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Manatū Mō Te Taiao

Contaminated Land Management Guidelines No. 2

Hierarchy and Application in New Zealand of Environmental Guideline Values (Revised 2011)

New Zealand Government

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The initial development of the Environmental Guideline Value (EGV) database was undertaken by Katipo Communications Limited under the direction of the Ministry for the Environment. The final database was produced by Landcare Research.

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Executive Summary

This guideline document is the second in a series of documents on contaminated land management to be produced by the Ministry for the Environment. This guideline document has been developed to ensure the consistent selection and application of the environmental guideline values most commonly used in contaminated site assessments in New Zealand. It will be of use to environmental consultants and landowners undertaking contaminated site investigations, and to council staff involved in reviewing contaminated site investigation reports.

The principles and basis for a hierarchy of environmental guideline values as contained in reference documents, including those documents most commonly used by contaminated site practitioners in New Zealand, is described and the hierarchy established. This hierarchy determines the order in which guideline values contained in those reference documents should be used in a contaminated site assessment. The hierarchy is:

1. New Zealand documents that derive risk-based guideline values
2. rest-of-the-world documents that derive risk-based guideline values
3. New Zealand documents that derive threshold values
4. rest-of-the-world documents that derive threshold values.

The Environmental Guideline Value (EGV) database has been developed as a companion to this guideline. It contains the guideline values provided in the reference documents and discussed here, and can be downloaded from the Ministry for the Environment's website at: www.mfe.govt.nz/issues/hazardous/contaminated/egv-database.html.

The database should be used with care as reference documents are revised and superseded by the various regulatory agencies that publish them. However, although these reference documents may change over time, the hierarchy itself will not change.

In all situations users of the guideline document and the EGV database should refer to the reference documents for the derivation and applicability of any guideline value to be used in assessing a contaminated site. Users are also cautioned against using the EGV database simply as a series of look-up tables: it is important to be fully conversant with the derivation of any guideline values that are applied in a contaminated site assessment.

The information presented here does not aim to provide a step-by-step process on how to select a suitable guideline value, or how to apply the criteria in assessing the effects of contamination and contaminants on the environment. The aim is to provide guidance only. There may be circumstances where strict adherence to the document and the guideline values in the EGV database is not appropriate. Using this document to apply guideline values to any site should be made only after considering all of the specific site conditions and circumstances.

Neither this document nor the EGV database is intended to replace the original reference documents. Users of both sources are advised in all situations to refer to these reference documents for the latest derivation and application of the guideline values contained in the documents.

A list of website links and addresses to the reference documents discussed in this guideline document and used in the EGV database is provided at the end of this document.

1 Introduction

A wide variety of contaminants are to be found in our environment – in soil, sediments, water and air. As a result we need to be able to tell when these contaminants are at concentrations that may be harmful. Numerical values that represent concentrations of contaminants in these environmental media that are protective of the environment and/or human health are used in many countries, including New Zealand. In this document these values are referred to as *environmental guideline values*.

If, as a result of site contamination, concentrations exceed these guideline values, a variety of actions may occur, including:

- further site investigation
- site remediation or management.

Guideline values are generally established in guideline documents or as environmental standards prepared by national jurisdictions (eg, Ministry for the Environment, 2011, 1997; 1999) or overseas agencies (eg, CCME, 2002; ANZECC and ARMCANZ, 2000). Many of these documents are used in New Zealand for assessing contaminated land. The guideline values contained in these documents may be referred to as environmental quality guidelines, trigger levels, intervention levels, maximum acceptable values, remediation goals, screening levels or acceptance criteria, and have been derived for different management purposes or as the result of directed research (Cavanagh and O'Halloran, 2002). The guideline values may relate to different receptors and have been calculated using different methodologies and assumptions (Cavanagh and O'Halloran, 2003).

Given these differences in derivation and purpose it can be confusing knowing which guideline value to choose for a given assessment scenario, or how the value should be applied to the investigation or management of a contaminated site.

Because of their responsibilities under the Resource Management Act 1991, regional councils and territorial local authorities are regularly contacted by environmental consultants and other interested parties for guidance on the use of appropriate guideline values. This advice can include which guideline values are acceptable for assessing or managing contaminated sites, and, where more than one set of values is available, in what order of preference they should be used.

Now, however, there is a national Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health (*the Methodology* – Ministry for the Environment, 2011). The Methodology supports the National Environmental Standard (NES) for Assessing and Managing Contaminants in Soil to Protect Human Health. The scope and application of the NES means that Guideline No. 2 and the associated EGV database should be used only in instances where there is no appropriate soil contaminant standard – and the assessor chooses not to derive a value using the Methodology –or when the NES does not apply.

This guideline document will assist risk assessors to select and apply environmental guideline values (complementary to the NES) when assessing contaminated land and reviewing site investigation reports. Previous guidance has been provided on the information requirements to be provided by consultants (and their clients) in site investigation reports (Ministry for the Environment, 2001).

This document outlines the reference documents containing guideline values, including those most commonly used by contaminated site practitioners in New Zealand, and provides background information on the guideline values contained in each reference document, and guidance on selecting the appropriate guideline values.

The Environmental Guideline Value (EGV) database has been developed as a companion to this guideline document. The EGV database contains the guideline values provided in the reference documents discussed in this document. The database maintains the hierarchy established in this document and is intended to provide a rapid and user-friendly reference to the guideline values. However, users are cautioned against using the EGV database simply as a series of look-up tables: it is important to be fully conversant with the derivation of guideline values used in site investigation reports.

Neither the guideline document nor the EGV database is intended to replace the original reference documents. Users of both are strongly advised to refer to these reference documents for the latest derivation and application of the guideline values, and to ensure that the values in the database have not been superseded.

The EGV database can be downloaded from the Ministry for the Environment's website at: www.mfe.govt.nz/issues/hazardous/contaminated/egv-database.html.

Changes from the 2003 version

This document has had minor updates including:

- updated website URLs
- updated references to other documents and government departments
- references to the Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations (to take effect on 1 January 2012).

