Risk Screening System

Contaminated Land Management Guidelines No. 3

While every effort has been made to ensure that this guideline is as clear and accurate as possible, the Ministry for the Environment will not be held responsible for any action arising out of its use. This guideline should not be taken as providing a definitive statement for any particular user's circumstances. All users of these guidelines should satisfy themselves, and their client(s) concerning the application of these guidelines to their situation and in cases where there is uncertainty seek expert advice.

Published in February 2004 by the
Ministry for the Environment
PO Box 10-362, Wellington, New Zealand

ISBN: 0-478-18922-2
ME number: 502

This document is available on the Ministry for the Environment's website:
www.mfe.govt.nz

Ministry for the Environment
Manatū Mō Te Taiao

Acknowledgements

We would like to thank the large number of people who contributed to this document, including representatives from regional councils and unitary authorities throughout New Zealand.

Thanks to Dr Simon Buckland, who represented the Ministry for the Environment.

Thanks also to Pattle Delamore Partners, especially Graeme Proffit and Richard Lucy, for the development of the document and template.

Contents

Executive Summary

This guideline describes the background to and use of the Risk Screening System (RSS). The system aims to provide a nationally consistent means of ranking sites that are, or are suspected of being, contaminated, using readily available information, regardless of location and who is carrying out the assessment. The purpose of ranking a site is usually so that it may be prioritised for further investigation.

The RSS is a simplified version of the Ministry for the Environment's Rapid Hazard Assessment System, published in 1993. The RSS is based on a risk equation made up of the hazard, the exposure pathway and the receptor. The presence of all three components means there is some level of risk, while the absence or near absence of any of the components means there is no or minimal risk.

The hazard and pathway components of the risk equation are, in turn, defined by a variety of parameters that are assigned values to reflect the degree to which the hazard exists or a pathway to a receptor is complete, and the sensitivity of the receptor. The hazard parameters include toxicity and quantity of a hazardous substance, and the pathway is defined by parameters such as depth to the hazard or distance to a receptor, as estimates of the completeness of the pathway.

Three pathways are independently analysed: surface water exposure, groundwater exposure and direct contact with soil. A site's risk ranking – reported as low, medium or high – is the pathway giving the worst case. In applying the RSS the user works through a series of analyses for each site, evaluating the risk posed by different substances that could exist in the environment at the time of the evaluation, either from historical activities or the current site use.

To enable rapid analyses the RSS is performed on the RSS template, either by hand or in a spreadsheet. The electronic version has the advantages of built-in guidance and error checking. The electronic RSS template is available on the attached CD-ROM or on the Ministry for the Environment's website, www.mfe.govt.nz.

The system may be operated in two modes:

- the standard mode, in which values must be assigned to all parameters
- the special case mode, a reduced version in which the hazard parameters may be bypassed.

The usual operation is the standard mode, which allows comparison and prioritisation between similar or dissimilar sites as defined on the Hazardous Activities and Industries List (HAIL). The standard mode is not intended to, and indeed cannot, provide *fine* distinctions between sites of similar type or risk, which is why only a coarse low, medium or high ranking is given.

The special case mode can be used where distinctions are sought between sites in which the nature of the hazard is similar. Typically this will involve sites with the same HAIL category, but may also involve different HAIL categories provided the hazardous substances are common and the perceived quantity is similar. The resultant special case score cannot be compared with the standard mode ranking, but may enable prioritisation within a group of like sites.

1 Introduction

The purpose of this guideline is to provide a nationally consistent system for ranking and prioritising contaminated sites for further investigation. The intention is that sites are consistently ranked, regardless of location and who is carrying out the assessment.

The previous site assessment system was the Rapid Hazard Assessment System (RHAS) (Ministry for the Environment, 1993), based on the Canadian Classification System for Contaminated Sites (CCME, 1992). This revised Risk Screening System (RSS) is a simplification of the original, which proved to be unnecessarily complicated for rapid screening. However, the RSS is not intended to completely replace the original RHAS. There may still be situations where a more rigorous hazard assessment is desirable, in which case the RHAS could be suitable.

The RSS is based on a risk equation made up of the *hazard*, the *exposure pathway* and the *receptor*. The presence of all three components means there is some level of risk, while the absence or near absence of any of the components means there is no or minimal risk. The hazard and pathway components of the risk equation are, in turn, defined by a variety of parameters that are considered to be the most important in determining the degree to which the hazard exists, or in defining whether a pathway to a receptor is complete.

The system operates by assigning values to these parameters to reflect estimates of such things as the toxicity and quantity of the hazard, the degree to which there are barriers to a pathway being complete, and the sensitivity or vulnerability of the receptor. In applying the RSS the user works through a series of analyses. Each analysis is specific to a particular contaminant that may exist in the ground from some period in the site's history, whether from the current use or from one or more past uses. The worst case is then reported as the current site risk.

The system may be operated in two modes:

- the standard mode, in which values must be assigned to all parameters
- the special case mode, a reduced version in which the hazard-specific parameters are bypassed.

The usual operation is the standard mode, in which a ranking of high, medium or low risk is returned. This allows comparison between similar or dissimilar sites, as defined on the Hazardous Activities and Industries List (HAIL) (Ministry for the Environment, 2004). The HAIL defines industries or activities that have a greater probability of causing land contamination because of the hazardous substances associated with the activity or industry.

The standard mode is not intended to – and in fact cannot – provide fine distinctions between sites of a similar type or risk, hence the name 'screening system'. Many sites that appear to be different will in fact fall into the same risk category. These sites should be considered to have an equal risk, and any distinction between these sites must be determined separately using other factors, such as prioritising the investigation of certain types of site use as a matter of policy. The RHAS can also be used to differentiate between such sites. The standard mode is the only way to compare sites in different HAIL categories, or sites of the same HAIL category but with what appears to be a different (typically a different extent) hazard.

The special case mode can be used where distinctions are sought between sites in which the nature of the hazards is similar, such as similar-sized sites with the same contaminants. Typically these will be sites with the same HAIL category, but may also be in different HAIL categories provided the hazardous substances are common and the perceived quantity or extent of contamination is similar (eg, a small timber treatment site and a large animal dip site). This is because the special case mode bypasses the hazard-specific parameters of toxicity, quantity/extent and mobility (in effect holding them constant) in order to gauge the differences caused by site-specific factors relating to the likelihood of the contaminant coming into contact with, or being transported to, a receptor. The resultant special case score *cannot and must not* be compared with that obtained using the full calculation, but may enable prioritisation within a group of like sites.

This document provides the conceptual background to the RSS development and serves as a guide for its use. The screening is performed on an RSS template, either on paper or in a Microsoft Excel spreadsheet. The Excel spreadsheet is included on the attached CD-ROM, and is also available from the Ministry for the Environment's web site, www.mfe.govt.nz.

2 Background to the Risk Screening System

The Risk Screening System (RSS) is based on a risk equation made up of the hazard, the exposure pathway and the receptor. The presence of all three components means there is some level of risk, while the absence or near absence of any of the components means there is no or minimal risk.

The hazard and pathway components of the risk equation are in turn defined by a variety of parameters that are considered to be the most important in determining the degree to which the hazard exists or a pathway to a receptor is completed. The equation is:

risk = hazard x pathway x receptor

where:

hazard = toxicity x quantity x mobility

pathway = containment x pathway barrier 1 x pathway barrier 2 x ...

(the likelihood of there being a complete pathway being defined by various barriers in the pathway)

and:

receptor = a single value between 0 and 1 defining the sensitivity or vulnerability of the receptor, whether people or an ecological environment.

A low value assigned to a parameter indicates a limitation to the overall risk (ie, a small hazard, or a large barrier to contact or transport along a pathway, or a low sensitivity receptor), while a high value suggests a high potential for risk. The combination of several high, low or intermediate values then gives a measure of the overall risk. This is a similar, but simplified, conceptual framework to the 1993 Rapid Hazard Assessment System (RHAS). The fundamental assumptions behind the design and use of the RSS are as follows.

The assessment is carried out for the hazard, pathways and receptors existing at the time of the assessment. The hazard (hazardous substances in the environment) at the time of the assessment must include consideration of historical uses and impacts. The risk ranking will be for the time of the assessment.

The three most common exposure pathways are:

- surface water migration
- groundwater migration
- direct contact (including ingestion, dermal contact and inhalation).

Each of these exposure mechanisms has a similar set of parameters to represent, and affect, the three parts of the risk equation:

- the contaminant source (the hazard)
- the receptors
- the transport pathways and exposure mechanisms (the pathway) between the source and receptors.

Only those parameters considered to be most important to the risk have been included. Parameters that require excessive efforts to evaluate relative to their contribution to a site's risk ranking have been excluded.

The ranking system is multiplicative. A low score in any of the risk components (hazard, pathway or receptor) reflects a lack of hazard or pathway and therefore a low risk associated with the site. For example, hydrocarbon-affected groundwater does not present a risk if there is no viable pathway between the groundwater and a receptor (perhaps because the groundwater is not used, is sufficiently deep that inhalation is unlikely and does not seep to the surface).

All parameters have been assigned a maximum input value of 1 (indicating a high contribution to the hazard, or a minimal barrier to contact or transport). Minimum values are set relative to their estimated impact on the overall site score (as outlined below). No parameter can be assigned a zero score (which would imply that either there is no hazard, the pathway is incomplete or there is no receptor), in recognition that all sites on the HAIL will have some risk, even if low.

The parameter input value ranges have been set according to their relative importance (weighting) in contributing to a site's risk. For example, the parameter values for depth (to the contaminant in the direct contact pathway) range from 0.5 to 1, whereas those for toxicity range from 0.2 to 1.

The RSS is not intended to be used like a recipe book by a non-specialist. You will need to have a knowledge of contaminated site issues and hazardous substances. If you have to deal with substances that are not commonly encountered, there are many databases available on the Internet that will allow you to make assessments of relative toxicity or mobility (see Additional Information).

