PRACTICAL TIPS TO SHARE:

HUMAN HEALTH RISK ASSESSMENT

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In June 2018, the Society of Brownfield Risk Assessment (SoBRA), The Geological Society Contaminated Land Group and RemSoc delivered a conference targeted towards early careers learning. Its aims were:

- To support technical excellence in the assessment, estimation & evaluation of risks and associated uncertainties from land affected by contaminants;
- To encourage "good practice" in the practical application of risk assessment to support decisions regarding the appropriate management of land contamination; and
- To facilitate and widen access to the dissemination of knowledge regarding land contamination risk assessment.

A commitment of this workshop has been the creation of a series of short tabular reports for each of the different discipline areas. These reports aim to

- Direct early career professionals to what is considered important;
- Provide clarity as change is often easier when we understand why we are doing it; and
- Focus on identifying small changes that are easy to deliver.

This report is neither intended to present prescriptive guidance nor be exhaustive in content. It is simply a distillation of each author's experience, shared with the intention of directing both field staff and risk assessors in their early careers towards some good practices, and helping them to avoid common mistakes. It presents work conducted by a volunteer.

Note (August 2024): This report has been updated in 2024 to reflect current legislation and guidance documents.

HUMAN HEALTH RISK ASSESSMENT

PRACTICAL TIPS	Descriptor
Always think back to the Conceptual Site Model	The Conceptual Site Model (CSM) is the foundation of any risk assessment. If we don't have a good understanding of the plausible source-pathway-receptor (S-P-R) linkages then we may end up not assessing all the plausible risks, using incorrect tools for assessing risks or making incorrect assumptions in our assessment.
Sketch up the CSM	It's good practice to have a pictorial representation of the CSM either as a drawing or even just a hand drawn sketch to help make sure we have captured all the plausible S-P-R linkages. Typically this would be a cross-section that depicts the geology and hydrogeology as well as sources, pathways and receptors. For example, it could be obvious from this pictorial representation that off-site residents are unlikely to be exposed to contaminants in groundwater due to 3m thickness of clay overlying the aquifer, or that vapour risks are unlikely to be an issue because the proposed residential apartments are underlain by below ground ventilated parking.
Think outside the box	We can become complacent when doing our human health risk assessments, only considering S-P-R linkages covered by the Contaminated Land Exposure Assessment (CLEA) model, i.e. risk to residents or commercial workers etc from soil and dust ingestion, consumption of homegrown produce, dermal contact with soil and dust and vapour inhalation. Could there be other S-P-R linkages that we might want to consider? For example, risk to ground workers, permeation of contaminants through drinking water pipes, abstraction wells used for drinking water or washing, people keeping chickens on their allotment/garden, risk to off-site receptors (e.g. from migration of groundwater, vapours or dust), risks from non-aqueous phase liquid (NAPL), migration of contaminants along service trenches etc? We might end up qualitatively ruling out many of these linkages but it is better to think of them and rule them out rather than ignoring them in the first place.
Remember the CSM can change/be updated as we receive more data	Don't be wedded to your preliminary CSM. The CSM may change as we receive more data (radically sometimes, but hopefully rarely). As geo-environmentalists we are always trying to interpret as best we can from an

	incomplete dataset. We have to use our intuition and sometimes we will get things wrong (through no fault of our own). With this in mind we must always be questioning our understanding based on the data we have. For example, we might have ruled out risk to the neighbouring allotments on the basis that groundwater is likely to be flowing in the opposite direction towards the nearest river, but then groundwater monitoring data collected at a later data shows otherwise
Decide which linkages require further assessment and decide how you will consider these further	The development of the CSM involves the identification of potential sources, pathways and receptors, determining how these could be linked and then a qualitative assessment of risk for each of the identified linkages to determine which could present a plausibly significant risk. The end of this process should result in a list of S-P-R linkages that require further consideration. You then need to decide how to consider these further. You may decide that some of the linkages could be assessed further using generic quantitative risk assessment (GQRA) (see below). Others may require detailed quantitative risk assessment (DQRA) (e.g. because there are no suitable generic screening values). Some may need to be assessed through gathering more data (e.g. groundwater level monitoring to determine depth to groundwater and flow direction). Some may best be addressed through risk management or mitigation (e.g. use of drinking water pipes resistant to contaminant permeation or application of appropriate health and safety measures for ground workers). (All this is explained in detail in the Environment Agency (2023) Land Contamination Risk Management (LCRM) Guidance, specifically Stage 1 Risk Assessment). You must keep track of these plausible linkages. All too often plausible linkages identified early on are forgotten about later in the project and never properly closed out.

