**reproduction**	**1000**	Von Westernhage, H. and V. Dethlefsen (1975) Combined effects of cadmium and salinity on development and survival of flounder eggs. J. Mar. Biol. Assoc. U.K., 55, (4), 945-957.
62	Prorocentrum micans	Dinophyceae	4-5w	reproduction	1,1	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
63	Rhizosolenia setigera	Diatomeae	4-5w	reproduction	11	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
64	**Skeletonema costatum**	**Diatomeae**	**4-5w**	**reproduction**	**34**	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
65	Streptotheca tamesis	Diatomeae	4-5w	reproduction	11	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
66	**Synechococcus bacillaris**	**Cyanobacteria**	**4-5w**	**reproduction**	**3,4**	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.
67	Thoracosphaera heimii	Dinophyceae	4-5w	reproduction	3,4	BKH (1995) Update toxiciteitsgegevens voor vier stoffen in het kader van MILBOWA. Versie maart 1995.

Table A5: Short-term acute toxicity data selected from tables 3.2.2, 3.2.4 & 3.2.6 of the RAR[10]. Normalised (hardness = 50 mg $CaCO_3$/l) and case by case averaged data (geometric mean) used as input for MAC-MPA derivation by means of statistical extrapolation (species sensitivity distribution). Full references are given in the RAR [10]

Taxon. Group	Species	Endpoint	Test Duration (d)	Hardness reported	Hardness used for normalisation	ELC50 reported [µg/l]	Reference	RI	ELC50 normalised (H=50) [µg/l]	$ELC50_{H=50}$ geometric mean [µg/l]	$ELC50_{H=50}$ input SSD [µgl]
Alg	Selenastrum capricornutum	Cell no.	3	49	49	23	LISEC, 1998a	1	23.3	20.7	20.7
Alg	Selenastrum capricornutum	Cell no.	3	49	49	18	LISEC, 1998a	1	18.3		
Alg	Scenedesmus subspicatus	biomass	3	60	60	62	Kühn & Pattardd 1990	3	54.2		54.2
Ane	Limnodrilus hoffmeisteri	mortality	4	152	152	2400	Williams et al. 1985	3	1053.1		1053.1
Cru	Asselus aquaticus	mortality	4	152	152	600	Williams et al. 1985	3	263.3		263.3
Cru	Ceriodaphnia reticulata	mortality	2	55-79	67	129	Spehar & Carlson 1984	3	71.9	55.5	55.5
Cru	Ceriodaphnia reticulata	mortality	2	120	120	110	Hall et al. 1986	3	57.5		
Cru	Ceriodaphnia reticulata	mortality	2	200	200	80	Hall et al. 1986	3	28.6		
Cru	Daphnia magna	mortality	2	45.3	45.3	65	Biesinger & Christensen 1972	3	69.9	32.6	32.6
Cru	Daphnia magna	mortality	2	32-76	54	23	Nebecker et al. 1986a	3	21.7		
Cru	Daphnia magna	mortality	2	55-79	67	129	Spehar & Carlson 1984	3	103.9		
Cru	Daphnia magna	mortality	2	120	120	35	Hall et al. 1986	3	18.3		
Cru	Daphnia magna	mortality	2	130	130	58	Attar & Maly 1982	2	28.6		
Cru	Daphnia magna	mortality	2	100-200	150	30	Canton & Slooff 1982	3	13.3		
Cru	Daphnia magna	mortality	2	150	150	320	Bodar et al. 1990	3	141.8		
Cru	Daphnia magna	mortality	2	160-180	170	38	Lewis & Horning 1991	2	15.3		
Cru	Daphnia magna	mortality	2	200	200	65	Hall et al. 1986	3	23.3		
Cru	Daphnia magna	mortality	2	200	200	69	Dave et al. 1981	3	24.7		
Cru	Daphnia pulex	mortality	2	80-100	90	42	Lewis & Horning 1991	2	27.2	34.5	34.5
Cru	Daphnia pulex	mortality	2	120	120	90	Hall et al. 1986	3	47.0		
Cru	Daphnia pulex	mortality	2	200	200	90	Hall et al. 1986	3	32.2		
Cru	Gammarus pseudolimnaeus	mortality	4	39-48	44	68.3	Spehar & Carlson 1984	3	75.1	57.3	57.3
Cru	Gammarus pseudolimnaeus	mortality	4	55-79	67	54.4	Spehar & Carlson 1984	3	43.8		