2 Reference Documents Used

The documents listed in Table 1 have been used in the preparation of this guideline document. This list was established from a survey of local authority staff and environmental consultants. The US EPA soil screening guidance documents (US EPA, 1996a and b; US EPA, 2001) have been included, as the US EPA Regional screening levels currently used refer to these documents for the basis of their derivation of guideline values. Documents detailing the derivation of soil guideline values currently being produced by the UK Department of Environment, Food and Rural Affairs (DEFRA) and the Environment Agency (EA) (DEFRA and EA, 2002, EA 2004; 2010) are also included because they represent robustly derived values that may be applicable in certain circumstances.

Many of these documents are frequently referred to by a common or abbreviated name (eg, *Timber Treatment Guidelines*), and this abbreviated name is also given in Table 1 (italicised and in square brackets). These documents are sorted according to the environmental medium for which they provide a guideline value. The full citation for each document is provided in the References list. Where available, an Internet reference for the document is provided.

Table 1: Reference documents used and included in the EGV database

Media	Document
Soil	*Assessment of Risks to Human Health from Land Contamination: An overview of the development of soil guideline values and related research*, Department of Environment, Food and Rural Affairs and the Environment Agency (2002) [*Soil Guideline Values*]
Soil	*Model Procedures for the Management of Land Contamination, Contaminated Land Report 11*. Bristol, UK: Environment Agency (2004)
Soil	*Updated technical background to the CLEA model. Science Report – SC050021/SR3.* Bristol, UK: Environment Agency (2010)
Soil	*Ecological Soil Screening Level Guidance*, US EPA (2003) [*Eco-SSL*]
Soil, groundwater	*Soil Remediation Circular*, Ministry of Housing, Spatial Planning and Environment, Directorate-General For Environmental Protection (2009) [*Dutch Guidelines*] http://www.vrom.nl//international
Soil, groundwater*	*Guideline on the Investigation Levels for Soil and Groundwater*, National Environmental Protection Council (1999) [*Contaminated Sites NEPM*] http://www.ephc.gov.au
Soil, groundwater	*Soil Screening Guidance: Technical background document* (US EPA, 1996a) and *User's guide* (US EPA, 1996b); *Supplemental Guidance for Developing Soil Screening Levels at Superfund Sites* (US EPA, 2001) [*US EPA SSG*]
Soil, water	*Identifying, Investigating and Managing Risks Associated with Former Sheep-dip Sites,* Ministry for the Environment (2006) *[Sheep-dip Guidelines]* http://www.mfe.govt.nz/
Soil, water	*Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand (Revised 2011)*, Ministry for the Environment (1999) [*Oil Industry Guidelines* or *Hydrocarbon Guidelines*] http://www.mfe.govt.nz/
Soil, water	*Guidelines for Assessing and Managing Contaminated Gasworks Sites in New Zealand*, Ministry for the Environment (1997) [*Gasworks Guidelines*] http://www.mfe.govt.nz/
Soil, water	*Health and Environmental Guidelines for Selected Timber Treatment Chemicals*, Ministry for the Environment and Ministry of Health (1997) [*Timber Treatment Guidelines*] http://www.mfe.govt.nz/

Media	Document
Soil, tap water, air	*Regional screening levels*, US EPA (see current version on website) http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
Soil, water, sediment, air, tissue residue	*Canadian Environmental Quality Guidelines*, CCME (see current version on website)[1] [*Canadian Guidelines*] http://www.ccme.ca
Water	*Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, ANZECC and ARMCANZ (2000) [*ANZECC Water Quality Guidelines*] http://www.ea.gov.au/water/quality/nwqms/
Water	*Drinking-water Standards for New Zealand 2005 (Revised 2008)*, Ministry of Health http://www.moh.govt.nz
Sediment	Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments*, Environmental Management*, 19(1): 81–97, Long *et al* (1995)

* Groundwater values provided are based on ANZECC (1992b), hence ANZECC/ARMCANZ (2000) *Water Quality Guidelines* are more relevant.

1 These documents are updated regularly; the year given is the latest update as at the time of preparation of this document (September 2011).

Not all documents available internationally are included in this document or the EGV database. Documents promulgated by overseas countries and jurisdictions have been omitted unless they are already commonly used in New Zealand, or they are particularly relevant. The US Department of Energy-sponsored Risk Assessment Information System (RAIS) is not discussed here, as extensive information on derivation methodologies and preliminary remediation goals for approximately 1400 contaminants (including radionuclides) can be accessed online at http://rais.ornl.gov.

Guideline values contained in the reference documents are referred to by different names and may be used differently. The names of the guideline values used in each document, their use and derivation are discussed further in section 3.

Environmental guideline values contained in the reference documents have been included in the EGV database, which is designed to provide users with a rapid and user-friendly way to access guideline values – with some exceptions. The surface and groundwater acceptance criteria provided in Ministry for the Environment 1997 and 1999 are not included in the EGV database, as for the most part they are based on outdated Canadian or Australian data (eg, *Australian Water Quality Guidelines for Fresh and Marine Waters* (ANZECC, 1992b)). Current New Zealand drinking water standards and guideline values for the protection of aquatic ecosystems from the *Australian and New Zealand Water Quality Guidelines for Fresh and Marine Waters* (ANZECC and ARMCANZ, 2000) are included in the EGV database. The original documents should be referred to for the guideline values for other water uses (see also section 3.5).

Similarly, only the guideline values for soil, aquatic life, and community (equivalent to drinking water) established in the *Canadian Environmental Quality Guidelines* (CCME, 2002 and subsequent updates) are used in the EGV database. Guideline values from the *Lead Guidelines* (Ministry of Health, 1998) have not been incorporated into the EGV database as this document establishes different concentrations of lead at which different actions should be taken, and includes a number of different scenarios and actions to be taken at each concentration. Also, the document does not provide the scientific basis on which these values were determined. Users are encouraged to refer to the document directly, which is available at the Ministry of Health's website (www.moh.govt.nz).

It is important that users of this guideline document, and of the EGV database, recognise that the guideline values contained in the database are only as up to date as the reference documents. Environmental guidelines are constantly being developed and reviewed, reflecting improvements in our understanding of the toxicity and risk posed by hazardous substances, and users should ensure that the guideline value they use is current.

3 Derivation of Environmental Guideline Values

The process of deriving environmental guideline values is highly complex, but an understanding of at least the general principles is necessary before any value is applied to a specific site. Most guideline values (especially for soil) are derived using standard default assumptions, and these may or may not reflect actual site conditions. Also, the *purpose* of the guideline values derived for soil (eg, whether for site investigation or remediation) will influence the protectiveness of the derived values in different countries. Similarly, the use or potential use of water or groundwater (eg, as drinking water or for irrigation) will influence the protectiveness of the derived values.