The idea is that the information required to assign parameter values in the RSS should be easily available – through maps, regional council databases, phone calls, site visits, and the like. The RSS should not require detailed site investigation information. In any case, the ranking is too coarse to greatly benefit from such detail, although it may boost the confidence placed on the final ranking. If a more detailed assessment is required, consider using the RHAS (Ministry for the Environment, 1993).

The site ranking is taken as the worst-case risk ranking of the three pathways, because a site is considered a high risk even if only one pathway poses a significant risk. The three exposure pathways are presented separately only for the purposes of the user's convenience, and the overall site ranking will not be diluted or masked by low risk rankings for the other exposure pathways.

The site score prioritises sites into one of three risk categories – high, medium or low. The method does not allow for, and is not intended to produce, fine distinctions between sites, hence the 'screening system' of the title. Sites within a particular risk category are considered equal, and any distinction between these sites must be determined separately using other factors, such as prioritising the investigation of certain types of site use as a matter of policy.

The numerical cut-off between the three categories is based on:

- a high-risk site having no more than two medium parameters (or in some cases one low) with the remainder high (overall score ≥ 0.4)
- a low-risk site having no more than three medium parameters, with the remainder being low (overall score ≤ 0.02)
- a medium risk site falling between the other two ($> 0.02 < 0.4$).

The special case mode allows finer distinctions to be made between similar sites. This mode holds the hazard parameters constant (by bypassing these parameters, in effect assigning them a value of 1 in the multiplicative system), resulting in fewer parameters being multiplied together and therefore a greater apparent variation between numerical scores. However, scores obtained by using the system in the special case mode *cannot* be compared with scores obtained from inputting all the parameter values.

3 Instructions for Use

3.1 Overview

The site screening is carried out by completing a Risk Screening System for Contaminated Sites Template (see Appendix A), which mirrors the risk equation for the three exposure pathways considered. To make the template easy to use it is presented as a spreadsheet, which is available on the attached CD-ROM or from the Ministry for the Environment's website, www.mfe.govt.nz. The template can also be used in hard copy format by manually calculating the ranking (ie, multiplying each parameter value together along each pathway).

Do not alter the RSS template without clearly noting this in the assessment. Altering the template may render the results incompatible with other regional or national site rankings.

The standard version of the RSS is intended to be used as a qualitative tool for the risk categorisation and general prioritisation of sites on a nationally consistent basis. It:

- is not considered suitable as a quantitative risk assessment tool
- may not always be able to distinguish between sites for the purposes of district or regional prioritisation (eg, all sites of a particular type within a region may return the same risk category, in which case other factors should be considered when assigning priorities).

The special case mode of the RSS, for comparing like sites, returns a numerical score rather than a high, low or medium risk ranking. This numerical score:

- can be used to compare sites of similar type in a qualitative way in order to assign priorities, but cannot be compared with scores from the standard version
- cannot be used for quantitative risk assessment.

A site is normally assessed by considering the risk from contaminants that are assumed to be in the ground at the time of the assessment, either from the current use or resulting from residues from past use(s). The relevant pathways are those existing at the time of the assessment. The system can also be used to predict past or future risks, assuming conditions applicable for the time. A new ranking should be completed for each scenario.

The spreadsheet format facilitates rapid 'what if' analyses to be carried out with alternative parameter values to assess the critical risk scenario for multiple hazards present at a site. Multiple hazards may result from:

- different hazardous substances
- different current or historical uses or management practices.

The overall site ranking should reflect the hazard that presents the greatest risk. This requires you to estimate the current degree of hazard a particular substance presents, whether from a past or present use. A particular substance may in fact have accumulated from a number of site uses, all of which you must consider before selecting the worst case for reporting.

Given that the pathway and receptors will be constant for a particular time of assessment, multiple analyses should only involve altering the hazard parameters (toxicity, extent/quantity and mobility) to reflect the different hazard being considered.

If multiple assessments are carried out for a site, each assessment can be identified using the Site Type and Assessment Type fields, with additional comments in the Comments box, at the top of the assessment template. As a minimum, the chemical(s) being considered should be entered into the Comments box. Each scenario can be saved as a separate electronic file or printed out after each trial for filing.[1]

An alternative use of the system is to assess how the risk might change if the site use were to change (in the case of redevelopment), or if the surrounding use were to change, particularly to a more sensitive use. In this case the hazard parameters may not change (unless attenuation or remediation is anticipated), but redevelopment might change pathway barriers and a site use change could change the receptor sensitivity.

You don't need detailed knowledge of contaminants and concentrations at the site. In fact such knowledge would suggest that site investigation and assessment have gone beyond the purpose of the screening system. Rather, you will need to exercise judgement as to the likely nature of the hazard, based on the type of industry and current or historical operational practices. Where some degree of investigation has been carried out at a site (providing quantitative analytical data), the results of that investigation will not be used in the assessment, but will increase the confidence of the final ranking by providing more specific site information.

What-if analysis can also be used to gauge the effect on the overall risk if you are uncertain of the best value to enter for a particular parameter. In general, altering a single parameter will only have a small effect.

The site risk ranking is obtained by examining three main exposure pathways (surface water, groundwater and direct contact) in turn, obtaining a score for each. The site ranking is taken as the worst-case (highest) risk ranking of the three pathways.

3.2 Assessment template

The template has space for entering the site name, the assessment type, the site type (see Ministry for the Environment, 2004), comments for the particular assessment, the assessor's name, aquifer type, parameter values, confidence flags, comments for each parameter, and a guide to the value range for the parameter.

1 Trialing of the system has shown that it is efficient to resave the file with a different name without clearing the parameters from the previous scenario. The new scenario analysis can then be very quickly performed by replacing the scenario description at the top and overwriting only those hazard parameters that need changing, before saving once again.

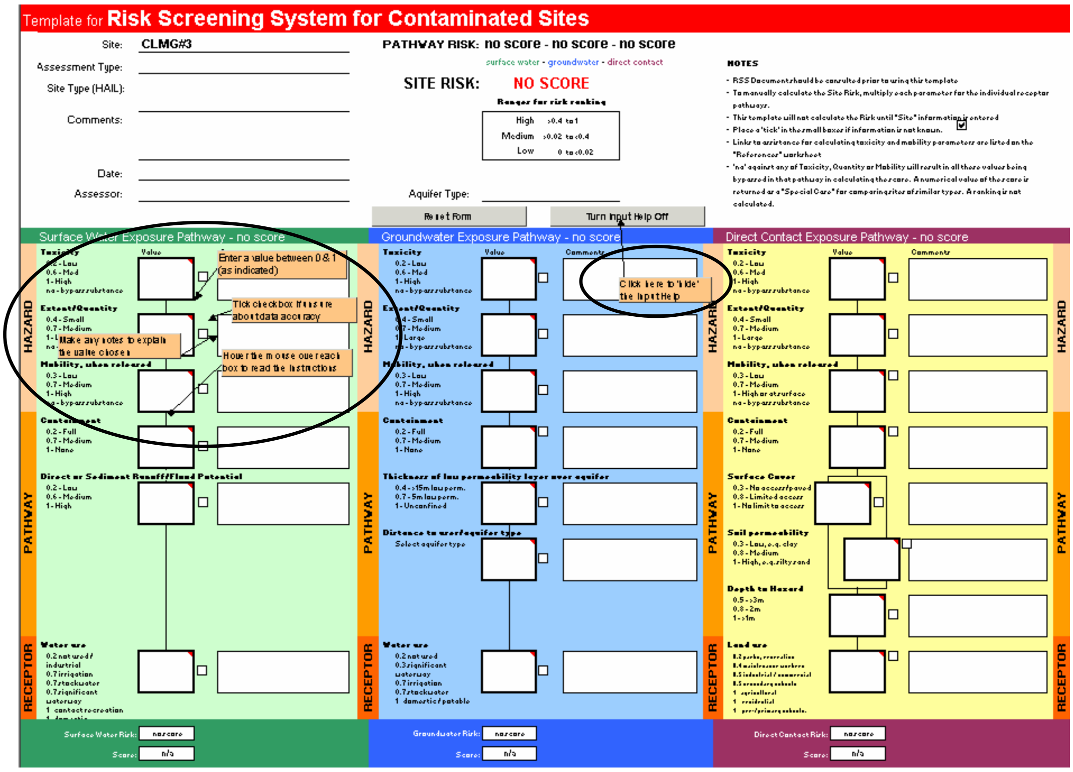
The Assessment Type field enables you to enter whether the assessment is for a historical use or activity, the current use or some proposed use. The Comments field at the top left should be used to describe the particular scenario being analysed, if the assessment is part of a what-if analysis. Comments against each parameter allow, for example, the source of the information to be noted or the reasons why standard values have not been used.

The assessment template is sized to fit on a single page, with the aim of visually and logistically simplifying the assessment process. The template is prepared in spreadsheet format, but can be printed out and used or stored as hard copy. The spreadsheet has been prepared using Microsoft Excel 97 and Excel 2000. It will also function if saved as a Corel Quattro Pro 8 file. The template's suitability for other spreadsheet packages has not been tested and should be verified before use.

Before opening the electronic assessment template, ensure that your spreadsheet programme (eg, Microsoft Excel) has macros enabled; otherwise the template will not function properly.

In electronic form, the template has some additional functions that are not available in hard copy.

