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Guidance

LCRM: Stage 1 risk assessment

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This publication is available at <https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm/lcrm-stage-1-risk-assessment>

You can only do a land contamination risk assessment if you are a competent person (<https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm/lcrm-before-you-start#competent>).

You will need to:

- identify the reasons for doing the risk assessment
- identify potential contaminant linkages
- assess and evaluate the risk to establish whether there is an unacceptable risk

Use a tiered approach to risk assessment. There are 3 tiers.

1. Preliminary risk assessment – first tier of risk assessment that develops the initial conceptual site model to establish whether there are any potentially unacceptable risks.
2. Generic quantitative risk assessment – uses generic assessment criteria and assumptions to estimate risk.
3. Detailed quantitative risk assessment – uses detailed site-specific information to estimate risk.

Technical approach to risk assessment

You must follow these steps for each tier of risk assessment.

1. Identify the hazard – establish contaminant sources.
2. Assess the hazard – use a source-pathway-receptor (S-P-R) linkage approach to find out if there is the potential for unacceptable risk.
3. Estimate the risk – predict what degree of harm or pollution might result and how likely it is to occur by using the tiered approach to risk assessment.
4. Evaluate the risk – decide whether a risk is unacceptable.

The meaning of the terms are:

- hazard – a property or situation that in particular circumstances could lead to harm or pollution
- risk – a combination of the probability, or frequency of occurrence of a defined hazard and the magnitude of the consequences of the occurrence
- risk assessment – the formal process of identifying, assessing and evaluating the health and environmental risks that may be associated with a hazard
- risk management – the formal process to identify, assess and determine the risks, and to select and take action to mitigate them

Source-pathway-receptor

Use a S-P-R approach. The meaning of the terms are:

- source – a contaminant or pollutant that is in, on or under the land and that has the potential to cause harm or pollution
- pathway – a route by which a receptor is or could be affected by a contaminant

- receptor – something that could be adversely affected by a contaminant, for example a person, controlled waters, an organism, an ecosystem, or Part 2A receptors such as buildings, crops or animals

In this guide:

- the terms source, pollutant and contaminant have the same meaning
- we refer to S-P-R linkages as contaminant linkages

During the risk assessment stage we use 'potential contaminant linkages' until they are confirmed. From the options appraisal stage onwards we refer to them as 'relevant contaminant linkages'.

Pathways will be specific to the receptor type. For example, they could be:

- ingestion, inhalation, dermal contact for human health receptors
- infiltration and contaminant migration through permeable strata such as the unsaturated zone for groundwater
- a secondary pathway from groundwater contamination to surface water
- migration of ground gases and vapours such as permanent gases, landfill gas and volatile hydrocarbons into buildings
- direct contact and uptake by plants

Risk assessment evaluation criteria

Evaluate the risk using risk assessment evaluation criteria together with a detailed knowledge of the conceptual site model.

You will develop an initial conceptual site model in the preliminary risk assessment. Refine and update it as you progress through LCRM.

Risk assessment evaluation criteria are the parameters used to judge whether particular harm or pollution needs further assessment or is unacceptable. Any evaluation criteria you use must:

- be relevant to your site
- relate to the type of contaminants and receptors you are dealing with

The exact choice of evaluation criteria will depend on:

- the reasons for doing the risk assessment and the regulatory context such as Part 2A
- the conceptual site model and potential contaminant linkages
- any criteria set by regulators
- any advisory requirements such as from Public Health England
- the degree of confidence and precaution required to judge whether a risk is unacceptable
- how you have used or developed more detailed assessment criteria in further tiers of risk assessment
- the availability of robust scientific data

- how much is known – for example, about the pathway and how the contaminants affect receptors
- any practical reasons, such as being able to measure or predict against the criteria

Evaluate the risks

For preliminary risk assessment, you will evaluate the risks qualitatively.

If you progress to a generic or detailed quantitative risk assessment, use evaluation criteria to judge whether particular harm or pollution needs further assessment or is unacceptable. You will need to collect detailed investigation data to support the use of evaluation criteria.

Evaluation criteria include generic assessment criteria and detailed site-specific assessment criteria.

For example, evaluation criteria for the risk to human health from exposure to contaminants are often based on direct intakes through pathways such as ingestion and inhalation. In this context, generic assessment criteria and site-specific assessment criteria are the levels in soil above which may present an unacceptable risk of harm to human health. The evaluation criteria will take into account different land uses and the type and sensitivity of the human health receptor.

If the assessment criteria are exceeded, you will need to evaluate if that level of risk is acceptable and whether further assessment is needed.

You can also use evaluation criteria directly. For example, you may use a drinking water standard (DWS) to evaluate whether the predicted level of a contaminant in groundwater at a compliance point is acceptable.

It is important that you understand any underlying assumptions, uncertainties and limitations of the evaluation criteria. Take these into account when you interpret the results of your generic or detailed quantitative risk assessment.

Examples of evaluation criteria include:

- category 4 screening levels (C4SLs)
- human health toxicological assessment of contaminants in soil (SR2) (<https://www.gov.uk/government/publications/human-health-toxicological-assessment-of-contaminants-in-soil>) tolerable daily intakes and index doses
- site-specific assessment criteria derived using remedial targets methodology (RTM) and a regulatory compliance point
- DWSs
- environmental quality standards (EQSs)
- ecosystem end-points which take into account the ecological value of a site – for example, used under Part 2A for assessing significant harm to ecosystems
- other sources of generic assessment criteria developed by industry

To find more detailed technical guidance see INFO-RA: risk assessment (<https://www.claire.co.uk/information-centre/water-and-land-library-wall>) on the CL:AIRE Water and Land Library.

Tier 1: Preliminary risk assessment

You must always start with a preliminary risk assessment. This will establish whether there are any potentially unacceptable risks arising from contamination at the site.

To complete a preliminary risk assessment you need to:

- define the overall site objectives
- do a desk study and site walkover
- develop an initial conceptual site model
- identify potential contaminant linkages
- decide whether to do an optional exploratory investigation
- assess the risks qualitatively and update the conceptual site model
- decide what further action is needed
- produce a preliminary risk assessment report

Define the overall site objectives

You must understand the reason for doing the assessment from the person who has commissioned it. This could be the:

- regulator
- landowner
- potential purchaser
- developer
- 'appropriate person' for Part 2A

You will need to establish the level of technical confidence needed, for example if it is:

- low, medium or high risk
- a preliminary or comprehensive assessment

You must understand the scope of assessment required, for example:

- a local authority may require a limited assessment because the site is of a lower priority than other Part 2A sites in their inspection strategy
- developers may require a more detailed assessment to meet planning conditions
- the assessment of a former industrial site for redevelopment as part of a planning application may have a different scope than one carried out for valuation purposes

Possible overall objectives for the site could be to:

- meet regulatory requirements or to anticipate regulatory action
- assess the site for Part 2A
- ensure the site is suitable for redevelopment
- take voluntary action to manage the risks
- assess the site to support funding decisions

- assess the site to comply with a permit or surrender a permit
- get a valuation, for example for insurance, sale or transfer purposes or to address any liability issues
- evaluate any previous assessment of the site

You will need to:

- know the required timescales, for example, if there is an immediate, medium or long term risk
- understand any time or cost constraints

Consider sustainability

From the outset you can consider sustainability. For example, you can use the Sustainable Management Practices (SMPs) (<https://www.claire.co.uk/projects-and-initiatives/surf-uk>) from Sustainable Remediation Forum UK (SuRE-UK) on the CL:AIRE website. This can help you to identify options to minimise the environmental, social and economic impact of the risk assessment stage.

You can also consider how climate change might impact your site.

Take this into account in your risk assessment and for any site investigation.

For further information see sustainability (<https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm/lcrm-before-you-start#sustainability>) in LCRM: Before you start.

Collect information for the preliminary risk assessment

You will need to collect current and historical information about the site.

You can do this through:

- a desk study
- a site walkover
- an optional exploratory investigation

Use this information to:

- interpret historical, archived and current information to establish the location of previous site activities
- understand the environmental setting of the site
- identify areas or zones that may contain distinct and different types of contamination
- identify potential contaminant linkages
- identify the types of contaminants likely to be present such as ground gases and vapours, solvents, metals
- identify any potential health and safety requirements such as immediate risks to human health from ground gases and vapours or unexploded ordnance that could cause asphyxiation or explosion
- develop an initial conceptual site model

- scope out the likelihood and requirements of a detailed investigation if you progress to the next tier or stage

For detailed guidance on preliminary risk assessment see INFO-RA1: risk assessment – preliminary (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/183-risk-assessment-preliminary-info-ra1>) on the CL:AIRE Water and Land Library.