The guideline values from the reference documents (Table 1) that are included in the EGV database are listed in Table 2. This section provides an overview of how these guideline values were derived. You should refer to the reference documents themselves for specific details and assumptions about how the individual guideline values were derived.

Environmental guideline values for soil, groundwater and water are the most commonly used in contaminated site assessments. The fundamental difference between guideline values for a given environmental medium is the basis of protection – whether for human health or ecological receptors.

Environmental guideline values can be risk-based or threshold values. Risk-based values are derived from a given exposure scenario (protection of human health) or the protection of a nominal proportion of species in an ecosystem. Threshold values may be derived from toxicological data where insufficient data is available to calculate risk-based values. Guideline values may also be classified as threshold values where insufficient information on their derivation is provided (eg, *Lead Guidelines*, Ministry of Health, 1998). The level of protection afforded by threshold values is unable to be determined.

Table 2 provides a summary of the name, purpose (what action exceedance of the guideline value initiates, or how the values are used within the specified reference document), and basis of protection of the guideline value used in each reference document and included in the EGV database. Further discussion on the methods used to derive criteria for the protection of human health and ecological receptors is provided below. This discussion focuses on the derivation of guideline values for soil. Discussion on the derivation of guideline values for surface water and groundwater is provided in sections 3.4 and 3.5, respectively.

Table 2: Name, purpose,* number, and basis of protection of guideline value in reference documents listed in Table 1 and included in the EGV database

Country		Name	Purpose*	Basis#	No. of guideline values	Source
New Zealand	Timber treatment	Acceptance criteria	Site investigation	HH/P	7	MfE and MoH (1997)
	Gasworks	Acceptance criteria	Site investigation	HH	19	MfE (1997)
	Oil industry	Acceptance criteria	Site investigation	HH	10	MfE (1999)
	Sheep-dip	Soil guideline values	Site investigation	HH	19	MfE (2006)
	Drinking-water standards	Maximum acceptable values (MAV)	Drinking water	HH	~130	MoH (2008)
Australia	Contaminated sites NEPM	Health investigation levels (HIL)	Site investigation	HH	26	NEPC (1999)
		Environmental investigation levels (EIL)	Site investigation	Eco	11	
	ANZECC water quality	Water quality guidelines	Sustainable water quality	Eco	81	ANZECC/ ARMCANZ (2000)
		Sediment quality guidelines	Investigation	Eco	34	
USA	Federal	Soil-screening level (SSL)	Site investigation	HH	110	US EPA (2001)
		Eco-SSLs		Eco	21	US EPA (2003)
	Regional screening levels	Human Health Medium-specific screening levels	Site investigation	HH	~600	US EPA (see current website version)
		Preliminary remediation goals (PRG)	Remediation goal	HH	~460	US EPA (see current website version)
Canada		Soil quality guideline values	Remediation goal	Integrated	29	CCME (see current website version
		Water quality guideline values	Sustainable water quality, drinking water	Eco HH	94	CCME (see current version on website)
UK		Soil guideline values	Site investigation	HH	10	DEFRA (see current website version)
Netherlands		Intervention value	Remediation urgency assessment	Integrated	75	VROM[1] (see current website version)
		Target value	Sustainable soil quality	Eco	75	VROM[1] (see current website version
Long et al (1995)		Effects range low	Concentration at which 10% of studies in a database observed an effect	Eco	28	Long et al (1995)
		Effects range median	Concentration at which 50% of studies in a database observed an effect	Eco	28	Long et al (1995)

* What action exceedance of the guideline value initiates, or how the values are used within the specified reference document.

\# Integrated = integration of human health and ecotoxicological data; Eco = ecotoxicological data only; HH = human health data only; P = phytotoxicity.

1 VROM: Former Ministry of Housing, Spatial Planning and the Environment; now Ministry of Infrastructure and the Environment.

3.1 Guideline values for the protection of human health

The toxicological basis for deriving human-health guideline values is either:

- tolerable daily intakes (TDI) for contaminants that have a threshold concentration, which needs to be exceeded for toxic effects to be manifested (*threshold contaminants*), or
- the excess cancer risk for contaminants that have the potential to cause detrimental effects at all concentrations (*non-threshold contaminants*).

Threshold and non-threshold terminology is used throughout this report in line with those countries (including New Zealand) that differentiate between genotoxic and non-genotoxic carcinogens. In this case, non-genotoxic carcinogens are considered threshold contaminants and the values are derived accordingly. Typically, the most sensitive end-point is used to set guideline values.

The TDI may also be expressed as a *hazard quotient*, which is the ratio of exposure to the tolerable daily intake. For non-threshold contaminants (genotoxic carcinogens) the individual excess cancer risk is expressed as the number of permissible or acceptable excess cancers allowable in a population exposed to the contaminant of concern. For example, an acceptable risk level of $1x10^{-4}$ indicates that one additional cancer in every 10,000 people in an exposed population is allowable. A risk level of $1x10^{-5}$ and $1x10^{-6}$ represents one additional cancer in 100,000 and 1,000,000 people, respectively. A risk level of $1x10^{-5}$ is used in New Zealand. If an overseas value has been derived with some other risk level, the guideline value should be adjusted up or down accordingly.

For soil, guideline values are predominantly risk based, in that they are typically derived using designated exposure scenarios that relate to different land uses. Table 3 lists the exposure scenarios used in the derivation of soil guideline values in the reference documents included in this guideline and the EGV database, and the acceptable cancer risk level used in different guidelines. For each exposure scenario, selected pathways of exposure are used to derive guideline values. These pathways typically include soil ingestion, inhalation of particulates and volatiles, and dermal absorption. For residential and agricultural exposure scenarios (where considered), produce consumption is used as an exposure pathway in guidelines from all countries except the US and Australia. The original documents should be consulted to ascertain the specific details and assumptions on which the individual guideline values are based.

It should be noted that for the human health soil guidelines referenced in this document, the soil ingestion rates are typically higher than those used in deriving the values in the Methodology. This means the soil guideline values in this document are often more conservative (lower) than if they had been derived using the methods detailed in the Methodology. On the other hand, some of the residential values cited in this document do not allow for the home-grown produce consumption pathway, which, for some contaminants, may result in values that are insufficiently conservative compared with values derived using the Methodology.