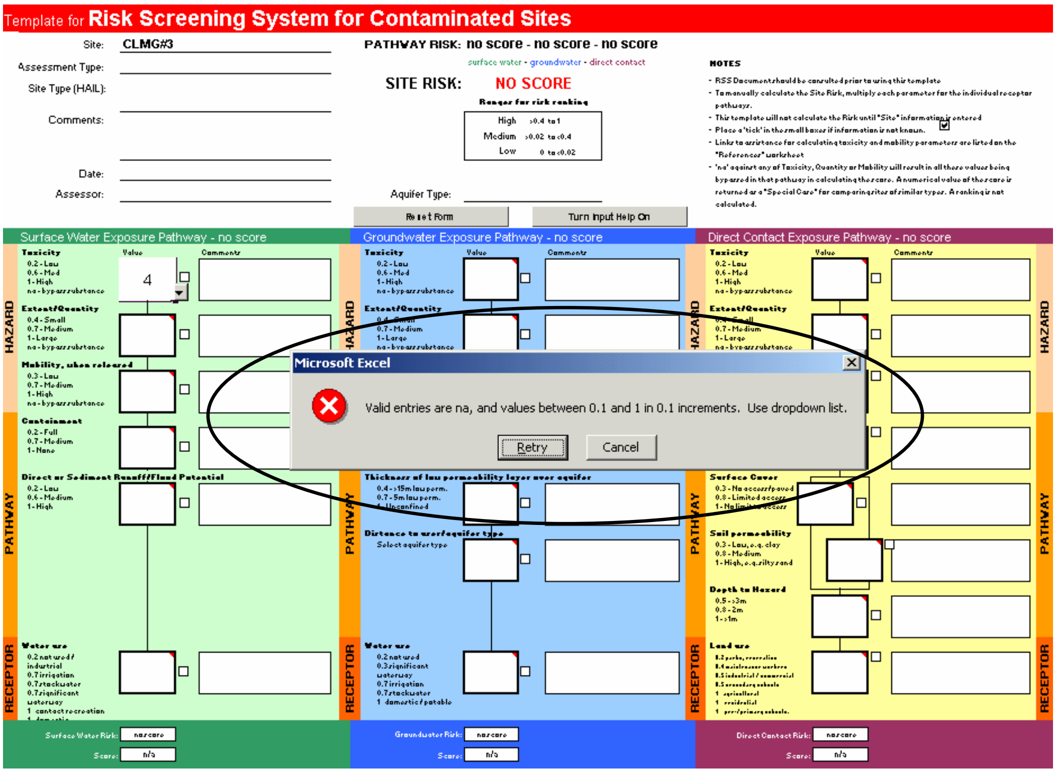
- There is a Help button that turns basic instructions on and off (see Screen shot 1).



Screen Shot 1: Help button

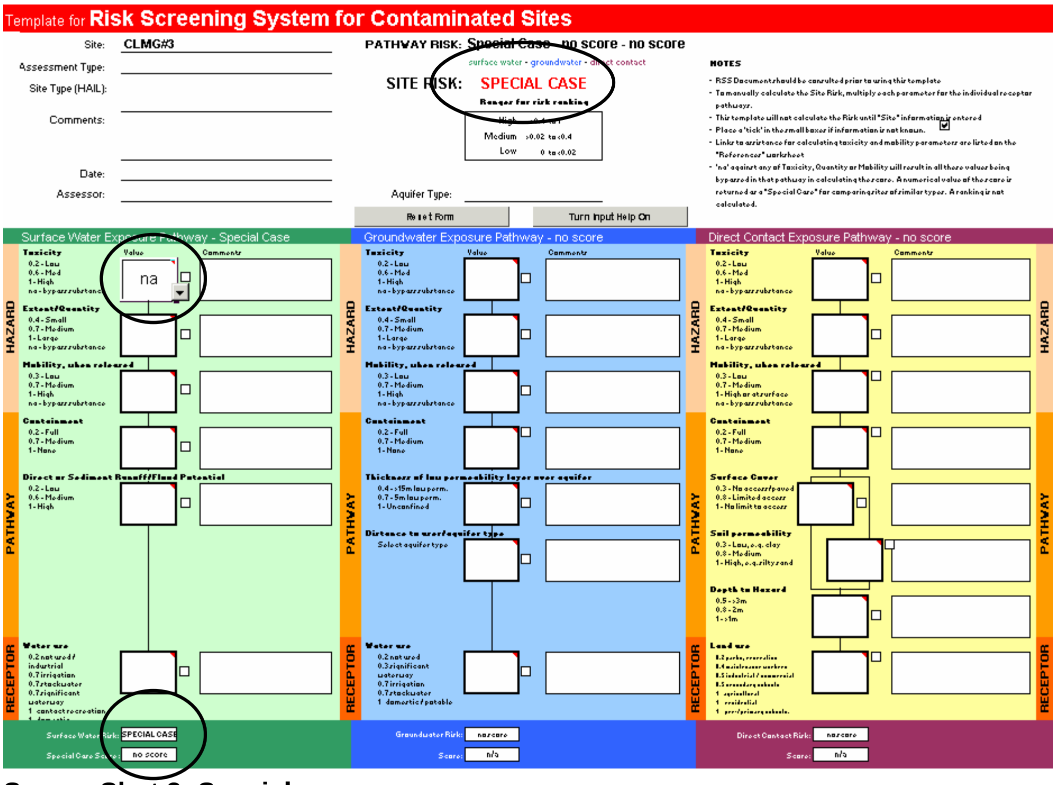
- A site name must be entered before the system will return a risk ranking (seen at the bottom of each pathway and in the centre-top of the template). Without the site name the ranking boxes will remain blank.
- Leaving one or more of the parameter values blank (or failure to select an aquifer type in the case of the groundwater pathway) will result in a risk ranking of 'no score', to signify that a value is missing.

- There are drop-down lists for many fields, including Assessment Type, Site Type, Aquifer Type and all the parameter value boxes. Trying to manually enter a value not in the list will produce an error message giving the valid values. Guidance on how to enter data is given for these fields.
- Parameter values less than or equal to zero, greater than 1, or to more than one decimal place will not be accepted. No more than one decimal place is allowed, as the risk screening system is incapable of providing greater accuracy than one decimal place. An error message will be displayed giving valid entries (see Screen shot 2).



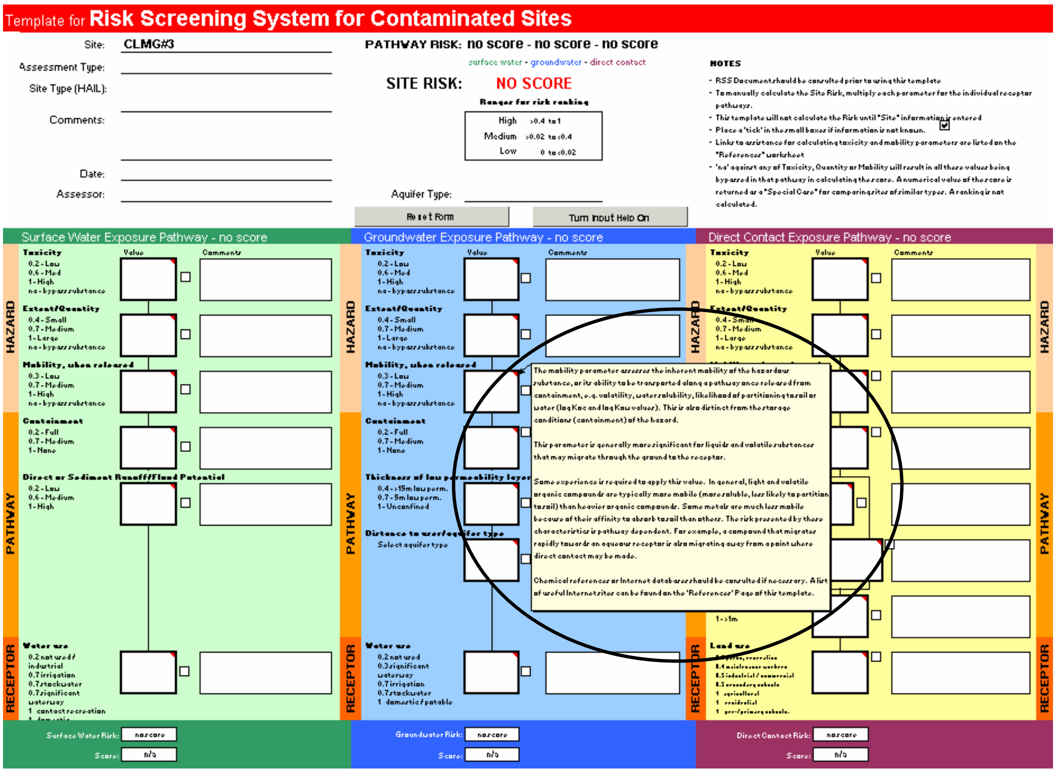
Screen Shot 2: Error box

- A parameter value entry of ‘na’ is accepted in any of the Toxicity, Extent / Quantity or Mobility fields to enable the special case mode of assessment where sites of the same type are to be compared. This has the effect of bypassing all three fields for the pathway in which ‘na’ is entered. It is only necessary to enter ‘na’ in one of Toxicity, Extent / Quantity or Mobility for each pathway for the bypass mode to be enabled for that pathway. However, make sure ‘na’ is entered in each pathway separately. Special case is signalled by ‘Special Case’ appearing in the Risk field for the particular pathway (see Screen shot 3). A numerical value will appear as a special case score at the bottom of each pathway when the remainder of the parameter boxes are validly filled. This numerical value is not displayed (the box will read ‘na’) when the special case mode is not enabled.



Screen Shot 3: Special case

- User guide information for each of the parameter entry boxes can be accessed by hovering the mouse pointer over the input box (see Screen shot 4).