You can also find detailed information in these [BSI](#) publications:

- BS 10175: Investigation of potentially contaminated sites – code of practice (<https://shop.bsigroup.com/ProductDetail?pid=000000000030362551>)
- BS 5930: Code of practice for ground investigations (<https://shop.bsigroup.com/ProductDetail?pid=000000000030268443>)
- BS 8576: Guidance on investigations for ground gas – permanent gases and volatile organic compounds (<https://shop.bsigroup.com/ProductDetail?pid=000000000030248027>)

You can use the desk study and site walkover checklists for examples of what you need to find out.

Desk study checklist

From a desk study find out the:

- site ownership and current status
- location, national grid reference
- size of the site – include any plans and maps
- history and general description of the site
- potential for unexploded ordnance
- contact details of relevant organisations

Get details of any:

- pollution incidents, spills, accidents or regulatory actions
- current or past permits, licences or authorisations
- proposed future changes to land use, such as planning applications
- previous investigations or remediation
- chemical or biological information from for example, previous site monitoring reports
- natural background contamination information, such as for radon gas (<https://www.gov.uk/government/collections/radon>), if available
- audit reports that may have been done

Also find out the:

- location of historical landfill sites (<https://data.gov.uk/dataset/17edf94f-6de3-4034-b66b-004ebd0dd010/historic-landfill-sites>)

- details of any reviews of coal or other mining related contamination hazards – current or historic
- presence or proximity of sensitive ecological receptors such as Special Protection Areas – to find out, you can use Natural England’s MagicMap (<https://magic.defra.gov.uk/MagicMap.aspx>)
- location of any protected areas of countryside (<https://www.gov.uk/check-your-business-protected-area>)
- presence of any archaeological or heritage sites such as scheduled ancient monuments
- details on other specific Part 2A receptors such as property in the form of crops, livestock, buildings

Find out geological, hydrogeological and hydrological information. Include:

- made ground, drift deposits, bedrock
- geological features such as faults
- presence of groundwater aquifers – unconfined, confined or a mixture of both
- the aquifer type (<https://www.gov.uk/government/publications/protect-groundwater-and-prevent-groundwater-pollution/protect-groundwater-and-prevent-groundwater-pollution#geological-characteristics>) – principal, secondary or unproductive strata
- sensitive groundwater locations (<https://www.gov.uk/government/publications/protect-groundwater-and-prevent-groundwater-pollution/protect-groundwater-and-prevent-groundwater-pollution#sensitive-groundwater-locations>) such as source protection zones or safeguard zones
- the vulnerability (<https://www.gov.uk/government/publications/protect-groundwater-and-prevent-groundwater-pollution/protect-groundwater-and-prevent-groundwater-pollution#groundwater-vulnerability>) of the groundwater to pollution
- the likelihood of perched groundwater
- any abstraction points or wells on or close to the site – you must include private water supplies (<https://www.gov.uk/government/publications/protect-groundwater-and-prevent-groundwater-pollution/protect-groundwater-and-prevent-groundwater-pollution#sensitive-groundwater-locations>)
- the presence of and proximity to other controlled waters such as surface water and coastal
- any available water quality information
- information on characteristics such as the likely groundwater flow direction

To find out more about groundwater see the groundwater protection (<https://www.gov.uk/government/collections/groundwater-protection>) document collection.

Unexploded ordnance

If you do not manage the potential risk from unexploded ordnance properly, you risk loss of life or injury.

Under the Construction (Design and Management) Regulations you must identify health and safety hazards and risks. You must assess the potential for the site to contain or have been affected by unexploded ordnance.

Do this ahead of the site walkover and intrusive site investigation. First do a preliminary unexploded ordnance risk assessment to identify if a detailed unexploded ordnance risk assessment is needed. Following the detailed risk assessment you may need to put relevant measures in place.

To find more information on unexploded ordnance see:

- guidance on the risk of unexploded ordnance (<https://www.ags.org.uk/item/guidance-on-the-risk-of-unexploded-ordnance-uxo/>) on the AGS website
- C681: Unexploded ordnance. A guide for the construction industry (<https://www.ciria.org/ItemDetail?iProductcode=C681&Category=BOOK>) on the CIRIA website

Site walkover checklist

You can do a site walkover to confirm details of the desk study.

Review the information collected from the desk study. This will allow a better understanding of the features identified and to address any initial uncertainties or unknowns.

You must consider health and safety issues before doing the site walkover.

Record and describe information such as the:

- current use and status of the site
- general condition of site and surrounding land use
- presence of surface staining and odours
- topography and surface condition – open ground, hardstanding and other geotechnical or surface features
- local surface water features
- ecology
- presence and type of vegetation
- signs of any vegetation dieback
- presence and extent of any non-native invasive plants such as Himalayan balsam, New Zealand pigmyweed or Giant hogweed
- buildings and below or above ground structures such as fuel tanks
- above and likely below ground services
- access to and security of the site
- presence of any potential off-site receptors
- potential presence of any asbestos cement material within buildings or throughout the site
- communications or discussions with site personnel

To find out more about asbestos, including links to types of surveys, see the Health and Safety Executive (<https://www.hse.gov.uk/asbestos/>) website.

If you suspect or confirm that non-native invasive plants are present you must follow stop invasive non-native plants from spreading (<https://www.gov.uk/guidance/prevent-the-spread-of-harmful-invasive-and-non-native-plants>) before you treat, bury, burn or dispose of them.

You can take photographs and consider the use of unmanned aerial vehicles (drones) for site reconnaissance.

Record the details of the potential contaminant linkages and their effects. Include the:

- type, extent, location and behaviour
- information on site drainage and other man-made potential pathways
- type of receptor you are dealing with – for example, human health, controlled waters, ecology or property
- characteristics of the people and the environment potentially affected by the contaminants

Use this information, combined with the overall site objectives you have set for the site, to identify potential contaminant linkages and develop your initial conceptual site model.

Identify potential contaminant linkages

Use a S–P–R approach.

A contaminant linkage must be present for there to be a S–P–R relationship. Without a linkage, there is not a risk – even if a contaminant is present.

Find out if there are one or more linkages and how each is related. For example:

- the same contaminant may be linked to 2 or more types of receptor
- different contaminants may affect the same receptor
- a new linkage may arise by changes over time, such as ongoing migration of contaminants or a change of land use

Conceptual site model

Use the information you have collected to develop an initial conceptual site model.

A conceptual site model is a representation of the characteristics of the site. It shows the possible relationships between contaminants, pathways and receptors.

It will form the basis of your initial assessment and all future decisions as you progress through LCRM.

You can present a conceptual site model in different ways, such as a:

- written description of the site
- tabular or matrix description
- drawing or other diagrammatic illustration

You may combine one or more of these formats.

For examples of different types of conceptual site model you can use BS EN ISO 21365 Soil quality – Conceptual site models for potentially contaminated sites (<https://shop.bsigroup.com/ProductDetail?pid=000000000030364954>).

Show:

- contaminant linkages – presence and relationship between contaminants, preferential pathways and receptors
- the subsurface – geology and hydrogeology
- more detailed information as it becomes available such as complex flow regimes and solute transport mechanisms

You can also use the conceptual site model to work out and show:

- what risks may result from the identified contaminant linkages
- uncertainties and gaps in information and any further assessment needed to address them
- any requirement for remediation

You can use it to communicate and convey complex contamination to stakeholders, non-specialists, members of the public and regulators.

Update the conceptual site model as you progress through LCRM. It is an iterative process. You can do:

- an intrusive site investigation to test and refine it
- monitoring to validate it

You can also use:

- detailed geological information such as the thickness of made ground, presence of natural and superficial deposits, depth to bedrock, presence of faults
- detailed hydrogeological information such as hydraulic gradient, flow direction, depth to water table, hydraulic conductivity
- it to address any uncertainties
- it to identify potentially different areas (or zones) of a site, based on differing ground conditions, potential contamination and past, present and future uses

To find detailed information on conceptual site models see INFO-RA1: risk assessment – preliminary (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/183-risk-assessment-preliminary-info-ra1>) on the CL:AIRE Water and Land Library.

Ground gases and vapours

Ground gases and vapours can pose a short and long term risk to human health and other receptors.