Taxon. Group	Species	Endpoint	Test Duration (d)	Hardness reported	Hardness used for normalisation	ELC50 reported [µg/l]	Reference	RI	ELC50 normalised (H=50) [µg/l]	ELC50$_{H=50}$ geometric mean [µg/l]	ELC50$_{H=50}$ input SSD [µgl]
Cru	Gammarus pulex	mortality	4	152	152	20	Williams et al. 1985	3	8.8		8.8
Cru	Simocephalus serrulatus	mortality	2	39-48	44	24.5	Spehar & Carlson 1984	3	26.9	51.6	51.6
Cru	Simocephalus serrulatus	mortality	2	55-79	67	123	Spehar & Carlson 1984	3	99.0		
Fis	Brachydanio rerio	mortality	4	100	100	3500	Bresch 1982	3	2094.3	1459.6	1459.6
Fis	Brachydanio rerio	mortality	4	100	100	1700	Dave et al. 1981	3	1017.2		
Fis	Carassius auratus	mortality	4	44.4	44.4	748	Phipps & Holocombe 1985	2	816.8		816.8
Fis	Jordanella floridae	mortality	4	44	44	2500	Spehar 1976	2	2748.4		2748.4
Fis	Orizas latipes	mortality & behaviour	4	100	100	70	Canton & Slooff 1982	3	41.9	32.4	32.4
Fis	Orizas latipes	mortality & behaviour	4	200	200	70	Canton & Slooff 1982	3	25.1		
Fis	Pimephales promelas	mortality	4	44.4	44.4	1500	Phipps & Holocombe 1985	2	1638.0	334.8	334.8
Fis	Pimephales promelas	mortality	4	200	200	90	Hall et al. 1986	3	32.2		
Fis	Pimephales promelas	mortality	4	201-204	202	2000	Pickering & Gast 1972	3	710.8		
Fis	Poecilia reticulata	mortality & behaviour	4	100	100	3400	Canton & Slooff 1982	3	2034.4	2843.5	2843.5
Fis	Poecilia reticulata	mortality & behaviour	4	200	200	11100	Canton & Slooff 1982	3	3974.3		
Fis	Salvelinus fontinalis	mortality	4	44-46	45	2.4	Carroll et al. 1979	3	2.6		2.6
Ins	Baetis rhodani	mortality	4	152	152	500	Williams et al. 1985	3	219.4		219.4
Ins	Ephemerella ignita	mortality	4	152	152	13000	Williams et al. 1985	3	5704.0		5704.0
Ins	Ephemerella subvaria	mortality	4	52-56	54	2000	Warnick & Bell 1969	3	1889.1		1889.1
Ins	Hydropsyche angustipennis	mortality	4	152	152	52000	Williams et al. 1985	3	22816.1		22816.1
Ins	Hydropsyche betteni	mortality	10	52-56	54	32000	Warnick & Bell 1969	3	30226.4		30226.4
Ins	Chironomus riparius	mortality	4	152	152	30000	Williams et al. 1985	3	13163.2		13163.2
Mol	Aplexa hypnorum	mortality	4	44.8	44.8	93	Holocombe et al. 1984	2	100.9		100.9
Mol	Brotia hainanensis	mortality	4	200	200	770	Lam 1996	3	275.7		275.7

Taxon. Group	**Species**	**Endpoint**	**Test Duration (d)**	**Hardness reported**	**Hardness used for normali-sation**	**ELC50 reported [µg/l]**	**Reference**	**RI**	**ELC50 normalised (H=50) [µg/l]**	**ELC50$_{H=50}$ geometric mean [µg/l]**	ELC50$_{H=50}$ input SSD [µgl]
Mol	Physa fontinalis	mortality	4	152	152	800	Williams et al. 1985	3	351.0		351.0
Mol	Physa gyrina	mortality	4	200	200	410	Wier & Walter 1976	3	146.8		146.8

Table A6: Toxicity to benthic organisms (table 3.2.31 of the RAR[10]; all underlined data are used for the effect assessment - see section 6.1.2 for details)