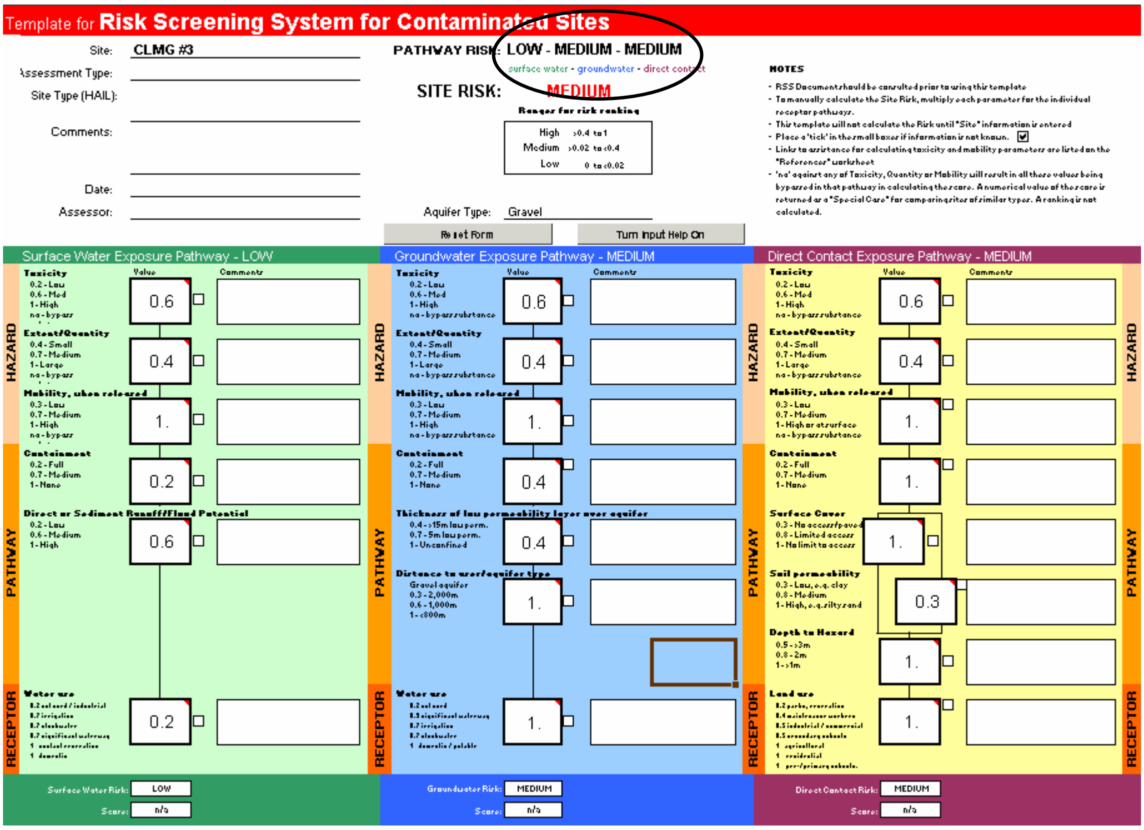
Screen Shot 4: User guide information

- Site ranking is calculated automatically, although a pathway's ranking will not be calculated until the site name has been entered and a value has been entered into each parameter box for that pathway.
- A summary compilation of the site's information is provided on a separate worksheet (labelled 'Results'), to enable the data to be easily copied to a separate database.
- The parameter boxes may be cleared by using the Reset button. This will not clear the information fields at the top left of the template.

3.3 Site ranking

The three exposure pathways considered (surface water, groundwater and direct contact) are independently assessed. A site's risk ranking is simply that of the 'critical' pathway (the pathway returning the highest risk).

While the overall site ranking is based on the worst-case pathway, all three pathways are reported, in the format 'surface water rank – groundwater rank – direct contact rank' at the top of the template, with the worst case (highest ranking) reported as the Site Risk immediately below (see Screen shot 5).



Screen Shot 5: Pathway risks

For example, if a site is assessed as having a high risk for both the ground and surface water pathways, and a medium risk for the direct contact pathway, the pathway risk is reported as 'High-High-Medium' and the overall site risk is 'High'.

An exposure pathway is considered to have one of the following levels of risk based on the overall calculated score (ie, the product of the individual parameter values) for that pathway:

- 0.4 to 1: high risk
- 0.02 to < 0.4: medium risk
- 0 to < 0.02: low risk.

3.4 Information gaps

The RSS is entirely multiplicative, and all parameter values need to be input before a site score can be calculated. Given that the RSS has been developed as an easy-to-use method based on the application of generalised assessment parameters, assigning arbitrary values to any one of these parameters may cause gross errors and is not recommended. Sufficient information should be available from readily accessible sources to enable valid entries to be made. However, if you consider the information to be questionable, note this fact on the template by marking the tick box beside the relevant parameter value, together with an explanation in the Comments box. As outlined above, a what-if analysis can be rapidly carried out to determine the degree of uncertainty caused by the parameter in question.

4 Parameter Descriptions and Input Values

4.1 Overview

This section describes each parameter and provides guidance on the value to assign to each parameter (without being overly prescriptive). The guidance values are not intended to be absolute. Within the range of values given you can apply any value you consider appropriate, since there may be particular situations that you consider are not reflected by the suggested parameter values.

In such situations, you can assign any valid value (> 0, ≤ 1, in 0.1 increments) you choose, but you will need to note the reasons for any values departing from the recommended values given in this guide, and on the Risk Screening System (RSS) template, as a comment against the value on the template. We recommend a cautious approach to deviating too far from the standard values. Note also that the guidance values indicate whether a parameter risk is considered to be linear from best to worst, or whether the risk increase (or decrease) is skewed (is weighted towards best or worst).

For each exposure pathway (surface water, groundwater and direct contact) the template requires input for each of the components of the risk equation – the hazard, the pathway and the receptor. The first two components consist of several parameters, while the receptor component comprises a single parameter.

- *Hazard component* – the parameters include toxicity, extent/quantity, and mobility. A greater extent or larger quantity, a more toxic substance or a more mobile contaminant presents a greater hazard than small quantities, low toxicities, or immobile contamination.
- *Pathway component* – the parameters are intended to represent the probability and extent to which the pathway between the hazard and receptor will be completed. The pathway parameters affect whether a receptor will come in direct contact with an immobile contaminant or whether a potentially mobile contaminant is likely to be transported to a receptor. Typical parameters are the distance between the hazard and receptor, and factors affecting transport such as potential for run-off and ground permeability.

The parameters are described in more detail below. In all cases, values are assigned to the parameters – whether for the hazard, the pathway or the receptor – for the current condition of the site, unless the assessment is being used to predict the risk for some future changed condition.

4.2 Hazard component

The hazard component has three parameters, each of which must be considered relative to the receptor pathway being considered:

- the toxicity of the contaminant
- the extent or quantity of the contaminant
- the mobility of the contaminant along a pathway when released into the environment.

These parameters are purely a measure of the hazard potential – not a measure of whether the hazard potential is realised as a risk. The potential for realising the risk is dealt with by the pathway and receptor parameters.

4.2.1 Toxicity

The toxicity parameter is a measure of the ability of the contaminants to cause adverse human health and environmental effects. This document does not present a definitive list of relative toxicities of various substances. If you are using the screening system you should have sufficient training and experience in hazardous substances to know the relative toxicities of common substances. A list of common types of contaminants is presented below for guidance on assigning appropriate values, and a list of some of the more commonly encountered substances is provided in Contaminated Land Management Guideline Schedule B. The most up-to-date version of the Schedule can be found at the Ministry's website, www.mfe.govt.nz. A number of Internet resources are also listed in 'Additional Information'.

In judging relative toxicities it is useful to compare the World Health Organisation (WHO) acceptable or tolerable daily intake (ADI, TDI), or equivalent values such as the United States Environmental Protection Agency's (US EPA) reference dose (RfD) or the Agency for Toxic Substances and Disease Registry (ATSDR) chronic minimum reference level (MRL). The WHO's ADIs are used in deriving the Drinking Water Standards for New Zealand, with many ADI values given in the Ministry of Health's drinking water quality management guideline document (Ministry of Health, 1995).

ADIs (TDIs or RfDs and MRLs) for threshold contaminants are given in terms of the amount of substance per kilogram of body weight per day (mg/ kg bw/day) that will not cause an observable health effect in a sensitive individual. For the purposes of the RSS, a high-concern substance is defined as one which has an ADI of ≤ 0.02 mg/kg bw/day, a medium concern substance has an ADI that falls between 0.02 and 0.2 mg/kg bw/day and a low concern substance has an ADI > 0.2 mg/kg bw/day. ADIs can be used to calculate guideline values for soil contaminants assuming particular exposure scenarios. Using the assumptions provided in the Timber Treatment Guidelines (Ministry for the Environment and Ministry of Health, 1997) for residential scenarios, a high concern substance is one which that creates a potential risk at concentrations less than approximately 3,000 mg/kg for exposure via soil ingestion. This is an indicative concentration and does not include other pathways of exposure (eg, produce consumption, dermal absorption), which are likely to result in a potential risk occurring at lower concentrations.

Parameter range:	0.2	Low-concern contaminants ADI > 0.2 mg/kg/day
	0.6	Medium-concern contaminants ADI ≤ 0.2 mg/kg/day
	1	High-concern contaminants ADI ≤ 0.02 mg/kg/day

Carcinogenic substances (non-threshold contaminants) cannot be treated in this way. If a substance has been determined as a potential human carcinogen then it should be considered a high-concern contaminant.

A generic list of high-, medium- and low-concern contaminants is given below and a more detailed list for some specific hazardous substances, compiled using ADI values, is given in Appendix C. Many substances are more toxic through the inhalation pathway than the oral pathway, and you should consider this when assessing toxicities. Also, some substances are far more toxic to plant life or the aquatic environment than they are to humans. Therefore human toxicity should be used with caution when considering risks to the wider environment.

High-concern waste/substance types are:

- materials that are persistent, bio-accumulative and toxic
- heavy metals (eg, mercury, arsenic, lead)
- industrial waste (eg, pesticides, herbicides, paint sludge, acid and alkaline solutions, petroleum hydrocarbons)
- institutional waste (eg, laboratories, hospitals)
- pathological waste
- radioactive waste.

Medium-concern waste/substance types are:

- liquid waste not covered above, including non-volatile hydrocarbons (eg, heavy oils), septic tank pumpings, agricultural and chemical containers
- food-processing wastes
- non-hazardous incinerator or boiler residues (eg, ash)
- municipal solid wastes (domestic)
- organic and vegetable wastes
- mining residues.

Low concern waste/substance types are:

- industrial and commercial solid wastes (eg, construction materials such as wood, metal, sand/silt piles, foundry sands).

4.2.2 Extent/quantity

The extent/quantity parameter is a measure of the amount of the potentially hazardous substances on the site being assessed *at the time of the assessment*. This must be treated independently of the toxicity, but the extent/quantity combined with the toxicity gives a measure of the hazard at the source. Thus, the combination of a small quantity of a highly toxic material may present a similar hazard to a large quantity of a substance with a lower toxicity.