Understand the potential for gases in and around the site. Consider the:

- short term risk of asphyxiation or toxicity
- risk of fire or explosion
- long term risk to human health
- risk to other receptors such as ecosystems, groundwater, surface water, the atmosphere, buildings and structures

The principal types of gases and vapours include:

- permanent gases such as hydrogen, methane, carbon dioxide and carbon monoxide
- volatile organic compounds (VOCs) such as toluene, benzene, trichloroethene and its daughter products
- inorganic vapours such as mercury

Some of these may occur naturally such as from Coal Measures geology and old mine workings. They may also result from land contamination, volatilisation, spills and leaks or from waste deposits such as a landfill.

To find further information on ground gases and vapours see INFO-RA2-4: assessing risks associated with gases and vapours (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/212-assessing-risks-associated-with-gases-and-vapours-info-ra2-4>) on the CL:AIRE Water and Land Library.

You can also find more detailed guidance in:

- BS 8485: Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings (<https://shop.bsigroup.com/ProductDetail?pid=000000000030377237>)
- BS 8576: Guidance on investigations for ground gas – permanent gases and volatile organic compounds (<https://shop.bsigroup.com/ProductDetail?pid=000000000030248027>)
- CIRIA C665: Assessing risks posed by hazardous ground gases to buildings (<https://www.ciria.org/ItemDetail?iProductCode=C665&Category=BOOK&WebsiteKey=3f18c87a-d62b-4eca-8ef4-9b09309c1c91>)
- CIRIA C735: good practice on the testing and verification of protection systems for buildings against hazardous ground gases (<https://www.ciria.org/ItemDetail?iProductcode=C735&Category=BOOK>)

Exploratory investigation

You can decide to do an exploratory investigation.

At this tier of risk assessment an exploratory investigation is a limited investigation. It can be intrusive or non-intrusive. The aim is to:

- reduce uncertainty
- update the initial conceptual site model

- provide information to support any future detailed investigation

For ground gases and vapours if you do an exploratory investigation or plan for a future detailed investigation you will need to:

- review the potential health and safety requirements
- provide suitable information for the design of the investigation and ground gas survey

For more information on exploratory investigation see the phases of investigation in the intrusive site investigation section.

Assess the risks

For a preliminary risk assessment you assess the risks qualitatively to decide whether particular harm or pollution is unacceptable. You need to base these on the:

- overall site objectives
- qualitative assessment criteria
- type of receptor you are dealing with such as human health, controlled waters, ecology or property

If appropriate, you can use a risk classification matrix to do qualitative screening to see what further action may be required.

You must base your assessment on the potential severity that the risk poses to the receptors against the likelihood of it happening.

You can find an example of a risk classification matrix in table 1.8 in the guidance for the safe development of housing on land affected by contamination

(<https://webarchive.nationalarchives.gov.uk/20140328111055/http://www.environment-agency.gov.uk/static/documents/Leisure/SR-DPUB66-e-e.pdf>) from the NHBC website.

Check with the relevant regulator if using this approach is acceptable.

See this example of a qualitative assessment for ground gases and vapours using a risk classification matrix.

Following a desk study and site walkover there is evidence of historical use of solvents and illegal waste deposits on a former industrial site. The site is going to be redeveloped as residential. The site is underlain by Coal Measures with evidence of abandoned workings.

An initial conceptual site model was developed, potential contaminant linkages were identified and a risk classification matrix was used. The outcome of the qualitative screening assessment was:

- potential sources – degradation and volatilisation of solvents, contaminated soils, geology and made ground, former mine workings, illegal waste deposits, underground storage tanks, spills and leaks
- possible pathways – migration and volatilisation of ground gases and vapours, inhalation, accumulation in confined spaces such as trenches or excavations
- receptors – human health, controlled waters and ecosystems
- probability – likely

- consequence – severe risk classification and justification – high risk
- proposed action – proceed to a generic quantitative risk assessment, design and plan a gas survey as part of a detailed investigation, incorporate health and safety measures

Conclude preliminary risk assessment

You must decide if:

- there are no unacceptable risks and you can exit the process
- more information is needed and you need to proceed to a generic quantitative risk assessment or go direct to a detailed quantitative risk assessment
- there are clear risks and you decide to proceed to the options appraisal stage

If you proceed direct to the options appraisal stage you still need to collect the detailed information required by the generic and detailed quantitative risk assessments. This includes doing an intrusive site investigation.

Your decision may need approval or agreement from the relevant regulator. For example, for a Part 2A obligation, to allow recommendation of or to satisfy a planning condition.

Produce a preliminary risk assessment report

You need to produce a risk assessment report which sets out your findings.

You may decide to use the NQMS (<https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm/lcrm-before-you-start#NQMS>).

Tier 2: Generic quantitative risk assessment

From your preliminary risk assessment you will have identified one or more potential contaminant linkages that need further assessment.

For a generic quantitative risk assessment you will need to:

- define the objectives for this tier of risk assessment
- establish if you can use generic assessment criteria and a standard set of generic assumptions to assess the risks
- do a detailed investigation – this is usually an intrusive site investigation
- confirm which linkages you need to assess
- decide if generic assessment criteria are suitable to use
- assess the risks and update the conceptual site model
- decide what further action is needed
- produce a report

Define the generic quantitative risk assessment objectives

Make sure the overall site objectives you set in the preliminary risk assessment are still valid.

To define your generic quantitative risk assessment objectives consider a range of management, other and site-specific technical factors.

Consider these examples of management and other factors:

- how you will meet any regulatory requirements and reach agreement with stakeholders
- the reasons for doing this tier of risk assessment are clear, as doing it will involve an increase in cost and time
- any constraints on time and cost
- that the expected degree of confidence in the assessment outcome is clear and realistic

Consider these examples of technical factors:

- the complexity of the conceptual site model and the interaction of the site and ground conditions, groundwater, surface water and ground gases and vapours
- the nature of the potential contaminant linkages
- possible combined or cumulative factors of different contaminants interacting with each other
- any potential changes in site circumstances
- any uncertainties or limitations in any previous information collected
- the methods of how you will collect and assess the data to achieve the required level of confidence

Consider how you will communicate the level of risk to regulators, stakeholders and other interested parties.

You may need to explain details of a complex site and its assessment to non-specialists, such as members the public – see communicate the risk

(<https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm/lcrm-before-you-start#communicate>).

Identify appropriate generic assessment criteria

Assess each potential contaminant linkage. You can do this by comparing the contaminant concentrations against appropriate generic assessment criteria.

Generic assessment criteria are screening criteria which are derived using a standard set of generic assumptions. They are designed to be broadly applicable to a wide range of site conditions and exposure scenarios. They must be appropriate and suitable for your site.

Generic assessment criteria:

- relate to the concentration of substances in air, water or soil
- make generic assumptions about the site characteristics, the contaminant, pathway and receptor behaviour
- aim to simplify the risk assessment by using a standard approach
- are used to determine if further risk assessment or more information is required

You may be able to use existing generic assessment criteria or with specialist knowledge derive new ones.

When you use generic assessment criteria consider:

- how they meet the overall site objectives you set in the preliminary risk assessment

- how you will use them to evaluate the risks

You must take into account if they are:

- too conservative – this may result in an unnecessary more detailed risk assessment or remediation
- not conservative enough – this would result in the assessment of the risk being incorrect

They must apply to the:

- type and form of contaminant you are assessing
- relevant media – soil, water, dust, sediments, ground gas, vapour and parameters such as soil type, pH, soil organic matter
- nature and characteristics of the pathway
- land use – for example, human health criteria are typically more stringent for residential end use than for commercial or public open space
- type of receptor

If you cannot use existing or derive new generic assessment criteria you will need to do a detailed quantitative risk assessment or decide to proceed to the options appraisal stage.

Use existing generic assessment criteria

Identify if existing generic assessment criteria are suitable to assess each potential contaminant linkage.

Examples of human health generic assessment criteria include:

- C4SLs (<http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=18341>)
- published soil guideline values (SGVs) (<https://www.claire.co.uk/information-centre/water-and-land-library-wall/44-risk-assessment/178-soil-guideline-values>)
- Society of Brownfield Risk Assessment (SobRA) development of generic assessment criteria for assessing vapour risks to human health from volatile contaminants in groundwater (<https://sobra.org.uk/resources/reports/>) – you will need to be member of SobRA to access this

For human health risk assessment you must use C4SLs if available rather than an SGV. See when you can use SGVs and C4SLs.

Examples of ground gases and vapours generic assessment criteria include:

- gas screening values as defined in CIRIA C665: Assessing risks posed by hazardous ground gases to buildings (<https://www.ciria.org/ItemDetail?iProductCode=C665&Category=BOOK&WebsiteKey=3f18c87a-d62b-4eca-8ef4-9b09309c1c91>)
- exclusion screening distances for assessing vapour intrusion risk – see INFO-RA2-4: assessing risks associated with gases and vapours (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/212-assessing-risks-associated-with-gases-and-vapours-info-ra2-4>) (Lahvis; USEPA) on the CL:AIRE Water and Land Library.