Table 3: Designated exposure scenarios[a] for guideline values

Country		Acceptable risk level (non-threshold contaminants)	Land use
New Zealand	*Timber Treatment Guidelines*	10^{-5}	Agricultural (100% produce consumption) Residential (10%, 50% produce consumption) Industrial – paved, unpaved Maintenance
	Gasworks Guidelines	10^{-5}	Agricultural/horticultural (100% produce consumption) Standard residential (10%, 50% produce consumption) High-density residential (no produce consumption) Commercial/industrial Maintenance Parkland/recreational
	Oil Industry Guidelines	10^{-5}	Agricultural (100% produce consumption) Residential (10%, 50% produce consumption) Commercial/industrial Maintenance
	Sheep-dip Guidelines	10^{-5}	Lifestyle block (50% produce consumption) Standard residential (10% produce consumption) High-density residential (no produce consumption) Parks/recreation Commercial/industrial (unpaved)
	Drinking Water Standards	10^{-5b}	Potable water
Australia	*Contaminated Sites NEPM*	None specified	Standard residential[c] Residential with minimal soil contact[d] Parks, recreation, open space Commercial/industrial
	ANZECC Water Quality Guidelines	None specified	Potable water
US	*SSL*	10^{-6}	Residential (no produce consumption) Industrial – indoor worker, outdoor worker Construction
	Regional Screening Levels	10^{-6}	Residential (no produce consumption) Industrial – indoor worker, outdoor worker
	Regional Screening Levels	10^{-6}	Residential (no produce consumption) Industrial
Canada		10^{-6}	Agricultural Residential/parkland Commercial Industrial
UK		None specified	Allotments Residential with and without produce consumption Commercial/industrial

Country		Acceptable risk level (non-threshold contaminants)	Land use
Netherlands		10^{-4}	Residential (10% produce consumption)

a The various scenarios may look similar, but they generally have differences in assumptions and they are all different to the similarly named scenarios in the *Methodology* (Ministry for the Environment, 2011).

b Arsenic in drinking water has been calculated at a different cancer risk rate. The *Drinking Water Standards for New Zealand* make the comment, "For excess lifetime skin cancer risk of 6 x 10^{-4}. P[rovisional] MAV, because of analytical difficulties".

c Includes children's day-care centres, kindergartens, preschools, and primary schools.

d Includes dwellings with fully and permanently paved yard space (eg, high-rise apartments and flats).

3.2 Guideline values for the protection of ecological receptors

How guideline values are derived for the protection of ecological receptors depends on the type (number of species and end-points) and amount of data. Standardised end-points, typically either the no-observed-effect concentrations (NOECs) or the lowest-observable-effect concentrations (LOECs), are used. Guideline values based on ecotoxicological data are based on a hierarchy of methods dependent on data availability. Risk-based methods are preferred, which use statistical extrapolation procedures or calculation of the geometric mean of data. These methods require a significant quantity of high-quality data.

For example, the Canadian protocol uses a 'weight of evidence' approach based on that of Long and Morgan (1990) and requires at least 10 LOEC data points from three studies, including a minimum of two soil invertebrate and two crop/plant data points (CCME, 1996). The Dutch protocol uses the statistical extrapolation method of Aldenberg and Jaworska (2000) and requires that at least four NOECs for four different taxonomic groups are available (de Bruijn et al, 1999). The US protocol uses the geometric mean of all toxicity values from the highest preference level to establish Eco-SSLs for plants and soil invertebrates. The preference level of a study is determined during the process of review, where studies are scored against nine criteria (maximum score is 2), including toxicological end-points and contaminant bioavailability. Risk-based methodologies are typically used to derive guideline values for aquatic ecosystems. Long et al (1995) used a weight-of-evidence approach to derive sediment quality criteria.

Where insufficient data are available for the preferred methodologies, guideline values are derived using factors that extrapolate available data to the desired ecotoxicological end-point (eg, LC_{50} to NOEC), and/or to take into consideration the limited amount of data. These extrapolation factors may range from 2 to 1000 (Cavanagh and O'Halloran, 2002 and 2003). Due to the lack of available soil ecotoxicity data, extrapolation factor methods are predominantly used to derive soil guideline values. If no data are available, the Dutch guidelines use quantitative structure activity relationships (QSAR) to extrapolate toxicity data from structurally similar compounds which have the same mode of action. Equilibrium partitioning (EqP) methods may also be used to derive values for soil toxicity by extrapolation from aquatic toxicity data. Values derived by these methods are termed 'threshold values'.

The interim ecological investigation levels (EIL) provided in the Australian *Guideline on the Investigation Levels for Soil and Groundwater* (NEPC, 1999) are also considered threshold values, as there is no information on their derivation. These values have been collated from ANZECC B-levels, which originate from Environment Canada (1988) and Richardson (1985), and soil survey data from four Australian cities.

A summary of the ecotoxicological end-points, methods and level of protection used in different reference documents is given in Table 4.

Table 4: Ecotoxicological end-points, method and level of protection

Country	Endpoint	Method	Level of protection*
Netherlands	NOEC	Statistical extrapolation Extrapolation factor EqP QSAR	95% (TV), 50% (IV) NAD NAD NAD
Canada	LOEC	Weight-of-evidence Extrapolation factor	75% NAD
Australia (*ANZECC Water Quality Guidelines*)	NOEC	Statistical extrapolation Extrapolation factor	95% NAD
US *Eco-SSL*	NOEC	Geometric mean	~50%

* Level of protection expressed as a percentage of species in an ecosystem.

Notes: TV = target value; IV = intervention value; EqP = equilibrium partitioning; QSAR = quantitative structure activity relationship; NAD = not able to be determined.

There is a growing body of information on guideline values for ecological receptors, including ecotoxicity data and how these data are used to derive criteria suitable for use by regulators. The document *A Critical Review of Methods for Developing Ecological Soil Quality Guidelines and Criteria* (American Petroleum Institute Biomonitoring Task Force, 1999, produced as US EPA, 2000, Exhibit 1-1) also provides useful background information on the derivation of ecological guideline values in a variety of countries. This document can be found at: http://rais.ornl.gov.