What generic screening values should I use?	There are a number of different generic screening values available to the risk assessor. These could be derived in-house or you could make use of published values. Some examples of commonly used generic screening values used in the UK are: • Environment Agency Soil Guideline Values (SGVs), Defra Category 4 Screening Values (C4SL), LQM/CIEH Suitable for Use Levels (S4ULs), Atkins Atrisk Soil Screening Values (SSVs) or the CL:AIRE/EIC/AGS Generic Assessment Criteria (GAC). Many Geo-environmental consultancies develop their own in-house generic screening values. SGVs were derived prior to the C4SLs, and use slightly different input parameters for the exposure modelling depending on the land use e.g. inhalation rates, home-grown produce consumption rates, soil adherence factors in children and exposure frequency for dermal contact outdoors. Some previously published SGVs have now been withdrawn. These screening values have all been derived using the Contaminated Land Exposure Assessment (CLEA) model and are intended for assessing chronic risk from long –term exposure to contaminants in soil for a range of land-uses (residential, allotments, public open space and commercial); • SoBRA Generic Assessment Criteria for Assessing Vapour Risks to Human Health from Volatile Contaminants in Groundwater (GAC_{gwvap}). These have been derived using CLEA and are intended for assessing chronic risk from long –term exposure to volatile constituents in groundwater via vapour migration and inhalation for residential and commercial land-uses; When conducting GQRA it is vital that you understand the assumptions and limitations behind the generic screening values you are using. Different published generic screening values for the same land use may have slightly different input parameters, depending on their date of publication, and may represent different levels of risk e.g. minimal/tolerable risk, or low risk. It's very easy to compare two numbers but far harder to make sure that the comparison is meaningful. Are the generic screening values you are using appropriate for assessing the S-P-R linkages identified in the CSM? Do they assess all the identified S-P-R linkages or are there linkages that they don't cover? For example, generic screening values produced by CLEA (e.g. SGVs, C4SLs, S4ULs etc) assess chronic risks to residents, allotment holders, users of public open space and office/warehouse workers from long- term exposure to contaminants although for some contaminants, such as free cyanide, acute exposure may be the risk driver, not chronic. Generic screening values assume that free phase contamination is not present. They cannot be used for assessing acute risks to ground workers coming into direct contact with contamination in the subsurface. Neither can they be used for assessing the risk from permeation of

	contaminants through drinking water pipes etc. You need to think about how you will assess/manage these linkages – don't simply ignore them.
What does exceedence of a generic screening value signify?	The significance of exceedance will depend on the level of conservatism in the screening criteria when applied to your site and the context of your risk assessment (Planning or Part 2A of the Environmental Protection Act 1990). For example, an exceedance of a generic screening value for arsenic for residential land-use in soil at 3m depth is unlikely to be an issue for future residents as there is no plausible pathway by which they could be exposed to arsenic at this depth. Likewise an exceedance of a generic screening value for xylenes for commercial land-use in soil below a car park well away from buildings is unlikely to be an issue because the principal exposure pathway that the S4UL is based on is vapour intrusion into buildings.
How can I use statistics?	The CLEA derived soil screening values are the theoretical concentration in soil that would result in the average daily exposure (ADE) to the critical receptor (child, adult) being equal to the health based guidance value (HBGV – the allowable dose). As such, it is really the average soil concentration to which a receptor is exposed (rather than maximum measured concentration) that we should compare with the screening value in order to assess chronic risk. We can use measured concentrations from a site to estimate this average concentration but we need to be careful how we do this. For example, for a large housing development we cannot simply average all the soil concentrations across the site if we know that the concentrations in one part of the site are significantly higher than elsewhere as we would under-estimate the risk to residents of the houses constructed on the area with higher concentrations. CL:AIRE (2020) Professional Guidance: Comparing Soil Contamination Data with a Critical Concentration provides guidance on the use of statistics for comparing measured concentrations with screening values. The SoBRA (2023) Conceptualising & Characterising Contaminant Distribution in Soil Top Tips document provides technical guidance to support risk assessment practitioners to understand the soil contaminant element of the CSM prior to carrying out any generic or detailed quantitative risk assessment (and any associated statistical analysis). .
Where should I take my soil samples?	For non-volatile contaminants the key exposure pathways for human health are often associated with direct contact with surface soils or generation of dusts from surface soils. It is therefore generally a good idea to ensure that the sampling plan includes sampling of surface soils as well as deeper soils so that the risks from these pathways can be accurately assessed. Unless, of course, surface soils will be removed as part of the development.