Parameter range:	0.4	Small quantity or proportion of site affected
	0.7	Medium quantity or proportion of site affected
	1	Large quantity or proportion of site affected

Quantity/extent is distinct from the actual quantities of a hazardous substance in the material that may have been released or deposited. Also, the quantity of hazardous material is distinct from the potential for escape, which is covered by the storage conditions (containment) of the hazard (see section 4.3.1).

It is difficult to entirely separate the extent/quantity from the site use for the direct contact pathway. You will need to consider the proportion of the site affected when determining the value for this parameter. Clearly, a small quantity of affected soil on a relatively small site (where occupancy is likely to be more intense) is more significant for direct contact than the same quantity on a much larger site.

Particular difficulties can be encountered for residential sites where small quantities can present a high risk if readily accessible to children (eg, lead paint flakes in garden soil). In that case, it is reasonable to assign a high value to extent/quantity. Another example is a small sheep dip site with a few cubic metres of affected soil, which may not present a particular risk on a farm but could present a significant risk if there are nearby residential properties from which children might gain access. A substantial risk would be presented if the same sheep dip ended up on a residential property following subdivision of the farm.

Historical contamination results in particular difficulties for assigning a value to this parameter, because past activities, storage conditions and management practices will affect the likelihood of the hazardous substances getting into the ground, and therefore will affect the current extent/quantity estimate.

For simple sites it is possible to assign a value to extent/quantity based on the quantity of the substance historically stored, and then deal with the likelihood of the substance being in the ground using the containment pathway parameter (see the discussion in the note at the end of section 4.3.1). However, for complex historical sites this simplified approach cannot be used and the historical containment conditions must be factored into the extent/quantity parameter. The containment parameter would then be assigned a value of 1 to indicate the substance is already in the ground.

Thus, for historical sites the extent/quantity parameter must consider:

- the activities and management practices that were typical of the time – poor storage and disposal practices will mean ground effects are more likely, and more severe
- the period of operation, which will affect the extent of effects if practices were not satisfactory
- whether a number of different activities might have resulted in the accumulation of the same or similar substance(s)
- the degree of natural attenuation of the substance that might have occurred since the historical activity or land use ceased – this is particularly relevant for substances that are volatile, soluble (where leaching is possible) or readily biodegradable
- the amount of soil removal that might have occurred if there had been any ground modification – this is relevant for sites that may have undergone redevelopment.

The following quantities of liquids currently or historically stored or used and contaminated soil are suggested as a rough guide:

- *small quantities* – tens to hundreds of litres or tens of cubic metres of soil; or, for the direct contact pathway, less than 10% of the site affected (noting that a residential site with a small quantity of readily accessible soil may present a high risk)
- *medium quantities* – hundreds to thousands of litres or hundreds of cubic metres of soil; or, for the direct contact pathway, 10–50% of the site affected
- *large quantities* – thousands of litres or hundreds to thousands of cubic metres of soil; or, for the direct contact pathway, greater than 50% of the site affected.

4.2.3 Mobility

The mobility parameter assesses the ability of the hazardous substance to migrate or be transported along a pathway once released from containment (eg, a measure of properties such as volatility, water solubility, likelihood of partitioning to soil or water (log K_{oc} and log K_{ow} values). Mobility is distinct from the storage conditions (containment) of the hazard (see section 4.3.1), which is a site factor rather than a property of the substance.

Parameter range:	0.3	Low mobility for the pathway
	0.7	Medium mobility for the pathway
	1	High mobility for the pathway

The mobility parameter is affected by the pathway. For example, a compound that migrates rapidly *towards* an aqueous receptor is also migrating *away* from a point where direct contact may be made. A substance that is immobilised on the surface, and therefore unlikely to affect groundwater, is available for direct contact. In addition, migration of the substance may not just be as the pure substance (whether as a gas or liquid), but also transported by another medium (eg, dissolved in water or attached to sediment or dust).

A substance would normally be considered highly mobile if it is:

- a liquid, particularly of low viscosity, facilitating migration through the ground
- a gas or a volatile liquid, facilitating migration through the ground in vapour phase
- soluble, facilitating leaching and/or transport by surface or groundwater
- conservative in solution (doesn't tend to partition to soil or degrade), facilitating transport in surface or groundwater.

The converse would apply for substances with the opposite properties. However, there are two exceptions where normally immobile substances with a tendency to partition to soil (eg, many metals and semi-volatile organic compounds) should be assigned high mobility so as not to spuriously reduce the risk:

- where adsorption to dust or sediment is likely, and the dust or sediment is readily available for transport to a receptor by wind or run-off (see section 4.3.2)
- for the direct contact pathway, where partitioning to soil ensures the substance remains on the surface available for contact.

There are also exceptions where highly mobile organic substances may in fact present a low risk for historical contamination, because the properties that suggest greater mobility can also increase susceptibility to more rapid attenuation. This must be factored into the quantity/extent parameter, as mentioned previously. Thus highly mobile substances may also:

- attenuate rapidly because of their high volatility
- degrade rapidly because their high solubility makes them available for bio-degradation.

As a result, some care and experience is required in assigning values to this parameter. As a guide, light and volatile organic compounds are typically more mobile (soluble) than heavier organic compounds. Semi-volatile organic compounds (eg, chlorinated pesticides and polyaromatic hydrocarbons) tend to have both a low solubility and a strong tendency to partition to soil. Many heavy metals and metalloids (eg, lead, copper, arsenic) have a low mobility because of their affinity to adsorb to soil, but this can be species- and soil pH-dependent.

Consult chemical references or Internet databases if necessary. A list of useful Internet sites is presented at the back in 'Additional Information'.

4.3 Pathway component

The pathway component defines the likelihood of contact with, or transport to, a receptor. The pathway to consider is normally the current pathway, not the pathway when some historical contamination may have occurred, because it is the current risk based on current site conditions that is being assessed (but see note under containment below). Historical site conditions or layout cannot affect whether a contaminant is now likely to come into contact with a receptor. Any history (including past pathways that might have facilitated spread of the contaminant) is factored into the hazard parameter of extent/quantity (see section 4.2.2). However, if predictions of future or past risk are required, then the pathway conditions applying at the time should be used.

The pathway component and associated parameters are functions of the site and surroundings, not of the hazardous substance itself. One parameter is common to each of the three exposure pathways considered: the containment parameter, which defines the security of the contaminant containment at the site. Otherwise, each of the exposure pathways has a different set of parameters, defining barriers to transport or contact.

There are either two or three pathway component parameters, depending on the pathway being considered. A consequence of the multiplicative nature of the assessment is that, for a given numerical value, three parameters will result in a lower apparent risk than two values. To avoid this bias, the recommended values have been adjusted so that, for example, applying medium values across all parameters produces a similar result for each exposure pathway when all the values are multiplied together. If you decide the suggested values are not appropriate, you will need to consider the potential for multiplicative bias between pathways when choosing alternative parameter values.

4.3.1 Containment

The contaminant parameter is an indicator of the current potential for a stored hazard to be released into the environment (see the note below for a discussion on historical storage). This parameter is intended to apply to engineered structures and does not include natural ground conditions providing containment, although it could include engineered soil linings. Containment provided by low ground permeability is considered as part of other parameters and should not be considered here.

Parameter range:	0.2	Fully contained
	0.4	Fully contained, but with the potential for the containment to be compromised
	0.7	Medium containment
	1	No containment, or contaminant already present in the environment

Where the hazard is shown to be present in the environment (eg, from knowledge of a spill or leak into the ground, from knowledge of deliberate disposal, or from observations or measurements of contamination), the site is considered to have no containment. Conversely, evidence of a double-skinned fuel storage container in a bunded compound would suggest a small potential for escape, and therefore the contents can be considered to be fully contained. Single-skinned underground storage tanks made of steel or poorly bunded storage areas might be considered to have the potential for the containment to be compromised.

Note on storage and containment

For historical sites where it is known that hazardous substances were stored in some form of engineered structure (eg, storage tanks, dangerous goods stores, warehouses), it is difficult to separate out the conditions of storage (the containment parameter) from the extent/quantity parameter in the hazard component. There are two ways of determining the probability of that substance now being in the ground and available for contact with, or transport to, a receptor.

Either:

- factor the past containment conditions in the estimate of extent/quantity and then assume the contaminant exists in the ground by assigning the containment parameter a value of 1; or
- assign a value to the extent/quantity parameter based on the amount of historical storage of the substance and then determine the probability of its being in the ground by using the containment parameter for the historical storage conditions.

In the first method, the historical containment is implicitly factored into the assessment of the quantity of affected ground that may now exist. The second method is rather more transparent, and attempts to separately account for the quantity stored and the historical storage conditions. Both methods are appropriate for simple sites with a single period of historical storage, and should give the same answer. However, the first method should be used where contamination is known to exist in the ground and for complex sites where multiple periods of use must be accounted for. Multiple uses will most likely have multiple historical containment conditions that must be considered in arriving at estimated amounts of hazardous substances that may now be in the ground.

4.3.2 Direct or sediment run-off and flood potential (surface water)

The remaining surface-water pathway parameter assesses the risk to a surface water receptor from:

- direct run-off of a leak or spill
- contaminated sediment transported by storm water run-off
- the surface waterway flooding the site.

Parameter range:	0.2	Low potential for run-off or flood
	0.6	Medium potential for run-off or flood
	1	Preferential path, or water body within tens of metres

This is a hybrid parameter that must take into account a number of site and topographical considerations. The choice of value will depend on a combination of surface cover on the site and between the site and waterway, topography (slope and a viable drainage path) and distance to the waterway. Run-off potential will be relatively higher for steep, unvegetated or impermeable slopes with a nearby surface water body, than for flat slopes, vegetated or permeable ground and/or a distant water body. A water body running through the site, or within a few tens of metres, would generally suggest a high potential for effects on that water body, whereas one more than a few tens of metres and up to a hundred metres away would suggest a medium potential. Distances greater than 100 metres would suggest a low potential for run-off effects unless there are factors that make run-off more likely, such as impermeable surfaces, steep slopes or preferential pathways.