Additional criteria may also be found at the URLs listed in the Appendix. Note that any criterion sourced from these locations should be independently verified with an experienced ecotoxicologist before applying it.

3.3 Integrated guideline values

The Canadian Environmental Quality Guidelines for soil and the Dutch intervention and target values are the only criteria that are based on protection of human health *and* ecological receptors. For the soil quality guidelines separate values are derived for the protection of human health and ecological receptors, as described above. These values are compared and the lowest is selected as the final guideline value.

The Dutch intervention values are similarly derived, but their target values are based on the assumption that organisms in ecosystems are probably more exposed to compounds in water, sediment, and soil than are humans, so these are solely based on ecotoxicological data (de Bruijn et al, 1999).

3.4 Surface water

The toxicological basis for guideline values for human consumption of water is the same as that described above; that is, a TDI, or an acceptable risk level (10^{-5} in New Zealand). These guideline values are also termed 'risk-based' and are typically based on the consumption of 2 L of water per day by a 70 kg adult over a defined exposure period, which in New Zealand is 70 years. In New Zealand, a variable proportion of the TDI (often 10%) is allocated to exposure via drinking water.

Guideline values for aquatic ecosystems in the *ANZECC Water Quality Guidelines* and the *Canadian Guidelines* are derived as described above, and are risk-based when sufficient data are available. Guideline values for aquatic ecosystems in New Zealand Guidelines are primarily based on older Australian, Canadian and US data.

Guideline values for additional water uses such as irrigation, stock watering and recreational use provided in these documents are largely threshold based, and limited (if any) information is provided on their derivation.

3.5 Groundwater

Groundwater quality may be protected either by deriving a soil concentration that is protective of the groundwater resource, or by setting a water concentration that cannot be exceeded. Soil concentration guidelines are typically derived by back-calculation of the soil concentration that would exceed a given water quality standard, using equilibrium partitioning equations and taking into account any dilution that is expected to occur. Dilution may occur for a number of reasons, including the infiltration/recharge rate of the aquifer, the size of the aquifer, and the depth of the aquifer in relation to the contaminated soil.

The New Zealand *Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand (Revised 2011)* (Ministry for the Environment, 1999) and the US EPA guidelines provide soil concentrations that are protective of groundwater resources. No specific dilution factor is provided in the New Zealand guidelines, although values were derived using parameters appropriate to New Zealand (Ministry for the Environment, 1999). The US EPA guidelines use default dilution factors of 1 and 20.

Where a water concentration is set, the potential use (eg, drinking water, irrigation) of the groundwater is typically taken into consideration. The exceptions to this are the Dutch intervention and target values. Here, groundwater intervention values are derived from the soil intervention values using equilibrium partitioning and may have been corrected for human consumption of groundwater (ie, if the derived value was higher than that based on consumption of 2 L per day over a lifetime, the value was lowered), or the detection limit of the compound (ie, if the derived value was lower than the detection limit, the value was corrected upwards). For groundwater target values a distinction is made between 'shallow' (less than 10 metres) and 'deep' groundwater for metal contaminants to take into account background (naturally occurring) concentrations of metals in the Netherlands. Groundwater target values for organic contaminants are derived from a separate study, although no information is provided on their derivation in Ministry of Housing, Spatial Planning and the Environment, 2000.

3.6 Hazardous Substances and New Organisms Act

The Hazardous Substances and New Organisms (HSNO) Act 1996 was introduced into New Zealand with the aim of protecting people and the environment from the adverse effects of hazardous substances and new organisms. The Act is administered by the Environmental Protection Authority (EPA) whose function under the Act is to make decisions on applications relating to the introduction of hazardous substances and new organisms into New Zealand. This includes the re-assessment of previously approved substances or organisms.

The HSNO Act provides for the EPA to establish exposure limits for hazardous substances for the protection of human health and ecological receptors. An exposure limit is defined as the maximum amount of a hazardous substance that can be legally present in a particular environmental medium such as air, water or soil, or deposited on a plant surface (such as plant foliage).

There are two types of exposure limits that may be set for hazardous substances.

- The **tolerable exposure limit (TEL)** is designed to protect humans from the adverse effects of toxic substances. It is the concentration of a substance in an environmental medium that will present a low risk of a toxic effect occurring in people exposed to that substance.
- The **environmental exposure limit (EEL)** is designed to protect organisms other than humans (including plants) from the adverse effects of ecotoxic substances. It is the concentration of a substance in an environmental medium that will present a low risk of adverse environmental effects in non-target areas.

TELs and EELs are set for 'new' toxic and ecotoxic substances that are assessed under the HSNO Act, and are also set for existing substances as they are transferred to the HSNO regime as required by the Hazardous Substances (Classes 6, 8, and 9 Controls) Regulations. Where a TEL or EEL has been set for a substance, it is an offence to use that substance in a way that causes the concentration to exceed the exposure limit set for that specific environmental medium. A limited number of TELs and EELs have been set and are available at www.epa.govt.nz.

4 The Hierarchy of Guideline Values

Determining the order in which available guideline values should be used when assessing a contaminated site is not a simple matter, resulting in uncertainty as to which criteria to use in which circumstances.

To help alleviate this uncertainty the Ministry for the Environment compiled a *derivation Methodology* for health-based standards to apply to soil contaminants in New Zealand (Ministry for the Environmental, 2011). **Soil contaminant standards** for a group of 12 priority contaminants were derived under a set of five land-use scenarios that are **legally binding** as gazetted under the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health.

The 'soil contaminant standards' are intended to supersede the 'soil acceptance criteria' used in previous New Zealand guidelines and comprise the following priority contaminants: arsenic, boron, cadmium, chromium, copper, inorganic lead, inorganic mercury, benzo(a)pyrene, DDT, dieldrin, dioxin and dioxin-like polychlorinated biphenyls (PCBs), and pentachlorophenol (PCP).

To help contaminated site practitioners prepare and review contaminated site assessments **for contaminants that are not part of the group of priority contaminants and for purposes other than protecting human health**, a hierarchy of guideline values contained in the reference documents has been established. The hierarchy is intended to provide guidance to preferred guideline values that should be used when assessing a contaminated site, and is provided in the form of a hierarchy of documents containing the guideline values. Not all guidelines values contained in a reference document are included (Table 2).

The hierarchy has been developed according to the following principles.