test substance	**organism**	**medium**	**test conditions**	**Nominal/ Measured**	**Equilibration period (d)**	**Duration (d)**	**endpoint**	**NOEC**		**Cat***	**LOEC**		**$EC_{x\geq50}$**		**references**	**R.I.**
								µg g^{-1}_{dw}	**µg L^{-1}**		**µg g^{-1}_{dw}**	**µg L^{-1}**	**µg g^{-1}_{dw}**	**µg L^{-1}**		
$CdCl_2$		uncontaminated freshwater sediment from:	semi-static; sed./water:1:3 (vol)	M-total	/	10	mortality								Di Toro et al., 1992	
	Helisoma sp.	Pequaywan Lake	AVS: 42 µmol/g					3390		1			4520			3
		East River	AVS: 8.8 µmol/g					2260		1			3340			3
		West Bearskin Lake	AVS: 3.6 µmol/g					340		1			790			3
	Lumbricus variegatus	Pequaywan Lake	AVS: 42 µmol/g					3390		1			4520			3
		East River	AVS: 8.8 µmol/g					680		1			1130			3
		West Bearskin Lake	AVS: 3.6 µmol/g					340		1			680			3
$CdCl_2$	*Hyalella azteca*	natural sediment (Soap Creek Pond - Oregon State University); 200 ml spiked natural sediment + 800 ml well water	static; T 19°C; sediment characteristics: 3% organic carbon, 15% sand, 29% silt, 56% clay; water characteristics: pH 7.1, H 54 mg L^{-1} $CaCO_3$, BC < 0.5 µg L^{-1}. AVS unknown	M (diss.)	0.5	4	mortality	167	1.1	2	334(26)	3.2		6.6	Nebeker et al., 1986b	3
$CdCl_2$	*Micropterus salmoides*	natural stream sediment; 250 g_{dw} sediment + 25 ml Cd-solution or distilled deionized water (control) +350 ml reconstituted water	DO 6.6-8.1 mg L^{-1}, T 22.1-22.5 °C, pH 7.9-8.4; sed: OM 2.3%, Cd_T 1.02 mg kg^{-1}, Zn_T 108.2 mg kg^{-1}, Fe_T 5.52%; 5.52% sand, 35.4% silt, 12% clay	M	0.42	7	mortality	540	22	2	1079 (14)	44 (14)			Francis et al., 1984	3
$CdNO_2$	*Chironomus (salinarius gp) sp.*	natural lake sediment (Lake Tantaré, Canada), sampled below the top 1-10 cm; spiked sediments in test trays replaced in the test location in the lake	field test; water characteristics: pH 5.5-5.6, H 3; sediment characteristics: AVS: 0.5 µmol/g_{dw}	N	/	14 months	abundance	115		1			563 (80)		Hare et al., 1994	2
$CdCl_2$			sediment AVS content:	M	4	10	mortality								Carlson et al., 1991	2
	Lumbricus variegatus	Pequaywan Lake	38-32 µmol/g					3000		1			6000			
		East River sediment	6.8-7.3 µmol/g					800		1			1400			
		West Bearskin Lake	2.8-3.2 µmol/g					380		1			700			
	Helisoma sp.	Pequaywan Lake	38-32 µmol/g													
		East River sediment	6.8-7.3 µmol/g					3000		1			6200			
		West Bearskin Lake	2.8-3.2 µmol/g					2300		1			4100			
			test water: sand filtered Lake Superior water; T 21-22 °C, alkalinity 45-46 mg L^{-1}, hardness 44-45 mg L^{-1}, pH 7.9-8, dissolved oxygen concentration >6 mg L^{-1}, continuous flow; T 23°C; 1.5L Cd sol. + 1L sed.					380		1			810			

test substance	**organism**	**medium**	**test conditions**	**Nominal/ Measured**	**Equilibration period (d)**	**Duration (d)**	**endpoint**	**NOEC**		**Cat***	**LOEC**		**$EC_{x\geq50}$**		**references**	**R.I.**
								µg g^{-1}_{dw}	**µg L^{-1}**		**µg g^{-1}_{dw}**	**µg L^{-1}**	**µg g^{-1}_{dw}**	**µg L^{-1}**		
Supporting data																
$CdCl_2$	*Hyalella azteca*	contaminated freshwater sediment from Foundry cove	semi-static; sed./water:1:3 (vol) AVS: 0.1-47 µmol/g; SEM (Ni+Cd) 0.3-1000 µmol/g	M-total	/		mortality						17 (100)		Di Toro et al., 1992	4
$CdCl_2$	*Rana pipiens* *Carassius auratus*	natural stream sediment; 250 g_{dw} sediment + 25 ml Cd-solution or distilled deionized water (control) +350 ml reconstituted water	DO 6.6-8.1 mg L^{-1}, T 22.1-22.5 °C, pH 7.9-8.4; sed: OM 2.3%, Cd_T 1.02 mg kg^{-1}, Zn_T 108.2 mg kg^{-1}, Fe_T 5.52%; 5.52% sand, 35.4% silt, 12% clay	M	0.42	7	mortality	1074(HT) 1008(HT)	77 69						Francis et al., 1984	4 4
Cd^{2+}	*Hyalella azteca*	natural sediment: Foundry cove	% total organic carbon: 0.55-16.4 µg/g, total Cd: 0.4-38900 µg/g, total Cu: 18-143 µg/g, total Ni: 18-31500 µg/g, total Pb: 6.1-357 µg/g, total Zn: 65-403 µg/g, sum metals: 2.9-893, SEM: 0.2-779 µmol/g, AVS: 0.4-64.6 µmol/g, SEM/AVS: 0.02-139	M-total	/	10	mortality	72			363(20)				Hansen et al., 1996a	4

TOC: total organic carbon**;** AVS: acid volatile sulphides; H: water hardness (mg $CaCO_3$ L^{-1}); *NOEC classification (see section 3.2.0.2)