Where there is the potential for preferential migration (eg, through service trenches or stormwater culverts in an urban setting, or surface drains in a rural setting), the run-off potential should be modified to compensate for the more direct flow paths. For example, in the extreme case, run-off going into a stormwater drain that discharges directly to a surface water body would be assigned a value of 1, but if there was a potential for dilution on the way then a lower value might be assigned.

Estimates of slope, distance and whether there is a viable drainage path may be obtained from 1:50,000 topographical maps, smaller-scale contour mapping (try district or city councils), estimates from city or district council service plans, or by site inspection.

Flood potential will depend on the topography and distance – whether a flood is likely to reach the site – and whether there is any protective cover on the site. Flood hazard analysis has been carried out for many rivers and may be available in the form of local authority flood hazard maps or by consulting regional council hydrologists. Where flood hazard maps are not available, an assessment of height above the nearest waterway, distance from the waterway and anecdotal evidence of floods will need to be used to estimate the potential for flooding at the site.

4.3.3 Groundwater pathway

For there to be a risk to a groundwater pathway receptor, the contaminant must migrate to an aquifer and travel through the aquifer to the point of contact. This has been assessed by including parameters for:

- the thickness of any low-permeability (silt, or clay equivalent) protective layer overlying aquifers of concern
- the distance to the nearest user.

(a) Thickness of protective layer

The thickness of overlying low-permeability layers, including surface paving where relevant, is a measure of the ability of contaminants to migrate down to an aquifer. The top of any low-permeable layers must be taken as the lowest point at which a hazard is released. A good-quality pavement in the case of a surface release can be considered to be the equivalent of greater than 15 m of low-permeability material overlying an aquifer.

Parameter range:	0.4	> 15 m of low-permeability material overlying aquifer
	0.7	5 m of low-permeability material overlying aquifer
	1	Unconfined

(b) Distance to user/aquifer type

The distance to user/aquifer type parameter is used to assess the ability of a hazardous substance to migrate through an aquifer to a point of use. 'Use' is broadly defined as a point where a receptor could come in contact with the contaminant, and includes a point of abstraction (a well) or a point of discharge to the surface (a spring) or surface water body.

Parameter range

Parameter value	Distance to receptor for aquifer type (typical permeability)				
	Clay, silt (low)	Fine sand, silty gravel (low–moderate)	Coarse sand, sandy gravel (moderate)	Gravel (high)	Fractured rock (moderate)
0.3 (low risk)	100 m	300 m	1000 m	2000 m	1500 m
0.6 (medium risk)	50 m	100 m	500 m	1000 m	800 m
1 (high risk)	< 20 m	< 50 m	< 300 m	800 m	600 m

The parameter is a measure of risk for different distances to the point of use as a function of broad aquifer types used to define permeability ranges (ranging from 10^{-8} m/s or lower for silts and clays, to 10^{-2} m/s or higher for gravels; see Freeze and Cherry, 1979, Table 2.2, or similar groundwater text). The greater the distance to the point of use for a particular aquifer type, the lower the risk value. Mobility of the substance is accounted for separately in the mobility parameter. Where the user is aware of preferential pathways (eg, gravel lenses over short distances within an otherwise low-permeability sediment), judgement must be exercised as to what average aquifer type should apply over the distance between the contaminant source and the particular groundwater use location. Where the bulk properties of the underlying aquifer are known (from pump tests), then the most suitable aquifer type should be used.

Five aquifer types have been selected to represent aquifers typically encountered in New Zealand. Distances for low-, medium- and high-risk values (values of 0.3, 0.6 and 1, respectively) have been determined from a combination of experience and 1-D dispersion calculations for a conservative contaminant over a period of 10 years. Degradation of the contaminant (as distinct from retardation due to adsorption, which is accounted for in the mobility parameter) has not been considered. Where degradation is likely to occur (eg, for biodegradable and volatile substances), the travel distances for each risk value should be adjusted down accordingly, meaning that for a given distance to a point of use, a substance that does not degrade will result in a higher risk of exposure than a substance that does degrade.

The fractured-rock aquifer type is intended to represent aquifers similar to the Auckland basalts, and perhaps closely jointed greywacke. Fractured rock is inherently variable and the values given must be used with caution. There is no attempt to represent cavernous limestone, where special consideration must be given. If you have any doubt on what aquifer type to select, consult a hydrogeologist or the relevant regional council.

Where one of the standard aquifer types does not fit the particular situation, there is provision in the electronic template to select 'Other' and then assign whatever value between 0 and 1 that is appropriate to the situation. Make sure you provide comments justifying the selected value.

4.3.4 Direct contact pathway

The direct contact exposure pathways considered are dermal and inhalation mechanisms. The inhalation pathway includes exposure to both volatile substances (eg, hydrocarbons) and particulate matter (eg, contaminated dust and asbestos). The two direct contact mechanisms are independent, although in both cases the likelihood of a complete pathway is dependent on whether there are barriers to the pathway (eg, the pathway length, surface cover or ground permeability). The pathway score reports the mechanism with the greatest assessed risk. The direct contact pathway is influenced by:

- the depth to the hazard, and either:
- the surface cover of the ground surface, or
- the permeability of the soil, in the event of a volatile hazard.

(a) Depth to hazard

The depth-to-hazard parameter is used to assess the risk to direct contact receptors from a sub-surface hazard. The hazard may have been released underground (eg, via storage tanks), may have been buried (eg, in landfills) or may have migrated through permeable materials to the water table. The risk presented by the hazard will lessen as the depth to the release point increases.

Parameter range:	0.5	Greater than 4 m below the ground surface
	0.8	1–4 m below the ground surface
	1	Within 1 m of the ground surface

(b) Surface cover

The surface cover parameter assesses the risk to human health from direct dermal contact with the hazard. This risk reduces with the increase in effectiveness of the ground surface cover. Effective cover includes paving and adequate earth-cover material over the affected ground (eg, cover over landfills), such that contact cannot reasonably occur during normal site use. For semi-volatile contaminants, a thick, well-maintained grass cover provides some barrier to contact relative to bare earth. The likelihood of excavation or other disturbance to the soil, with subsequent soil contact, should be considered for the particular site use.

Parameter range:	0.3	No access, or paved
	0.8	Limited access or paving
	1	No restraint to access

(c) Soil permeability

The soil permeability parameter assesses the risk relating to the inhalation of a sub-surface volatile hazard. The presence of low-permeability ground may reduce this risk.

Parameter range:	0.3	Low-permeability soils (eg, clay)
	0.8	Medium-permeability soils
	1	High-permeability soils (eg, silty sand soils, gravel)

4.4 Receptor component

The risk to receptors is dependent on contact with contaminated material, whether soil or water. This may depend on the type of site use, in the case of the direct contact pathway, or the likelihood of a person or ecological receptor coming into contact with, or using, contaminated water.

These parameters assess only the physical criteria relating to a site. There may be other concerns that affect the perceived site ranking, such as cultural values, but these cannot be considered in a generic fashion as part of the Risk Screening System. Where this occurs, you will need to use your best judgement and factor the value accordingly. In such cases it is imperative to provide a comment to justify the selected value.

4.4.1 Water use

The water use parameter applies to both groundwater and surface water receptors, where appropriate. The risk may be to human health through use of water as drinking water or for recreation, to crops or stock in an agricultural setting, or to ecological values where ground- or surface water discharges to a significant waterway.

Parameter range:	0.2	Not used/industrial
	0.7	Irrigation
	0.7	Stockwater
	0.7	Ecologically significant waterway
	1	Contact recreation
	1	Domestic/potable

Where the discharge of groundwater to surface water is being considered, dilution in the receiving waterway must be taken into account. In general, the risk to all but the smallest of waterways from groundwater discharge will be low (see section 4.5).

A value for industrial water use has also been given. A low risk value has been assigned to this use, because concerns regarding industrial water use are generally not health-based.

4.4.2 Land use

The land-use parameter defines the risk to receptors for the direct contact pathway in proportion to a number of exposure factors that are unique to the receptor's environment. These include the exposure frequency (days per year) and exposure rate (rate at which hazard is ingested, inhaled or contacted). Land-use scenarios and relevant exposure rates broadly match those used in health-based soil guideline documents developed for timber treatment (Ministry for the Environment and Ministry of Health, 1997), petroleum hydrocarbon (Ministry for the Environment, 1999) and gasworks (Ministry for the Environment, 1997) sites.

Parameter range:	0.2	Parks, recreation
	0.4	Maintenance work
	0.5	Industrial/commercial
	0.5	Secondary schools and higher educational establishments
	1	Agricultural
	1	Pre- and primary schools
	1	Residential

The values recognise, for example, the relatively higher exposure to soil a residential receptor has relative to a receptor on an industrial site. A residential occupant is considered to spend more time at home and be more likely to have contact with bare soil than a worker at an industrial site. Preschools and primary schools are given a high value because, although the receptors spend only a small part of the day at the site, there is the likelihood with young children of increased contact with the hazard (eg, through direct soil ingestion).

4.5 Pathway interaction

Some interaction may occur between different pathways, such as groundwater in hydraulic contact with surface water presenting a risk to the surface water, or groundwater seeping to the surface and presenting a direct contact risk. There is no simple way of presenting these scenarios on the template without jumping from one pathway to another, which has the potential to create confusion. In such cases, therefore, the risk via one pathway should be assessed separately, off the template, on the basis of the contribution by the other pathway, and the input parameters modified on the template accordingly. A note should be made to this effect on the template.

For example, in the case of groundwater discharging to surface water, the surface water receptor (whether water use, ecological, stockwater, etc.) would in effect become the water use value of the groundwater pathway. The distance to the receptor and ground permeability as they affect the likelihood of reaching the receptor are already included in the groundwater pathway. But, as discussed in section 4.4.1, effects of dilution in the surface waterway and whether there is likely to be any surface water receptor (given that different receptors will have a different tolerance to contaminants, as shown by the suggested values for the surface-water water use parameter) must be considered separately.