- The New Zealand guideline values should be used in preference to guideline values from other nations or jurisdictions.
- Guideline values using a risk assessment methodology to establish guideline values (risk-based guideline values) should be used in preference to those that present threshold values.

Following these principles an overall hierarchy of reference documents has been established. This hierarchy, in order from most to least preferred, is:

1. New Zealand derived risk-based guideline values
2. rest of the world derived risk-based guideline values, with preference given to those that employ risk assessment methodologies and exposure parameters consistent with that already used in New Zealand
3. New Zealand derived threshold values
4. rest of the world derived threshold values.

This hierarchy has been developed for the following reasons.

- New Zealand documents have been developed using international best practice at the time. They have been through substantial national and international peer review, and are accepted by national and local government and industry. In some cases they also reflect

exposure pathways common in New Zealand (eg, consumption of home-grown produce) that are often omitted from international documents.

- On the one hand, some countries have been addressing contaminated site issues for much longer than New Zealand and have invested heavily in the development of methodologies for deriving guideline values. Indeed, some of these methodologies have been used in the derivation of some New Zealand guideline values. On the other hand, internationally derived guideline values are likely to contain regulatory and social assumptions that are not necessarily applicable in the New Zealand context, and therefore these values should be used only in the absence of New Zealand values.

4.1 The hierarchy of documents

To assist in the selection of the appropriate guideline values for a given environmental media and/or purpose, a hierarchy of reference documents containing guideline values is established separately for those documents that contain guideline values for soil and water. Further differentiation of documents within those groupings is made on the basis of protection (eg, human health, ecological receptors). However, users should note that different parameters and, in some cases, pathways of exposure, are used to derive the guideline values from different jurisdictions and users should refer to the original documents to ascertain the applicability of a selected guideline value. Where multiple guideline values in a given reference document exist (eg, ANZECC and ARMCANZ, 2001), users should refer to Table 2 for the guideline values to which the hierarchy applies.

Table 5: Hierarchy of documents containing guideline values for soil[a]

Basis of protection	Reference document	Grouping
Human health only[b]	*Guidelines for Assessing and Managing Contaminated Gasworks Sites in New Zealand* (Ministry for the Environment, 1997) (cyanide and phenols only)_ *Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand* (Revised 2011) (Ministry for the Environment, 1999) *Identifying, Investigating and Managing Risks Associated with Former Sheep-dip Sites, (*Ministry for the Environment, 2006) (lindane only)	NZRB
	Guideline on the Investigation Levels for Soil and Groundwater (NEPC 1999) (health investigation levels, residential land use only). *Model Procedures for the Management of Land Contamination, Contaminated Land Report 11*. Bristol, UK: Environment Agency (2004). Subsequent updates available at: http://www.environment-agency.gov.uk/research/planning/64015.aspx *Soil Screening Guidance: Technical background document* (US EPA, 1996a) and *User's guide* (US EPA, 1996b); *Supplemental Guidance for Developing Soil Screening Levels at Superfund Sites* (US EPA, 2001) Regional *Screening Levels* (US EPA, see current website version available at: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm	IRB[c]
	Guideline on the Investigation Levels for Soil and Groundwater (NEPC, 1999) (all land uses except residential)	ITB
Human health and ecological receptors	*Canadian Environmental Quality Guidelines* (CCME, 2002 and subsequent updates available at http://st-ts.ccme.ca/) *Soil Remediation Circular* (Ministry of Infrastructure and the Environment, 2009) [d]	IRB
Ecological receptors	*Ecological Soil Screening Level Guidance* (US EPA, 2003)	IRB

only	*Guideline on the Investigation Levels for Soil and Groundwater* (NEPC 1999) (ecological investigation levels)	ITB
Groundwater	*Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand* (Revised 2011) (Ministry for the Environment, 1999)	NZRB
	Soil Screening Guidance[e] (US EPA, 1996a and b)	IRB

NZRB = New Zealand risk-based; IRB = international risk-based; NZTB = New Zealand threshold based; ITB = international threshold based.

a No hierarchy is established for the documents within each category.

b The underlying premise in existing New Zealand industry-based guidelines is that protection of on-site ecosystems is only required to the extent necessary to facilitate the use of the land (ie, plant growth and livestock). These guidelines have been classed as protecting human health only, as they do not consider the full extent of the protection of ecosystems as do the Canadian and Dutch documents.

c UK, Canadian and Dutch criteria are the only criteria (other than New Zealand) that include produce consumption.

d While Dutch criteria for human health protection are based on a residential land-use scenario, the majority of intervention values are based on protection of the ecosystem as these were lower than values derived for protection of human health. Hence, these values have a wider applicability than just to a residential land-use scenario.

e US EPA Region 6 and Region 9 guidance documents also provide groundwater values. However, these values originate from US EPA, 1996a.

Table 6: Hierarchy of documents containing guideline values for surface water, groundwater and sediment

Basis of protection	Reference document	Grouping
Human health	*Drinking-water Standards for New Zealand* 2005 (Revised 2008) (MoH, 2008)	NZRB
	Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000)[1] *Canadian Environmental Quality Guidelines* (CCME, 2002) *Soil Remediation Circular* (Ministry of Infrastructure and the Environment, 2009)	IRB
Ecosystems	*Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC and ARMCANZ, 2000)[1]	NZRB
	Canadian Environmental Quality Guidelines (CCME, 2002 and subsequent updates available under http://st-ts.ccme.ca/)	IRB
Livestock[2]	*Identifying, Investigating and Managing Risks Associated with Former Sheep-dip Sites, (*Ministry for the Environment, 2006)	NZTB
Agriculture, recreational use[2]	*Health and Environmental Guidelines for Selected Timber Treatment Chemicals* (MfE and MoH, 1997) *Guidelines for Assessing and Managing Contaminated Gasworks Sites in New Zealand* (MfE, 1997) *Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand (Revised 2011)* (Ministry for the Environment, 1999)	NZTB
	Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000)[1]	ITB
Sediment	*Soil Remediation Circular* (Ministry of Infrastructure and the Environment, 2009) Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments (Long et al, 1995)	IRB

NZRB = New Zealand risk-based; IRB = international risk-based.

1 The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* is grouped as an international risk-based document for human health, agriculture and recreational use as these sections use Australian-specific data. In contrast, New Zealand ecotoxicity data have been used in the derivation of values for protection of ecosystems. Hence these values are termed New Zealand risk-based.