Examples of controlled waters generic assessment criteria include:

- DWSs
- EQSs

For ecology see:

- soil screening values (<https://www.gov.uk/government/publications/soil-screening-values-for-use-in-uk-ecological-risk-assessment>) for assessing ecological risk
- INFO-RA2-5: assessing risks to ecosystems (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/210-assessing-risks-to-ecosystems-info-ra2-5>) on the CL:AIRE Water and Land Library

For emissions to air see air quality limits (<https://uk-air.defra.gov.uk/air-pollution/uk-eu-limits>) and objectives.

You may:

- be able to use other suitable values published by industry or groups
- have to purchase some of these and check with the relevant regulator if they are suitable

If you use a standard intended for a different purpose this could result in conclusions that are too conservative or not conservative enough. For example, you must only use values such as DWS or EQS if their inclusion is relevant to your site, the contaminant linkages and the legislative context.

Use of SGVs and C4SLs

Where an SGV and a C4SL are available for the same contaminant, we expect you to use the C4SL. You can use a published SGV if an alternative, such as a C4SL, has not been developed. For example, you can use the SGV for dioxins.

The published SGVs are available on the CL:AIRE website (<https://www.claire.co.uk/home/news/44-risk-assessment/178-soil-guideline-values?showall=&limitstart=>).

The CL:AIRE website also shows which SGV reports have been withdrawn. You can still refer to these for background information but not use the SGV itself. We are not publishing any new SGVs but we will continue to develop C4SLs.

C4SLs are precautionary compared to the older SGVs. C4SLs have been derived to incorporate a revised toxicological approach and updates to the original exposure model.

You may consider using generic assessment criteria derived by industry. These use the published C4SL, SGV frameworks and the contaminated land exposure assessment (CLEA) model software. For example, generic assessment criteria may have been derived using the toxicological approach to SGV and the exposure modelling approach for C4SL. You need to understand how any generic assessment criteria you intend to use were derived. Check with the relevant regulator if they are suitable.

For guidance on SGVs see Land contamination: using soil guideline values (<https://www.gov.uk/government/publications/contaminated-soil-assessing-risks-on-human-health>) (SGVs).

You can find more information on **C4SLs** on the CL:AIRE website.
(<https://www.claire.co.uk/projects-and-initiatives/category-4-screening-levels>).

Derive new generic assessment criteria

In some cases you may be able to derive new generic assessment criteria.

You will need to use conservative assumptions about the behaviour of each potential contaminant linkage.

If you derive new generic assessment criteria, you must:

- have specialist knowledge and proceed with caution
- develop a standard set of appropriate generic assumptions
- work out what information you need to collect about the linkages, other properties of the site and its setting
- check that they are consistent with others applied to similar linkages
- record the information and assumptions you used to derive them
- set out any requirements for how they will be applied appropriately

You can consider using some models and formulae that are normally used in a detailed quantitative risk assessment. Examples include:

- the **CLEA** (<https://www.gov.uk/government/publications/contaminated-land-exposure-assessment-clea-tool>) tool for risks to human health
- **RTM** (<https://www.gov.uk/government/publications/remedial-targets-worksheet-v22a-user-manual>) spreadsheet model for risks to soil and groundwater
- ConSim (<http://www.consim.co.uk/>) for risks to groundwater

These are however, designed for detailed assessments.

When you derive new generic assessment criteria using these models you must:

- use appropriate and justified information sources for additional parameters such as chemical properties
- keep the assessment generic and understand the limitations at this level of assessment
- check with the relevant regulator if they are suitable

Decide what information you need for generic quantitative risk assessment

Having selected existing or derived new generic assessment criteria, collect relevant information so that you can use them to assess the risks. Use this information to:

- confirm which potential contaminant linkages need to be assessed
- compare the contaminant concentrations from the site investigation against the relevant generic assessment criteria

The information you need to collect will build upon the preliminary risk assessment and will depend on the:

- potential types of contaminants you are assessing

- complexity of the contamination – for example, if there are mixtures of contaminants from multiple sources
- type of receptors you are dealing with
- complexity and scale of the site

You may need to collect more detailed information on:

- contaminants – types, lateral and vertical extent, chemical form, concentrations, potential for contaminant leaching and migration, background levels
- pathways – location, type, number and extent
- nature of pathways – such as direct contact, inhalation or migration
- ground type and geology
- any required parameters such as soil organic matter and pH
- ground gases and vapours
- receptors – location, types, relationship to site, vulnerability to particular substances, existing condition and history

You may need to collect more detailed information on hydrogeological and hydrological properties including:

- depth to water table
- thickness of saturated zone
- presence of perched groundwater
- groundwater chemistry
- hydraulic gradient
- groundwater flow direction and other hydraulic properties
- direction and rate of flow of surface water under low flow (Q95) conditions
- seasonal variations in groundwater table and surface waters
- surface water chemistry

You may also need further information on other site conditions such as:

- any previous investigation or remediation already done
- weather and natural patterns – such as seasonal variations in water levels, tidal impacts and potential for or evidence of previous flooding, climate change implications
- presence of structures and buried services

When you collect data, you can use a wide range of statistical techniques and other approaches to obtain corroborative evidence. This is to make sure the site characterisation data provides the basis for doing the risk assessment.

Use this information to refine the conceptual site model and confirm the contaminant linkages to improve your understanding of the site.

Collect site investigation information

You will need to design and carry out a detailed investigation. This is usually an intrusive site investigation.

Read the guidance given in the intrusive site investigation section.

For sites that we regulate see chemical testing of soils for details of the:

- monitoring certification scheme (MCERTS) requirements
- use of in situ testing and rapid measurement techniques

Confirm contaminant linkages to assess

Use the detailed investigation information to refine your understanding of the contaminant linkages and to update the conceptual site model.

You may:

- find you can rule out some of the contaminant linkages
- need to add some new ones
- investigate or re-evaluate the ones that were ruled out in the preliminary risk assessment

Check if there are any changes in site circumstances that might affect which linkages you will assess.

If you do not have sufficient information to confirm or rule out contaminant linkages then you may need to:

- go back and review the overall site objectives set in the preliminary risk assessment
- collect further information

Assess the risks

Compare the contaminant concentrations from the site investigation against the relevant generic assessment criteria.

Consider:

- how rigid the generic assessment criteria are – for example, if they are advisory screening values or strict limit values
- if the standard set of generic assumptions are representative for the site
- if any exceedance matters and how this will affect your evaluation of the risk – this may need agreement from the regulator
- if concentrations are representative of background conditions – published background concentrations are available from a range of sources including the British Geological Survey (<http://www.bgs.ac.uk/>)
- if there are any uncertainties and limitations
- any additional evidence to support interpretation

You may wish to use a statistical approach – for example see the Professional guidance: Comparing soil contamination data with a critical concentration (2020) (<https://www.claire.co.uk/component/phocadownload/category/9-other-cl-aire-documents%3Fdownload%3D433:gasworks-profile-d-producer-gas-plants>) on the CL:AIRE website.

For groundwater monitoring data, if you are assessing time series data, you can use the groundwater spatiotemporal data analysis tool (GWSDAT).

GWSDAT

The **GWSDAT** can help you visualise and interpret groundwater monitoring data. It is designed to work with simple time-series data for solute concentration and groundwater elevation. It can also plot non-aqueous phase liquid thickness.

For details see **GWSDAT** (<https://www.claire.co.uk/projects-and-initiatives/gwsdat?showall=1>) on the CL:AIRE website.

You can use the results to assess potential contaminant linkages and update the conceptual site model.

Justify how you have evaluated the risks and include this information in your generic quantitative risk assessment report.