A judgement must then be made as to what value to give the groundwater water use parameter. For a remote surface waterway with a large flow, the value would be small – probably 0.1. However, for a small but ecologically significant waterway receiving seepage through gravels from an immediately adjacent site, the value could be higher, perhaps 0.7, similar to that given for the surface-water water use parameter for a significant waterway.

5 Conclusions

The Risk Screening System (RSS) is intended as a screening tool that consistently assesses and ranks the risk that any site presents. It does this by considering the completion of the risk pathway from a contaminant source, or hazard, to a receptor, using weighted factors for the various parameters making up the pathway. Three overall receptor pathways are considered: exposure to surface water, exposure to groundwater and direct contact. Each of these pathways is treated independently and given an equal importance, with the overall ranking of a site obtained by choosing the worst-case pathway (ie, the pathway with the highest assessed risk).

The RSS has been designed for ease of use, based on readily obtainable information. As such, it is not intended to provide a fine differentiation between sites. More detailed information (if available) will increase the confidence of the score, but the coarse nature of the ranking should still allow valid comparisons with sites that have less detailed information available.

While the RSS uses a minimum set of data to enable a rapid assessment, with most of the data readily available from public sources, the system does require some experience in contaminated site assessment for the user to be confident of the results. This is because some of the parameters, such as contaminant toxicity and mobility, require knowledge that only a person with some contaminated site (or similar) expertise could be expected to have.

The RSS is intended to be sufficient to prioritise sites for further investigation. Therefore, the assessment is not intended to be used on sites that have already been assessed on the basis of a specific site investigation, as these sites have already passed the point where the basic prioritisation decisions have been made.

References

CCME (1992). *National Classification System for Contaminated Sites*. Canadian Council of Ministers of Environment, Winnipeg, Canada.

Freeze RA, Cheery JA (1979). *Groundwater*. Prentice Hall, Englewood Cliffs, New Jersey.

Ministry for the Environment (1993). *National Rapid Hazard Assessment System for Potentially Contaminated Sites (draft)*. Ministry for the Environment, Wellington, New Zealand.

Ministry for the Environment (1997). *Guidelines for Assessing and Managing Contaminated Gasworks Sites in New Zealand*. Ministry for the Environment, Wellington, New Zealand.

Ministry for the Environment (1999). *Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand*. Ministry for the Environment, Wellington, New Zealand.

Ministry for the Environment (2003). *Contaminated Land Management Guidelines No. 1: Reporting on Contaminated Sites in New Zealand*. Ministry for the Environment, Wellington, New Zealand.

Ministry for the Environment (2004). *Contaminated Land Management Guidelines Schedule A: Hazardous Activities and Industries List (HAIL).* Ministry for the Environment, Wellington, New Zealand.

Ministry for the Environment (2004). *Contaminated Land Management Guidelines Schedule B: Hazardous Activities and Industries List (HAIL) with Hazardous Substances.* Ministry for the Environment, Wellington, New Zealand.

Ministry for the Environment (in preparation). *Contaminated Land Management Guidelines No. 4: Classification and Information Management Protocols.* Ministry for the Environment, Wellington, New Zealand.

Ministry for the Environment/Ministry of Health (1997). *Health and Environmental Guidelines for Selected Timber Treatment Chemicals*. Ministry for the Environment and Ministry of Health, Wellington, New Zealand.

Ministry of Health (1995). *Guidelines of Drinking-water Quality Management for New Zealand*. Ministry of Health, Wellington, New Zealand.

Additional Information

Internet resources

The following Internet resources are given to assist with determining the parameters associated with toxicity and mobility.

ATSDR Minimum Risk Levels (MRLs)

The United States Agency for Toxic Substances and Disease Registry have developed minimum risk levels (MRLs). An MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure. These substance-specific estimates, which are similar to the US EPA's RfD values, are intended to serve as screening levels to be used by ATSDR health assessors and other responders to identify contaminants and potential health effects that may be of concern at hazardous waste sites. MRLs are derived for acute (1–14 days), intermediate (> 14–364 days), and chronic (365 days and longer) exposure durations, and for the oral and inhalation routes of exposure.

http://www.atsdr.cdc.gov/mrls.html

IRIS Substance List

The Integrated Risk Information System (IRIS), prepared and maintained by the US EPA, is an electronic database containing information on human health effects that may result from exposure to various chemicals in the environment. IRIS was initially developed for EPA staff in response to a growing demand for consistent information on chemical substances for use in risk assessments, decision-making and regulatory activities. The information in IRIS is intended for those without extensive training in toxicology, but with some knowledge of health sciences.

http://www.epa.gov/iris/subst/

Pennsylvania's Land Recycling Program Technical Guidance Manual

The Department of Environmental Protection, Bureau of Land Recycling and Waste Management, developed this manual to assist remediators in satisfying the requirements of the Land Recycling and Environmental Remediation Standards Act (Act 2 of 1995). Tables provided include K_{oc} and K_d values.

http://www.dep.state.pa.us/dep/deputate/airwaste/wm/landrecy/MANUAL/anchor86714

http://www.dep.state.pa.us/dep/deputate/airwaste/wm/landrecy/MSCs/Table_5A.pdf

http://www.dep.state.pa.us/dep/deputate/airwaste/wm/landrecy/MSCs/Table_5B.pdf

IPCS INCHEM – Environmental Health Criteria Monographs

IPCS INCHEM is produced through co-operation between the International Programme on Chemical Safety (IPCS) and the Canadian Centre for Occupational Health and Safety (CCOHS). IPCS INCHEM directly responds to one of the Intergovernmental Forum on Chemical Safety (IFCS) priority actions to consolidate current, internationally peer-reviewed chemical safety-related publications and database records from international bodies, for public access.

http://www.inchem.org/pages/ehc.html

The Extension TOXicology NETwork (EXTOXNET)

The EXTOXNET InfoBase provides a variety of information about pesticides.

http://ace.orst.edu/info/extoxnet/

UNEP Chemicals

Inventory of Information Sources on Chemicals. Compiled by the United Nations

http://www.chem.unep.ch/irptc/invent/igo.html

Appendix A: RSS Template

Template for **Risk Screening System**

Site:

Assessment Type:

Site Type (HAIL):

Comments:

Date:

Assessor:

PATHWAY RISK: - -

surface water - groundwater - direct contact

SITE RISK:

Ranges for risk ranking

High	>0.4 to 1
Medium	>0.02 to <0.4
Low	0 to <0.02

Aquifer Type:

NOTES

- RSS Document should be consulted prior to using this template
- To manually calculate the Site Risk, multiply each parameter for the individual receptor pathways.
- This template will not calculate the Risk until "Site" information is entered
- Place a 'tick' in the small boxes if information is not known. ☑
- Links to assistance for calculating toxicity and mobility parameters are listed on the "References" worksheet
- 'na' against any of Toxicity, Quantity or Mobility will result in all these values being bypassed in that pathway in calculating the score. A numerical value of the score is returned as a "Special Case" for comparing sites of similar types. A ranking is not calculated.

Surface Water Exposure Pathway

Value | Comments

HAZARD

Toxicity
- 0.2 = Low
- 0.6 = Med
- 1 = High
- na = bypass substance

Extent/Quantity
- 0.4 = Small
- 0.7 = Medium
- 1 = Large
- na = bypass substance

Mobility, when released
- 0.3 = Low
- 0.7 = Medium
- 1 = High
- na = bypass substance

PATHWAY

Containment
- 0.2 = Full
- 0.7 = Medium
- 1 = None

Direct or Sediment Runoff/Flood Potential
- 0.2 = Low
- 0.6 = Medium
- 1 = High

RECEPTOR

Water use
- 0.2 not used / industrial
- 0.7 irrigation
- 0.7 stockwater
- 0.7 significant waterway
- 1 contact recreation
- 1 domestic

Surface Water Risk:

Score:

Groundwater Exposure Pathway

Value | Comments

HAZARD

Toxicity
- 0.2 = Low
- 0.6 = Med
- 1 = High
- na = bypass substance

Extent/Quantity
- 0.4 = Small
- 0.7 = Medium
- 1 = Large
- na = bypass substance

Mobility, when released
- 0.3 = Low
- 0.7 = Medium
- 1 = High
- na = bypass substance

PATHWAY

Containment
- 0.2 = Full
- 0.7 = Medium
- 1 = None

Thickness of low permeability layer over aquifer
- 0.4 = >15m low perm.
- 0.7 = 5m low perm.
- 1 = Unconfined

Distance to user/aquifer type

RECEPTOR

Water use
- 0.2 not used
- 0.3 significant waterway
- 0.7 irrigation
- 0.7 stockwater
- 1 domestic / potable

Groundwater Risk:

Score:

Direct Contact Exposure Pathway

Value | Comments

HAZARD

Toxicity
- 0.2 = Low
- 0.6 = Med
- 1 = High
- na = bypass substance

Extent/Quantity
- 0.4 = Small
- 0.7 = Medium
- 1 = Large
- na = bypass substance

Mobility, when released
- 0.3 = Low
- 0.7 = Medium
- 1 = High or at surface
- na = bypass substance

PATHWAY

Containment
- 0.2 = Full
- 0.7 = Medium
- 1 = None

Surface Cover
- 0.3 = No access/paved
- 0.8 = Limited access
- 1 = No limit to access

Soil permeability
- 0.3 = Low, e.g. clay
- 0.8 = Medium
- 1 = High, e.g. silty sand

Depth to Hazard
- 0.5 = >3m
- 0.8 = 2m
- 1 = >1m

RECEPTOR

Land use
- 0.2 parks, recreation
- 0.4 maintenance workers
- 0.5 industrial / commercial
- 0.5 secondary schools
- 1 agricultural
- 1 residential
- 1 pre-/primary schools

Direct Contact Risk:

Score:

Appendix B: Hazardous Activities and Industries List

The following list is an abridged version of the Hazardous Activities and Industries List (HAIL) taken from Ministry for the Environment, 2004. That document should be consulted for the full descriptions and most current version. The hazardous substances have been taken mainly from Table I1 in AS 4482.1-1997, *Guide to Sampling and Investigation of Potentially Contaminated Soil. Part 1: Non-volatile and semi-volatile compounds*, and *Potentially Contaminating Activities, Industries and Landuses* (Department of Environmental Protection, Government of Western Australia, 2001). Other substances have been added to the list based on the experience of New Zealand contaminated site practitioners.