2 These values are not included in the EGV database. However, they are mentioned in this table to indicate that these values do exist. Readers should refer to the original documents to ascertain the basis of their derivation.

It is important to note that a hierarchy is *not* established for the guidance documents within each category – the documents are listed alphabetically. Final selection of the appropriate criteria

should be conducted according to the principles outlined in section 5. Particular attention should be given to the selection of guideline values for residential land use, as New Zealand, UK, Canadian and Dutch criteria are the only ones that include produce consumption as a pathway of exposure in this scenario.

If a reference document and its guideline values are not found in the database, this does not necessarily mean these criteria cannot be used in assessing a contaminated site. Guideline values from overseas jurisdictions can be used as long as:

1. the hierarchy established in this guideline document is followed
2. the user can demonstrate that the methodology used to derive the guideline values is consistent with New Zealand risk-based methods, or justify the appropriateness of using values based on different derivation methodologies for the particular site under consideration
3. the exposure pathways on which the criteria are based are those that operate at the site being assessed.

Users should apply this hierarchy in selecting appropriate guideline values in the assessment of any contaminated site (see section 5). If, for any reason, users deviate from the hierarchy established above, the reasons for the deviation should be given and fully documented within the contaminated site investigation report. The minimum information requirements of site investigation reports have previously been outlined (see *Contaminated Site Management Guideline No. 1: Reporting on Contaminated Sites in New Zealand (Revised 2011) (*Ministry for the Environment, 2001).

While this document and the EGV database have been developed as a tool for contaminated site practitioners, users should ensure they are conversant with the derivation of any guideline value referenced in a contaminated site assessment.

4.2 EGV database

The guideline values presented in the reference documents listed in this guideline (Table 1) and included in the EGV database are listed in Table 2. The database is designed to provide users with a rapid and user-friendly means by which criteria can be accessed. In addition, criteria from the database will be displayed in keeping with the hierarchy established; that is, where available, New Zealand risk-based criteria will be displayed before any other criteria. However, it is important that the database is not used solely as a series of look-up tables without the users being conversant with the principles and assumptions underlying the derivation of the criteria.

Users of the database should not assume that the criteria contained in the EGV database have not been superseded. Users therefore need to acknowledge this in their use of guideline values from the database, or confirm the status of the value with the organisation responsible for publishing it.

5 Applying Environmental Guideline Values

In section 4 we established a hierarchy for applying the guideline values for contaminated sites that are given in various New Zealand and international documents. Before applying the hierarchy, however, it is important to understand the principles that govern the application of these environmental guideline values, and to understand the factors that can influence their applicability. Doing so should ensure that the guideline values used in contaminated site assessment and management are chosen appropriately.

The following discussion establishes some principles for applying the hierarchy, and provides alternative information sources if guideline values are not available in the EGV database.

5.1 Principles of application

The hierarchy established in section 4 should be applied in keeping with the following principles.

Principle 1

In the Resource Management Act 1991, "sustainable management" means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety (RMA 1991, section 2). Therefore, guideline values should be applied to contaminated sites that are appropriate for the site itself and the likely use of the site. For example, an industrial site that is to be rezoned as parkland should be remediated or managed to ensure that parkland criteria are met – not industrial criteria. Similarly, it is important to consider *all* receptors (human and ecological) on and near a site.

Principle 2

There are a large number of environmental guideline values available internationally for the assessment of contaminated sites. The guideline values and documents referenced in this document and provided in the EGV database are those identified by contaminated site practitioners in New Zealand at the time of writing as being the most commonly used, or are significant documents to which attention should be drawn.

If no New Zealand guideline value is available, there are three approaches that can be used to select a value from an international source.

1. the lowest (most conservative) appropriate guideline value is used, or
2. the user presents all the international guideline values identified, but selects one for use and justifies why that particular value has been chosen, or
3. none of the available criteria are used and a site-specific risk assessment is undertaken according to the derivation methodology (Ministry for the Environment, 2011), see also sections 5.3.1 and 5.3.3 for further information.

While there are an increasing number of reference documents available, occasionally a guideline value may not be available for a particular contaminant. In this situation it is also appropriate to undertake a site-specific risk assessment.

5.2 Factors for consideration

It is important to note that no value represented in the EGV database should be taken and arbitrarily applied to a site without considering the following factors.

5.2.1 Background contaminant concentrations

The identification and use of data about background concentrations is necessary in any contaminated site assessment to see if any contaminants present are the result of anthropogenic activities, and to allow a reasoned assessment of risk. Background concentrations of contaminants will vary widely from area to area, depending on soil type, geology and other factors. Ideally, the background concentrations of contaminants in the area under investigation should be determined for each investigation. However, where this is not feasible, the following documents are available:

- *Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health* Appendix 6: Natural Background Topsoil Datasets for Arsenic and Cadmium, (Ministry for the Environment, 2011)
- *Background Levels of Agrichemical Residues in Bay Of Plenty Soils A preliminary technical investigation* (Prepared by SEM NZ Limited, March 2005)
- *Historic Pesticide Residues in Horticultural and Grazing Soils in the Tasman District* (SK Gaw, June 2003)
- *Assessment of Background Concentrations of Selected Determinands in Canterbury Soils* (Canterbury Regional Council, 1996)
- *Trace Element Concentrations in Soils and Soil Amendments from the Auckland Region* (Auckland Regional Council, 1999)
- *Background Concentrations of Inorganic Elements in Soils from the Auckland Region* (Auckland Regional Council, 2001)
- *Determination of Common Pollutant Background Concentrations for the Wellington Region* DRAFT (URS New Zealand Ltd for Greater Wellington, July 2003).

These documents contain background concentrations of inorganic contaminants in soil in selected areas of New Zealand. Documents such as these that detail contaminant concentrations in environmental media relevant to the area being evaluated can also be used in assessing whether contaminant concentrations detected are above background concentrations and require further investigation.

Additionally, while organochlorine contaminants such as organochlorine pesticides and dioxins are generally not considered to be naturally occurring (although some natural sources for dioxins exist), they are often present in the environment at low levels due to atmospheric transport. The following documents provide an indication of ambient concentrations of organochlorines in soil, rivers, and estuaries in New Zealand.