Find further information on risk assessment to assess the risks to these specific receptors on the CL:AIRE Water and Land Library:

- INFO-RA2-1: risk assessment – general (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/182-risk-assessment-general-info-ra2-1>)
- INFO-RA2-2: assessing risks to human health (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/209-assessing-risks-to-human-health-info-ra2-2>)
- INFO-RA2-3: assessing risks to the water environment (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/208-assessing-risks-to-the-water-environment-info-ra2-3>)
- INFO-RA2-4: assessing risks associated with gases and vapours (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/212-assessing-risks-associated-with-gases-and-vapours-info-ra2-4>)
- INFO-RA2-5: assessing risks to ecosystems (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/210-assessing-risks-to-ecosystems-info-ra2-5>)
- INFO-RA2-6: assessing risks to buildings and services (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/211-assessing-risks-to-buildings-and-services-info-ra2-6>)

You can also find detailed information in these **BSI** publications:

- BS 10175: Investigation of potentially contaminated sites – code of practice (<https://shop.bsigroup.com/ProductDetail?pid=000000000030362551>)
- BS 5930: Code of practice for ground investigations (<https://shop.bsigroup.com/ProductDetail?pid=000000000030268443>)
- BS EN ISO 15175: Soil quality – characterisation of contaminated soil related to groundwater protection (<https://shop.bsigroup.com/ProductDetail?pid=000000000030338450>)

For ground gases and vapours see:

- CIRIA C665: Assessing risks posed by hazardous ground gases to buildings (<https://www.ciria.org/ItemDetail?iProductCode=C665&Category=BOOK&WebsiteKey=3f18c87a-d62b-4eca-8ef4-9b09309c1c91>)
- BS 8576: Guidance on investigations for ground gas – permanent gases and volatile organic compounds (<https://shop.bsigroup.com/ProductDetail?pid=000000000030248027>)
- BS 8485: Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings (<https://shop.bsigroup.com/ProductDetail?pid=000000000030377237>)

Conclude generic quantitative risk assessment

When you have assessed each potential contaminant linkage and updated the conceptual site model, decide if:

- the assessment has shown the risks are low enough that no further action is needed and you can exit the process
- further assessment, site investigation and monitoring are required to address uncertainties and complete the risk assessment
- there are unacceptable risks and you need to proceed to detailed quantitative risk assessment or direct to the options appraisal stage

If you proceed to options appraisal you may need to collect more detailed information as required by detailed quantitative risk assessment, such as a supplementary investigation.

Your decision may need approval or agreement from the regulator. For example, for a Part 2A obligation, to allow recommendation of or to satisfy a planning condition.

Produce a generic quantitative risk assessment report

You need to produce a generic quantitative risk assessment report which sets out all of your findings.

You may decide to use the NQMS (<https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm/lcrm-before-you-start#NQMS>).

Tier 3: Detailed quantitative risk assessment

You will have identified one or more potential contaminant linkages that need a detailed assessment.

For a detailed quantitative risk assessment:

- define the objectives for this tier of risk assessment
- do a detailed or supplementary investigation
- confirm which linkages you need to assess

- identify or develop tools and criteria such as site-specific assessment criteria
- assess the risks and update the conceptual site model
- decide what further action is needed
- produce a report

Define the detailed quantitative risk assessment objectives

Make sure the overall site objectives you set in your preliminary risk assessment are still valid.

To define your detailed quantitative risk assessment objectives consider a range of management, other and site-specific technical factors. This may involve refining the generic quantitative risk assessment objectives if you did one.

Consider these examples of management and other factors:

- how you will meet regulatory requirements and reach agreement with stakeholders
- the reasons for doing this tier of risk assessment are clear, as doing it will involve an increase in cost and time
- any constraints on time and budget – you may need to phase information collection
- the expertise that may be required due to complex contamination
- the expected degree of confidence in the assessment outcome is clear and realistic

Consider these examples of technical factors:

- the complexity of the site, conceptual site model, ground conditions and processes – you may need to get a more detailed understanding of particular areas or zones of the site
- potential contaminant linkages – you may need to get highly specialist information to assess the complexity, toxicity, effects and characteristics of individual linkages
- the current condition of any groundwater impacts for example, whether a plume is expanding, shrinking or at a steady state
- any combined or cumulative factors – this may require specialist toxicological and environmental fate and transport knowledge
- any potential changes in site circumstances
- any uncertainty of data – such as unexpected monitoring results
- the methods you will use to assess the data to achieve the required degree of confidence

Consider how you will communicate the level of risk to regulators, stakeholders and other interested parties.

You may need to explain details of a complex site and its assessment to non-specialists, such as members of the public – see communicate the risk

(<https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm/lcrm-before-you-start#communicate>).

Decide what information to collect for detailed quantitative risk assessment

The information you will need will depend on the:

- contaminants being assessed
- type of receptors – for example human health, controlled waters, ecosystems, other Part 2A receptors
- complexity of the site – for example, if there are mixtures of contaminants and the potential for degradation products

Build on the information you have collected so far. If you did not do a generic quantitative risk assessment you must see the information requirements for a generic quantitative risk assessment.

For this tier of assessment you will need to get more detailed information on for example, the:

- site characteristics and surroundings
- contaminants and degradation products
- hydrogeological and hydrological properties
- ground gases and vapours
- current or proposed site-specific building parameters

You may also need to get or do:

- site-specific exposure data for example, current and future receptor age classes and exposure frequencies
- sampling of home grown produce
- bioaccessibility testing
- monitoring of indoor air quality
- site-specific parameters for the risk assessment model such as fraction organic carbon and half-lives for degradation
- additional information on the nature of the contaminant, soil, vapour and water matrix

The nature of the contaminant includes:

- chemical type – for example, organic, inorganic, ionic
- toxicity
- concentration, amount and distribution – laterally and vertically
- solid, liquid or gas
- solubility, volatility and density
- potential for biodegradation
- bioavailability and bioaccessibility
- information on changes in source or contaminant properties over time – for example, hydrocarbon weathering, concentration reduction, change in bioavailability
- partitioning behaviour of soil, sediment, water, air or biological factors
- contaminant transport properties including evidence of breakdown products and the potential for the accumulation of daughter and degradation products

The nature of the soil, water and vapour matrix includes:

- physical form and properties – such as particle size

- lateral and vertical distribution of contaminants
- gas and liquid permeability – such as diffusion and preferential pathways
- chemical composition – such as pH, organic matter content, other pollutants, including inhibitors
- physical and chemical stability

Collect detailed site investigation information

If you did not do a generic quantitative risk assessment then you will need to design and carry out a detailed investigation. This is usually an intrusive investigation.

Read the guidance given in the intrusive site investigation section.

For sites that we regulate see chemical testing of soils for details of the:

- MCERTS requirements
- use of in situ testing and rapid measurement techniques

If you have previously done a detailed investigation as part of a generic quantitative risk assessment then you can evaluate the data you collected to:

- address uncertainty and data gaps
- decide if a supplementary investigation is required

Use the site investigation information you have collected to refine the conceptual site model and confirm which potential contaminant linkages you need to assess. You may:

- be able to rule some of them out
- need to add some new ones

Check if there are any changes in site circumstances that might affect which ones you need to assess.

If you have insufficient information to confirm or rule out contaminant linkages then you may:

- have to go back and review the overall site objectives you set in the preliminary risk assessment
- collect further information

Update the conceptual site model with your findings.

Assess the risks

To assess the risks you can:

- do forward modelling
- get detailed information about the receptor
- derive site-specific assessment criteria

Forward modelling

You can use fate and transport models to do forward modelling to:

- predict concentrations at a compliance point to compare with allowable concentrations or generic assessment criteria for example, using **RTM** or **ConSim**
- predict a dose to compare with an allowable dose for example, use the average daily exposure: health criteria value (ADE:HCV) ratio model in **CLEA**

You may wish to use a statistical approach – for example see the Professional guidance: Comparing soil contamination data with a critical concentration (2020) (<https://www.claire.co.uk/component/phocadownload/category/9-other-cl-aire-documents%3Fdownload%3D433:gasworks-profile-d-producer-gas-plants>) on the CL:AIRE website.

Collect information about the receptor

In some cases, you do not always need to derive site-specific assessment criteria or use a risk estimation tool.

You may be able to collect additional information to confirm contaminant linkages. For example, this might include collecting site-specific information on land use or sampling home grown produce to decide whether there is an unacceptable risk.

If there is an unacceptable risk then you can use this additional information to develop remediation criteria in the options appraisal stage.

Derive site-specific assessment criteria

Site-specific assessment criteria are values for concentrations of contaminants derived using risk estimation models such as **CLEA** (<https://www.gov.uk/government/publications/contaminated-land-exposure-assessment-clea-tool>) or **RTM** (<https://www.gov.uk/government/publications/remedial-targets-worksheet-v22a-user-manual>). They are based on detailed site-specific information about the characteristics and behaviour of contaminants.

If you derive site-specific assessment criteria you must have sufficient specialist knowledge and proceed with caution.

Despite the site-specific nature of these assessment criteria, we still expect them to be suitably precautionary, especially in the context of regulatory decisions and agreement.