Activity or industry	Hazardous substances
1. Abrasive blasting – carrying out abrasive blast cleaning (other than cleaning carried out in fully enclosed booths) or disposing of abrasive blasting material	Heavy metals, iron
2. Acid/alkali plant, formulation and bulk storage	Mercury; sulphuric, hydrochloric and nitric acids; sodium and calcium hydroxide
3. Agrichemical spray contractor's premises used for filling and washing out tanks for commercial agrichemical application	Arsenic, lead, copper, organic pesticides
4. Airports – fuel storage, workshops, washdown areas, stormwater run-off from hardstanding	Hydrocarbons, metals
5. Analysts – commercial analytical laboratory sites	Solvents, acids, mercury
6. Asbestos products production and disposal; also sites with buildings containing asbestos products known to be in a deteriorated condition	Asbestos
7. Asphalt or bitumen manufacture or bulk storage – manufacturing asphalt or bitumen, or bulk storage of these products, other than at a single-use site used by a mobile asphalt plant	Petroleum hydrocarbons, PAHs
8. Battery manufacture or recycling – assembling, disassembling, manufacturing or recycling batteries (other than storing batteries for retail sale)	Heavy metals (lead, mercury, zinc, cadmium, nickel, antimony, silver, manganese), sulphuric acid
9. Brake lining manufacturers, repairers and recyclers	Asbestos, copper
10. Cement or lime manufacturing – manufacturing cement or lime from limestone material using a kiln and storing wastes from the manufacturing process	Lime, calcium hydroxide, alkalis
11. Cemeteries	Nitrates, lead, formaldehyde, biological hazards
12. Chemical manufacture and formulation and bulk storage such that land-use consent is required	Wide range of organic and inorganic compounds – see AS 4482.1, Table II
13. Coal and coke yards	PAHs
14. Concrete manufacture and bulk cement storage	Cement, calcium hydroxide, alkalis
15. Defence works and defence establishments, including ordinance storage and training areas where live firing is carried out	Explosives, lead, copper, antimony (firing ranges), solvents and metals (workshops), hydrocarbon storage
16. Drum and tank reconditioning or recycling	Wide range of chemicals from drums
17. Dry-cleaning plants – restricted to premises where dry cleaning is carried out and solvents are stored	Trichloroethylene, 1,1,1-trichloroethane, perchloroethylene, carbon tetrachloride, VOCs

Activity or industry	Hazardous substances
18. Electrical transformers – manufacturing, repairing or disposing of electrical transformers or other heavy electrical equipment	PCBs, hydrocarbons, copper, tin, lead, mercury
19. Engine reconditioning – use of solvents and degreasers	Solvents, hydrocarbons, heavy metals
20. Explosive production or bulk storage	Acetone, nitric and sulphuric acid, ammonium nitrate, fuel oil, PCP, nitroglycerine, lead, mercury, copper, aluminium, silver, sodium hydroxide
21. Fertiliser manufacture – manufacturing or bulk storage of agriculture fertiliser	Calcium phosphate, calcium sulphate, copper chloride, sulphur, sulphuric acid, molybdenum, selenium, boron, cadmium, nitrates, ammonia
22. Foundry operations – commercial production of metal products by injecting or pouring molten metal into moulds and associated activities	Metals (particularly iron, aluminium, lead, zinc, copper, tin, nickel, chromium, and oxides, chlorides, fluorides and sulphates of these), acids, coke, fuel oil
23. Gasworks – manufacture of town gas from coal or oil feedstocks	PAHs, phenolics, BTEX, metals (particularly arsenic, lead, copper, chromium), cyanide compounds, sulphides and sulphates, thiocyanates, ammonia, nitrates, coke
24. Gun, pistol or rifle ranges	Metals – lead, antimony, copper, zinc, tin, nickel
25. Iron and steel works	BTEX, phenolics, PAHs, metals and oxides of iron, nickel, copper, chromium, magnesium and manganese
26. Landfill sites	Hydrocarbons, BTEX, PAHs, metals, organic acids, landfill gas
27. Livestock dip or spray race operations	Arsenic, organochlorines and organophosphates, carbamates, and synthetic pyrethroids
28. Market gardens, orchards, glass houses or other areas where the use of persistent agricultural chemicals occurred	Arsenic, lead, copper, mercury, organochlorines and organophosphates, carbamates, and synthetic pyrethroids
29. Metal treatment or coating – including polishing, anodising, galvanising, pickling, electroplating, heat treatment using cyanide compounds and finishing; curing works or commercially finishing leather	Metals (zinc, aluminium, cadmium, chromium, lead, copper, tin), acids (sulphuric, nitric, hydrochloric, phosphoric), sodium hydroxide, solvents and degreasers, cyanide
30. Mining and extractive industries and mineral processing – including chemically or physically extracting metalliferous ores, exposure of faces or release of groundwater containing hazardous contaminants, and storing hazardous wastes, including waste dumps and tailings dams, but not gravel extraction	Arsenic, mercury, cyanides, sulphides, metals – also workshop activities, fuel storage
31. Motor vehicle workshops	Hydrocarbons, PAHs, solvents, metals
32. Paint manufacture and formulation	Solvents, resins, heavy metals

Activity or industry	Hazardous substances
33. Pest control – commercially operating premises (or former pest destruction board, now regional council sites) where storage and preparation of pesticide occurs, including preparation of poisoned baits and filling or washing of tanks	Arsenic, cyanide, strychnine, mercury, phosphorus, 1080
34. Pesticide manufacture (including animal poisons, insecticides, fungicides and herbicides) – commercially manufacturing, blending, mixing or formulating pesticides	Wide range of insecticides, herbicides and fungicides, including arsenic, lead, mercury, copper, tin, chromium, organochlorines, organonitrogens, organophosphates, acid herbicides, dioxin, carbamates
35. Petroleum or petrochemical industries or storage, including oil production and operating a petroleum depot, terminal, blending plant or refinery, retail or commercial refuelling facility, and facilities for recovery, reprocessing or recycling petroleum-based materials and bulk storage above and below ground	Hydrocarbons, including BTEX, PAHs, solvents, lead
36. Pharmaceutical manufacture – commercially manufacturing, blending, mixing or formulating pharmaceuticals, including animal remedies	Solvents
37. Port activities – including dry docks and ship and boat maintenance facilities	Metals, paint residues (tin, lead), fuel storage
38. Power stations and switchyards	PCBs , asbestos, metals (in fly ash), water treatment chemicals (thermal stations)
39. Printing – commercial printing, using metal type, inks and dyes, or solvents	Solvents, acids, alkalis, heavy metals
40. Railway yards – operating a railway yard including goods-handling yards, workshops, refuelling facilities and maintenance areas	Hydrocarbons, heavy metals, solvents
41. Sawmills – use of antisapstain chemicals during milling	Antisapstain fungicides, PCP, hydrocarbons
42. Scrap yards – operating a scrap yard including automotive dismantling or wrecking yard or scrap metal yard	Metals, hydrocarbons, solvents
43. Service stations	Hydrocarbons, lead, copper
44. Smelting or refining – fusing or melting metalliferous ores or refining the metal	Metals and oxides, fluorides and chlorides thereof
45. Tannery, fellmongery or hide curing – operating a tannery or fellmongery or hide-curing works or commercially finishing leather	Chromium, manganese, copper, ammonia, sulphides, acids, sodium hydroxide, lime
46. Transport depots	Hydrocarbon fuels, metals in workshops
47. Storage tanks and drum storage for fuel, chemicals and liquid waste	Wide range of chemicals, biological hazards
48. Waste storage, treatment and/or disposal including land disposal of wastes, but not the use of biosolids as soil conditioners	Depends on type of waste – biological hazards (bacteria, viruses), metals, PAHs, semi-volatile organic compounds, solvents
49. Wood treatment and preservation and bulk storage of treated timber	PCP, copper, arsenic, chromium, boron organo-tin, PAHs and phenolics (creosote), organochlorine pesticides
50. Wool, hide and skin merchants (eg, drying, scouring)	
51. Any other facility or activity that stores, uses or disposes of hazardous substances in sufficient quantity that intentional or accidental discharge of the substance could be a risk to human health or the environment	

Appendix C: Toxicity Guidelines

The toxicity guidelines in Table C1 have been derived on the basis of ADI values for the substances listed. In accordance with section 4.2.1, the substances that have an ADI of ≤ 0.02 mg/kg/day or are carcinogenic are high-concern contaminants. Substances with an ADI between 0.02 and 0.2 mg/kg/day are medium-concern contaminants, and substances with an ADI greater than 0.2 mg/kg/day are low-concern contaminants.

Table C1: Examples of contaminants with high, medium and low concern for human health – soil ingestion

High-concern contaminants	Medium-concern contaminants	Low-concern contaminants
Aldrin	Boron	Chromium III
Arsenic	Cobalt	Iron
Benzene	Copper	Zinc
Benzo(a)pyrene	Fluoride	
Chlordane	Formaldehyde	
Chromium VI	Glyphosate (Roundup)	
Cyanide and compounds	Methanol	
DDT	Permethrin	
Diazinon	Phenol	
Dieldrin	Styrene	
2,4-Dichlorophenoxyacetic Acid (2,4-D)	Tin and compounds	
Dioxin		
Endrin		
Ethylbenzene		
Lead		
Lindane		
Malathion		
Mercury		
Naphthalene		
Nickel		
Pentachlorophenol		
Polychlorinated biphenyls (PCBs)		
Tetrachloroethane		
Tetrachloroethylene (PCE)		
Trichloroethylene (TCE)		
Toluene		
Vinyl chloride		
Xylenes		