Include soil organic matter (SOM) in the analytical suite?	Soil generic screening values for organic contaminants are often dependent on SOM – the higher SOM the higher the screening value. Laboratory analysis for SOM is relatively inexpensive and so should generally be scheduled alongside analysis for organic constituents to help choose the most appropriate screening value.
Can I use bioaccessibility testing?	Bioaccessibility testing can be a useful tool for contaminants such as arsenic or lead where the measured soil concentrations are above the generic screening values. In the case of arsenic, the CLEA derived C4SLs for all land uses are based on the assumption that 100% of the ingested arsenic, or inhaled arsenic in dust, will be absorbed into the bloodstream. Whilst this may be realistic for exposure to dissolved phased arsenic in water it is often highly conservative for arsenic in soil. In contrast, in the case of lead, the CLEA derived C4SLs for all land uses are based on the assumption that 60% of the ingested lead, and 64% of the inhaled lead in dust, will be absorbed into the bloodstream. The Unified BARGE Method (UBM) has been validated for arsenic (and some other metals) using in- vivo data (with pigs) and is considered the best practice method to use in the UK for assessing the bioaccessibility of arsenic and lead. The UBM results can be used to adjust the relative oral bioavailability in the CLEA model to derive a site specific assessment criteria for comparison with measured total concentrations.

REFERENCES

- CL:AIRE, 2020. Professional Guidance: Comparing Soil Contamination Data with a Critical Concentration. CL:AIRE, Buckinghamshire. ISBN 978-1-905046-35-5. [Available at https://www.claire.co.uk/home/news/1374-new-cl-aire-publication-guidance-on-applying-statistics-to-land-contamination-decision-making]
- Defra, 2014. SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document. Department for Environment, Food and Rural Affairs. December 2014. [Available at https://www.claire.co.uk/projects-and-initiatives/category-4-screening-levels] Environment Agency, 2003. Land Contamination Risk Management [available at https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm]
- Environment Agency, 2009. A Guide to using Soil Guideline Values. Science Reports SC050021/various. [Available at https://www.gov.uk/government/publications/contaminated-soil-assessing-risks-on-human-health]
- Nathanail, C.P., McCaffrey, C., Gillett, A.G., Ogden, R.C. and Nathanail, J.F. 2015. The LQM/CIEH S4ULs for Human Health Risk Assessment. Land Quality Press, Nottingham
- SoBRA, 2023. Conceptualising & Characterising Contaminant Distribution in Soil Top Tips. ISBN 978-1-9161111-7-2. [Available at https://sobra.org.uk/wp-content/uploads/2023/11/SoBRA_Sub_Group_CSM_v1.0_Final.pdf]
- SoBRA, 2017. Development of Generic Assessment Criteria for Assessing Vapour Risks to Human Health from Volatile Contaminants in Groundwater Version 1.0 February 2017. Society of Brownfield Risk Assessment (SoBRA). [Available at https://sobra.org.uk/category/groundwater-vapour/]