Site-specific assessment criteria will correspond to how you will evaluate the risks for the site. To derive them you will need detailed site-specific information on the characteristics and behaviour of:

- contaminants
- pathways
- receptors

Find further information on risk assessment to assess the risks to these specific receptors on the CL:AIRE Water and Land Library:

- **INFO-RA2-1: risk assessment – general** (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/182-risk-assessment-general-info-ra2-1>)

- INFO-RA2-2: assessing risks to human health (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/209-assessing-risks-to-human-health-info-ra2-2>)
- INFO-RA2-3: assessing risks to the water environment (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/208-assessing-risks-to-the-water-environment-info-ra2-3>)
- INFO-RA2-4: assessing risks associated with gases and vapours (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/212-assessing-risks-associated-with-gases-and-vapours-info-ra2-4>)
- INFO-RA2-5: assessing risks to ecosystems (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/210-assessing-risks-to-ecosystems-info-ra2-5>)
- INFO-RA2-6: assessing risks to buildings and services (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/211-assessing-risks-to-buildings-and-services-info-ra2-6>)

You can also find detailed information in these **BSI** publications:

- BS 10175: Investigation of potentially contaminated sites – code of practice (<https://shop.bsigroup.com/ProductDetail?pid=000000000030362551>)
- BS 5930: Code of practice for ground investigations (<https://shop.bsigroup.com/ProductDetail?pid=000000000030268443>)
- BS EN ISO 15175: Soil quality – characterisation of contaminated soil related to groundwater protection (<https://shop.bsigroup.com/ProductDetail?pid=000000000030338450>)

For ground gases and vapours see:

- CIRIA C665: Assessing risks posed by hazardous ground gases to buildings (<https://www.ciria.org/ItemDetail?iProductCode=C665&Category=BOOK&WebsiteKey=3f18c87a-d62b-4eca-8ef4-9b09309c1c91>)
- BS 8576: Guidance on investigations for ground gas – permanent gases and volatile organic compounds (<https://shop.bsigroup.com/ProductDetail?pid=000000000030248027>)
- BS 8485: Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings (<https://shop.bsigroup.com/ProductDetail?pid=000000000030377237>)

If you are dealing with ecological receptors you can find detailed information – see INFO-RA2-5: assessing risks to ecosystems (https://www.claire.co.uk/index.php?option=com_content&view=article&id=210&catid=41&Itemid=256) on the CL:AIRE Water and Land Library.

Select a detailed quantitative risk assessment risk estimate tool

For human health you can use the **CLEA**

(<https://www.gov.uk/government/publications/contaminated-land-exposure-assessment-clea-tool>) tool.

We expect that risk assessments for pollution of controlled waters are done in line with the tiered framework set out in the:

- **RTM** (<https://www.gov.uk/government/publications/remedial-targets-worksheet-v22a-user-manual>)
- land contamination groundwater compliance points: quantitative risk assessments (<https://www.gov.uk/guidance/land-contamination-groundwater-compliance-points-quantitative-risk-assessments>)

Other risk estimation tools are available. You will have to purchase some of these. They include:

- RISC-HUMAN
- RBCA toolkit for chemical releases
- ConSim

You can use these detailed quantitative risk assessment tools to derive site-specific assessment criteria, if it is appropriate to do so. They will need detailed site-specific information as input parameters.

Check the model's sensitivity to any particular assumptions. Where appropriate, you can do a model calibration exercise to provide confidence in the predicted model results.

You will also need to evaluate the uncertainties and any limitations to ensure that the site-specific assessment criteria are sufficiently precautionary and conservative.

Check with the relevant regulator if the tool you are planning to use is acceptable.

For groundwater monitoring data, if you are assessing time series data you can use the **GWSDAT** to visualise and interpret it.

Decide if there are unacceptable risks

Consider:

- if any exceedance matters and how this will affect your evaluation of the risk – this may need agreement from the regulator
- if concentrations are representative of background conditions
- if any assumptions used are representative of the site
- any uncertainties and limitations within the assessment
- any additional evidence collected to support interpretation

Understand the sensitivity of the site-specific assessment criteria. You will also need to evaluate any uncertainties to ensure that the site-specific assessment criteria are as representative as possible for the actual site conditions.

Justify how you have evaluated the risks and include this information in your detailed quantitative risk assessment report.

Conclude detailed quantitative risk assessment

When you have assessed each potential contaminant linkage and updated the conceptual site model, decide if:

- the assessment has shown the risks are low enough that no further action is needed and you can exit the process
- further assessment, site investigation and monitoring are required to address uncertainties and complete the risk assessment
- there are unacceptable risks and you need to move to the options appraisal stage

Your decision may need approval or agreement from the regulator. For example, for a Part 2A obligation, to allow recommendation of or to satisfy a planning condition.

Produce a detailed quantitative risk assessment report

You need to produce a detailed quantitative risk assessment report which sets out all your findings.

You may need to submit your detailed quantitative risk assessment risk estimation tool (if possible), input parameters and output reports if requested by the regulator.

You may decide to use the NQMS (<https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm/lcrm-before-you-start#NQMS>).

Intrusive site investigation

As you progress through LCRM you will need to collect and analyse more detailed information about the site.

You may need to excavate trial pits, drill exploratory boreholes and construct gas, vapour and groundwater monitoring wells.

This section provides an overview of what you need to consider for an intrusive site investigation.

If it is not possible to collect all the required information you may have to go back and review the overall site objectives set in the preliminary risk assessment.

For more complex sites, or where piling or penetrative ground improvement methods are proposed (see new pathways), we advise you to consult with the relevant regulator. You may need to discuss the proposals for the site investigation and find out if there are any specific regulatory or reporting requirements.

Non-intrusive investigation

You can use non-intrusive investigation techniques.

These include geophysics, aerial surveys and satellite image analysis. For example, you can use these to help locate below-ground structures or other features such as buried foundations.

However, in many cases this does not negate the need for an intrusive investigation.

Health and safety

An intrusive site investigation presents its own risks and is often closely linked to construction, geotechnical and engineering works. You need to consider health and safety. This is beyond the scope of this document.

As a starting point see for example:

- the Construction (Design and Management) Regulations (<https://www.hse.gov.uk/construction/cdm/2015/index.htm>) and other information on the Health and Safety Executive website
- INFO-PM2: health and safety and quality management (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/191-health-and-safety-and-quality-management-info-pm2>)

You can also refer to Annex C of BS 10175: investigation of potentially contaminated sites – code of practice (<https://shop.bsigroup.com/ProductDetail?pid=000000000030362551>).

See also unexploded ordnance.

Phases of investigation

For an intrusive site investigation you can use a phased approach such as that given in table 1 of BS 10175: investigation of potentially contaminated sites – code of practice (<https://shop.bsigroup.com/ProductDetail?pid=000000000030362551>).

There are 3 phases.

1. Preliminary investigation – which can include an exploratory investigation.
2. Detailed investigation.
3. Supplementary investigation.

Preliminary investigation

A preliminary investigation is a desk study and site walkover – this is done as part of a preliminary risk assessment. It includes an optional exploratory investigation. This can be intrusive, non-intrusive or both.

An exploratory investigation is a limited investigation. Its main aims are to:

- get more details about the site and potential contaminant linkages
- reduce uncertainty
- test and update the conceptual site model
- provide information for any planned detailed investigation

Detailed investigation

A detailed investigation is the main stage of an intrusive investigation. It involves the collection and analysis of soil, groundwater, ground gases and vapours, surface water, other media and in situ testing.

Use a detailed investigation to:

- find out about the nature and extent of contaminants
- test any initial assumptions made in the preliminary risk assessment, address uncertainties and update the conceptual site model
- build on any information collected in an exploratory investigation, if done
- be able to assess the hazards and risks
- provide information for the later stages of LCRM such as to provide data for the selection and design of remedial works

You may need to:

- do separate stages or phases of investigation
- zone the site
- design non-targeted sampling and use statistical methods to assess the data
- do targeted sampling to delineate or confirm an area of contamination detected during an exploratory investigation, if done

Supplementary investigation

After a detailed investigation you may need to do a supplementary investigation. For example, you can use it to:

- address uncertainties
- provide up to date information
- further delineate zones of contamination or plumes
- address or clarify technical matters – for example, to confirm the applicability and feasibility of potential remedial options
- provide additional information when developing the remediation strategy – for example, to design and cost remedial works
- delineate volumes of soil requiring remediation
- provide chemical testing information to classify wastes
- provide information for ongoing or post-remediation monitoring such as groundwater quality and levels or ground gas conditions
- check for any adverse changes in site conditions
- refine and update the conceptual site model

Find detailed information on site characterisation on the CL:AIRE Water and Land Library:

- INFO-SC1 general (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/194-general-info-sc1>)
- INFO-SC2: sampling design (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/181-sampling-design-info-scp2>)
- INFO-SC3: field and laboratory analysis (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/195-field-and-laboratory-analysis-info-sc3>)

- INFO-RA2-4: assessing risks associated with gases and vapours
(<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/212-assessing-risks-associated-with-gases-and-vapours-info-ra2-4>)

Find detailed information for sampling quality of soil and groundwater in the guidance on the design and installation of groundwater monitoring points
(<https://www.gov.uk/government/publications/guidance-on-the-design-and-installation-of-groundwater-quality-monitoring-points>).