- *Ambient concentrations of selected organochlorines in soil* (Buckland et al, 1998a)

- *Ambient concentrations of selected organochlorines in rivers* (Buckland et al, 1998b)
- *Ambient concentrations of selected organochlorines in estuaries* (Scobie et al, 1999).

Some environmental consultants and analytical laboratories may also hold information about background concentrations of contaminants in the environment.

5.2.2 Ecological receptors

To provide protection for natural resources, ecological receptors on or near a site should be considered. The majority of the documents referenced in this guideline and provided in the EGV database consider *either* effects on humans *or* ecological effects. The Canadian and Dutch soil guideline values are the only ones that are based on protection of *both* humans and ecological receptors, although guideline values in New Zealand documents incorporate protection of on-site ecosystems to the extent necessary to facilitate the use of the land (ie, plant growth and livestock). The basis for deriving guideline values (which ones take into account ecological end-points) is provided in section 3. Where appropriate values are not available, an ecological risk assessment should be conducted (see section 5.3.3).

5.2.3 Site-specific conditions

Not all sites investigated will conform to the assumptions or parameters used in the derivation of the guideline value (ie, pathways/receptors). There are also likely to be things that are not addressed in the derivation of the criteria, such as sensitive populations, or unusual site characteristics. These factors should be identified during the development and application of a conceptual site model and, where necessary, a site-specific risk assessment should be undertaken or an alternative guideline value selected and justified.

5.2.4 Cumulative effects of multiple contaminants

'Cumulative effect' can be used to describe the additive or synergistic effect of multiple contaminants at a site, or as a result of more than one site releasing contaminants into the same receiving environment.

There is much debate about the extent and nature of cumulative effects, and how they can be most effectively investigated, monitored, and managed on any given site. It is beyond the scope of this document to discuss these, apart from commenting that the majority of criteria given in the EGV database have been derived from a single chemical dose/response assumption. Therefore, where there are combinations of chemicals or exposures, attention should be paid to the increased or decreased effects these chemicals have in combination as opposed to individually.

Users should seek advice from toxicologists on specific issues, as necessary.

5.3 When no guideline value is available

When no appropriate guideline value or concentration for the contaminant source/pathway/ exposure scenario being evaluated can be found in the EGV database or other reference

document published internationally, it may be appropriate and cost-effective to develop a site-specific guideline value, as follows.

5.3.1 Human health

An appropriate methodology to develop a site-specific guideline value is outlined in the derivation *Methodology* (Ministry for the Environment, 2011). Users should familiarise themselves with this document and/or seek specialised technical advice prior to undertaking this development.

The process of developing site-specific risk-based guideline values simply utilises more detailed and less generic information in the assessment process, and is explained in various levels of detail in a variety of documents (eg, Ministry for the Environment, 1997, 1999, 2011).

The general steps in the *Methodology* used in establishing risk-based guideline values for humans is described below (modified from Ministry for the Environment and Ministry of Health, 1997):

1. a preliminary assessment of the chemicals of concern based on reported concentrations at the site and safety data
2. identification of exposure paths for humans
3. estimation of the likely human exposure to each chemical of concern for significant exposure routes, within the limits described in the *Methodology* (Ministry for the Environment, 2011).
4. estimation of the effects of human exposure from available animal, occupational health, and epidemiological data
5. derivation of contaminant soil concentrations that are considered not to pose an unacceptable risk to human health.

The US Department of Energy-sponsored Risk Assessment Information System provides an online system to select guideline values and can be accessed at http://rais.ornl.gov.

Users must ensure that the assumptions used in these models are appropriate for the site under consideration and acceptable to all parties involved.

5.3.2 Drinking water

Where water is used as a drinking-water source and no guideline value (referred to as a maximum acceptable value, or MAV) is given in the *Drinking-water Standards for New Zealand 2005 (Revised 2008)* (Ministry of Health, 2008), the following documents should be consulted:

- *Australian Drinking Water Guidelines* (NHMRC/ARMCANZ, 1996)
- *Guidelines for Drinking-water Quality* (WHO, 1993 and addenda 1998).

If neither of these documents provide any clarification or guidance on appropriate guideline values, the local medical officer of health should be contacted and appropriate advice sought.

5.3.3 Ecological risk assessment

Ecological risk assessment (ERA) focuses on the impacts from contaminants on non-human receptors, including both flora and fauna in terrestrial and aquatic ecosystems and encompassing microbes, invertebrates, and vertebrates. Ecological risk assessment is growing in research and regulatory application internationally. Information that has a specific New Zealand focus and includes general information on ecological risk assessment is available at: www.landcareresearch.co.nz.

This website aims to help environmental risk managers to make informed ecological risk assessments at contaminated sites and to derive New Zealand-specific environmental tolerance levels in soil, groundwater, and surface water for key contaminants.

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Appendix: URLs for Ecological Risk Assessment, Ecotoxicity Data, and Ecological Guideline Values

Websites containing guideline values, by geographical area

North America

US Environmental Protection Agency (human health soil screening levels)
http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
Office of Environmental Health Hazard Assessment (OEHHA)
http://www.oehha.org/ecotox.html

Canadian Council of Ministers of the Environment (environmental quality values)
http:// http://st-ts.ccme.ca/

Europe

UK Environment Agency
http://www.environment-agency.gov.uk/research/planning/33714.aspx

Ministry of Infrastructure and the Environment (target and intervention values)
http://www.ministryofinfrastructureandtheenvironment.nl/topics/the-environment/roles_and_responsibilities_of_the_ministry/

A collection of tables of soil and groundwater quality guidelines from around the world:
http://www.sanaterre.com/guidelines/index.html

Australasia

National Environment Protection Council (environmental investigation and intervention values)
http://www.ephc.gov.au

Landcare Research
www.landcareresearch.co.nz

Websites that provide information on ecological risk assessment

US Environmental Protection Agency
htm http://rais.ornl.gov/guidance/epa_eco.html

Landcare Research
www.landcareresearch.co.nz

Websites that have ecotoxicity data

Landcare Research
www.landcareresearch.co.nz

Oak Ridge National Laboratory
http://rais.ornl.gov/tools/eco_search.php

United States Geological Survey (Columbia Environment Research Center)
http://www.cerc.usgs.gov/data/data.htm

US Environmental Protection Agency (Ecotoxicology)
http://www.epa.gov/ecotox)

Toxicology Data Network
http://toxnet.nlm.nih.gov