You can also find further detailed information in these British Standard Institute (BSI) publications:

- BS 10175: Investigation of potentially contaminated sites – code of practice
(<https://shop.bsigroup.com/ProductDetail?pid=000000000030362551>)
- BS 5930: Code of practice for ground investigations
(<https://shop.bsigroup.com/ProductDetail?pid=000000000030268443>)
- BS 8576: Guidance on investigations for ground gas – permanent gases and volatile organic compounds (http://shop.bsigroup.com/ProductDetail/?pid=000000000030248027&_ga=2.222174747.2050614235.1574236012-208901667.1549440036)

You may also find useful:

- BS 8485: Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings
(<https://shop.bsigroup.com/ProductDetail?pid=000000000030377237>)
- BS ISO 18400: Soil quality sampling series (<https://shop.bsigroup.com/SearchResults/?q=BS+ISO+18400>)
- BS ISO 15800: Soil quality – characterisation of soil with respect to human exposure
(<https://shop.bsigroup.com/ProductDetail?pid=000000000030368502>)
- BS EN ISO 16133: Soil quality – guidance on the establishment and maintenance of monitoring programmes (<https://shop.bsigroup.com/ProductDetail?pid=000000000030352176>)
- BSI Water quality. Sampling series including:
- BS ISO 5667-11: Water Quality, Sampling, Guidance on sampling of groundwaters
(<https://shop.bsigroup.com/ProductDetail?pid=000000000030152313>)
- BS ISO 5667-22: Water Quality, Sampling, Guidance on the design and installation of groundwater monitoring points (<https://shop.bsigroup.com/SearchResults/?q=5667-22>)
- BS EN ISO 5667 – 6: Water Quality, Sampling, Guidance on sampling of rivers and streams (https://shop.bsigroup.com/en/ProductDetail/?pid=000000000030329721&_ga=2.227262941.1309657748.1589182312-208901667.1549440036)

You can use CIRIA 665: assessing risks posed by hazardous ground gases to buildings
(<https://www.ciria.org/ItemDetail?iProductCode=C665&Category=BOOK&WebsiteKey=3f18c87a-d62b-4eca-8ef4-9b09309c1c91>) for the number of monitoring points required, duration of monitoring programme and information on gas risk assessment.

For asbestos see asbestos in soil and construction and demolition materials (<https://www.claire.co.uk/projects-and-initiatives/asbestos-in-soil>).

There may be other guidance you can use.

Practicability, cost, effectiveness, benefits and sustainability

When you collect site information consider all of the following.

1. Practicability.
2. Cost.
3. Effectiveness and benefits.
4. Sustainability.

Practicability

Examples of what to consider include:

- on-site or off-site access
- timeframes and staging requirements
- regulatory, health and safety and other management requirements
- identifying site services and making sure you can avoid them during intrusive investigation
- weather conditions

Cost

Examples of what to consider include:

- total cost against available budget
- if you can justify the cost against the level of risk present
- potential delays as information is collected
- that better quality information could reduce costs
- that poor quality information could increase costs

Effectiveness and benefits

You can consider these examples:

- that the information you collect will be useful and relevant to the aims of the investigation and any other aspects, such as geotechnical design
- that the extent of information will match the requirements for certainty in decision making
- any advantages or disadvantages of using additional or alternative methods, such as non-intrusive geophysical surveys
- any implications of making wrong decisions in the absence of information – for example, failure to establish particular areas of contamination

Sustainability

You can use the Sustainable Management Practices (SMPs) (<https://www.claire.co.uk/projects-and-initiatives/surf-uk>) from ~~SuRE-UK~~ on the CL:AIRE website. This can help you to identify options to minimise the environmental, social and economic impact of the investigation.

Check the quality of the information

The information you collect must be:

- relevant
- sufficient
- reliable
- transparent

Relevant

The information you collect must be relevant and match the site's parameters, particularly the:

- contaminant type
- characteristics of pathways and receptors
- soil type

Sufficient

It is important you consider that:

- a sufficient number of samples are taken for measuring against the assessment criteria for the type of receptor
- the sampling and monitoring points are located and spaced so they are sufficient to define zones

To make sure you meet the required degree of confidence you can use the guidance given in BS 10175: Investigation of potentially contaminated sites – code of practice (<https://shop.bsigroup.com/ProductDetail?pid=00000000030362551>) on sampling densities.

For ground gases and vapours you can use BS 8576: Guidance on investigations for ground gas – permanent gases and volatile organic compounds (<https://shop.bsigroup.com/ProductDetail?pid=00000000030248027>).

Reliable

The information must be reliable and reflect true or likely conditions.

You need to include appropriate quality control checks. Include trip blanks, duplicates and any relevant calibration certificates.

For sites that we regulate see chemical testing of soils for details of the:

- MCERTS requirements
- use of in situ testing and rapid measurement techniques

Transparent

It is important that the information you collect is transparent and the origin is clear. You must:

- record and identify the consequences of any uncertainties and limitations
- put in place mitigation measures to address any unacceptable consequences

When collecting data for risk assessment, you may need to use a wide range of statistical techniques and other approaches to obtain corroborative evidence. See INFO-SC2: sampling design (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/181-sampling-design-info-scp2>) on the CL:AIRE Water and Land Library.

Make sure the site characterisation data are fit for the purpose of risk assessment.

Geotechnical investigation

Your site investigation may be required to inform any geotechnical engineering design element.

Integrating geotechnical investigations with those for contamination, ground gas and other types of investigations is likely to be of benefit for the majority of sites.

You can find more information on this approach in BS 5930: Code of practice for ground investigations (<https://shop.bsigroup.com/ProductDetail?pid=000000000030268443>).

New pathways

Constructing boreholes may introduce new pathways. You may need to do an assessment to decide if boreholes need to be decommissioned to prevent any ongoing risks. Discuss this with the relevant regulator.

Piling and penetrative ground improvement methods are typically deeper than standard foundations. This is likely to increase the risk by creating new pathways. It also has the potential to increase the risk to human health, contaminate groundwater, or to allow migration of ground gases and vapours.

For pollution scenarios see piling into contaminated sites in INFO-RA2-3: assessing risks to the water environment

(<http://webarchive.nationalarchives.gov.uk/20140328084622/http://cdn.environment-agency.gov.uk/scho0202bisw-e-e.pdf>) on the CL:AIRE Water and Land Library.

Piling and penetrative ground improvement methods can also result in significant changes to the conceptual site model, risk assessment, remediation and the subsequent verification of land contamination.

For piling and penetrative ground improvement methods you will need to:

- factor in any decisions made if you are proposing to use them

- keep them under review for the risk assessment, remediation and verification stages

You must contact the relevant regulator if you propose to use these methods. You may need to do a piling risk assessment.

Chemical testing of soils

Use this section to find out the requirements for:

- MCERTS
- in situ testing and rapid measurement techniques

The information in this guidance only applies to the chemical testing of soils for land contamination on sites that we regulate. See the monitoring emissions to air, land and water (MCERTS) (<https://www.gov.uk/government/collections/monitoring-emissions-to-air-land-and-water-mcerts>) requirements for other applications or regimes.

For sites that we do not regulate, discuss any specific requirements with the relevant regulator.

All of your laboratory monitoring data must be derived from methods that are accredited to the MCERTS soil monitoring performance standards (<https://www.gov.uk/government/collections/monitoring-emissions-to-air-land-and-water-mcerts#soil-monitoring-performance-standards>). MCERTS accreditation can also apply to in situ testing and rapid measurement techniques.

You can still use in situ testing and rapid measurement techniques that do not have MCERTS accreditation if you can meet our requirements. See in situ testing and rapid measurement techniques for more details.

MCERTS

MCERTS is the Environment Agency's monitoring certification scheme. It is applicable to the chemical testing of soil. It provides:

- a framework for meeting our quality requirements
- laboratory accreditation based on international standards

The MCERTS standard covers laboratory accreditation to ISO/IEC 17025. Laboratories can be a fixed site or mobile. They can also include organisations that take samples and carry out on-site analysis.

Contact us (<https://www.gov.uk/government/organisations/environment-agency#org-contacts>) for advice if MCERTS is not available or do not apply for specific contaminants.

Using MCERTS will:

- ensure good quality measurements of the contaminants in the soils
- provide confidence that the results you submit are acceptable and reliable
- help you make informed decisions when assessing the potential risk of the soil's contaminants
- support the use of in situ testing and rapid measurement techniques
- support the regulatory decisions we make

You must:

- make sure the chemical analysis results you submit meet **MCERTS** requirements
- check the laboratory doing the analysis has **MCERTS** accreditation for all the parameters you requested
- work with the laboratory to keep complete audit trails of samples
- make sure the audits are available if requested by us

The soil monitoring performance standards

(<https://www.gov.uk/government/collections/monitoring-emissions-to-air-land-and-water-mcerts#soil-monitoring-performance-standards>) guidance explains how to submit chemical test data on potentially contaminated sites. These performance standards do not directly cover sampling. You must make sure your sampling, preserving and transport procedures are appropriate.

You can find further information in BS 10175: Investigation of potentially contaminated sites – code of practice (<https://shop.bsigroup.com/ProductDetail?pid=000000000030362551>).

In situ testing and rapid measurement techniques

For land contamination you can use in situ testing and rapid measurement techniques to:

- improve the quality of the site investigation
- potentially reduce the cost of investigation and remediation
- provide information on characteristics of a site within a timescale that will allow you to make real-time decisions
- improve how you target further sampling for laboratory analysis
- get a better idea of contaminated areas to help develop the conceptual site model
- support other analytical methods

If the rapid measurement technique method has **MCERTS** accreditation we will accept the results without any further laboratory testing.

If the rapid measurement technique method does not have **MCERTS** accreditation provide:

- complementary **MCERTS** accredited laboratory analysis for an appropriate proportion of the results
- evidence of training for those who carry out the on-site measurements
- evidence of quality control and equipment calibration procedures

You will need to reach agreement with us for the appropriate proportion of results that will need **MCERTS** accredited laboratory analysis. This will be a site-specific decision.

Use the quality control and calibration procedures set out in the Framework for the use of rapid measurement techniques in the risk management of land contamination. See INFO-SC3d: Field and laboratory analysis (<https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/195-field-and-laboratory-analysis-info-sc3>) on the CL:AIRE website.

You can also find further information for some of the common types of rapid measurement techniques in Annex F of BS 10175: Investigation of potentially contaminated sites – code of practice (<https://shop.bsigroup.com/ProductDetail?pid=000000000030362551>).

Check with other regulators if the use of rapid measurement techniques is appropriate.

Dealing with uncertainty

All land contamination investigation and analysis involves a level of uncertainty. Every analytical method has benefits and limitations.

You can reduce uncertainty by collecting the same, or complementary data from different sources. For example, by using MCERTS and in situ testing and rapid measurement techniques. Consider the technique or method, how you will use it, the site characteristics and the contaminants present or likely to be present.

The data you collect must be relevant, sufficient, reliable and transparent – see check the quality of the site investigation information.

When we assess the results, we will take into account the entire dataset and use a lines of evidence approach to reach any regulatory decisions.

Field investigation reporting

You will need to report on the findings from the field investigation. See field investigation reporting for further details.

Risk assessment reporting requirements

You must be a competent person (<https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm/lcrm-before-you-start#competent>) to produce risk assessment reports.

You need to report on each tier of risk assessment. You can produce a single report for this stage as long as it contains the correct information and follows the requirements of this guide.

For large, complex sites, or if you are phasing intrusive site investigations you may need to produce individual reports.

Your reports will need to include both factual and interpretative information. Keep factual and interpretive information separate.

You can use these checklists to find out what reports you need to produce and what type of information to include.

You may decide to use the NQMS (<https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm/lcrm-before-you-start#NQMS>).

All risk assessment reports

Include these basic site details:

- site name and address
- site ownership and current status
- location, national grid reference and general description of the site
- site plan
- size of site
- contact details for relevant organisations

Include for example:

- the overall site objectives
- the reasons for doing this tier of risk assessment
- the site characteristics and setting
- details of decisions made
- any consultations with regulators or other appropriate bodies
- what needs to be done, by whom and over what timescale
- details of an exploratory, detailed or supplementary investigation where relevant

Additional information requirements for preliminary risk assessment report

Include the general information for all risk assessment reports and the:

- details of the desk study and site walkover
- details of any unexploded ordnance assessment
- potential contaminant linkages and how you evaluated them
- initial and updated conceptual site model including the basis for how you developed it
- interpretive information from any exploratory investigation done
- details of the qualitative risk screening – for example, include the information from your risk classification matrix if used
- potential risks – unacceptable or acceptable, including the degree of confidence
- details about which potential contaminant linkages need further assessment and why
- justification for the potential contaminant linkages identified for no further assessment
- details of any uncertainties, data gaps and limitations
- conclusions and justification for your next steps
- factual details of any exploratory investigation done – see field investigation reporting

Additional information requirements for generic quantitative risk assessment report

Include the general information for all risk assessment reports and the:

- summary of the preliminary risk assessment
- objectives and approach for this tier of risk assessment
- details of how generic assessment criteria were selected or derived and what assumptions were used or made
- information collected and the methods used
- interpretive information from the detailed site investigation
- quality assessment of data
- results of the comparison with generic assessment criteria
- details of how the risk was evaluated – both unacceptable or acceptable
- details of any tools used to assess the risks
- initial and updated conceptual site model – explain how it was updated with the site investigation results
- contaminant linkages you have identified

- details of any uncertainties, data gaps and limitations
- reasons for not considering any potential contaminant linkages
- confirmed contaminant linkages
- conclusions and justification for next steps
- factual details of the investigation and monitoring results – see field investigation reporting

Additional information requirements for detailed quantitative risk assessment report

Include the general information for all risk assessment reports and the:

- summary of the preliminary risk assessment (and generic quantitative risk assessment if done)
- objectives and approach for this tier of risk assessment
- information collected and the methods used
- interpretive information from the detailed or supplementary site investigation
- information on zoning, outliers and other anomalous features
- quality assessment of data
- details of how the risk was evaluated
- derivation of site-specific assessment criteria
- criteria, tools and assumptions you used or developed to estimate the risk
- risk assessment model results such as remedial targets
- model validation and sensitivity analysis
- initial and updated conceptual site model – explain how it was updated with the site investigation results
- statement of unacceptable or acceptable risks identified
- details of any uncertainties, data gaps and limitations
- reasons for not considering any potential contaminant linkages
- confirmed contaminant linkages
- conclusions and justification for the next steps
- factual details of the investigation and monitoring results – see field investigation reporting

If applicable, you may have to provide, your detailed quantitative risk assessment risk estimation model or input parameters to the regulator as part of your submission.

Field investigation reporting

The report on the field investigation is factual information. Keep it separate from interpretative information.

How you report the information will relate to the site-specific details and how complex the investigation or site is. You can report the field investigation separately or more usually as a part of other reports such as a risk assessment report.

You can report other information, such as a geotechnical investigation, monitoring or laboratory analysis results separately or you can include them in the section on factual information.

When you report on field investigations include:

- the basic site details
- a summary of the investigation and the scope of the work
- which part of LCRM it relates to
- the investigation objectives and strategy
- who commissioned it
- which phase, stage or zone of investigation it relates to
- the results
- any uncertainties and limitations

Include factual information such as:

- a description of ground conditions at the site
- the sampling and fieldwork – include sampling design, site investigation techniques, sample management, surveys, visual inspection and on-site testing methods
- any non-intrusive methods used
- the monitoring and sampling locations – maps, plans, cross-sections, photographs, gas wells, borehole and trial pit logs
- descriptions of soils and rocks to BS 5930: Code of practice for ground investigations (<https://shop.bsigroup.com/ProductDetail/?pid=000000000030400754>)
- the type of sampling equipment used and calibration records
- details of rapid measurement techniques or in situ testing if used
- details of the scheduled chemical analysis and geotechnical testing
- gas flow rates, concentrations, atmospheric conditions, instruments and techniques used
- summary tables of chemical analyses, site monitoring and geotechnical tests
- laboratory certificates for chemical analysis (MCERTs if applicable) and geotechnical testing
- health and safety controls, environmental controls and the quality assurance plan

You may also need to submit full laboratory data sheets.

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