Applying Sustainable Development Principles to Contaminated Land Management Using the SuRF-UK Framework

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In the past decade, management of historically contaminated land has largely been based on prevention of unacceptable risks to human health and the environment, to ensure a site is "fit for use." More recently, interest has been shown in including sustainability as a decision-making criterion. Sustainability concerns include the environmental, social, and economic consequences of risk management activities themselves, and also the opportunities for wider benefit beyond achievement of risk-reduction goals alone. In the United Kingdom, this interest has led to the formation of a multistakeholder initiative, the UK Sustainable Remediation Forum (SuRF-UK). This article presents a framework for assessing "sustainable remediation"; describes how it links with the relevant regulatory guidance; reviews the factors considered in sustainability; and looks at the appraisal tools that have been applied to evaluate the wider benefits and impacts of land remediation. The article also describes how the framework relates to recent international developments, including emerging European Union legislation and policy. A large part of this debate has taken place in the "grey" literature, which we review. It is proposed that a practical approach to integrating sustainability within risk-based contaminated land management offers the possibility of a substantial step forward for the remediation industry, and a new opportunity for international consensus. © 2011 Wiley Periodicals, Inc.

INTRODUCTION

Sustainable development was defined by the World Commission on Environment and Development (WCED) in 1987 as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). This definition forms the basis for much of the UK government's policy on sustainable development (Her Majesty's Government et al., 2005). It is commonly interpreted as those actions that, taking account of environmental, social, and economic factors, optimize the overall benefit.

In August 2007, the European Environment Agency (EEA) concluded that soil contamination requiring "cleanup" is present at approximately 250,000 sites in the EEA member countries (EEA, 2007). "Potentially polluting activities" are estimated to have occurred at nearly 3 million sites. The data vary between countries, and numbers may

Published online in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/rem.20283

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change as definitions develop and information improves as more sites are investigated. It has been estimated that in England and Wales, 33,500 sites (67,000 hectares) have been affected by contamination, and there are 325,000 sites (300,000 hectares) where previous land use was potentially contaminative (Environment Agency, 2005). The Scottish Environment Protection Agency (SEPA) estimated that there might be 82,000 hectares of land affected by contamination (across 67,000 sites) in Scotland (SEPA, 2009).

In the Netherlands, there are estimated to be 1,700,000 sites that are or have been used for potentially polluting activities. Some 1,500 to 2,500 of these sites are expected to have "serious" and "urgent" remediation problems (Harmsma, 2010), with action likely to be required at an estimated 56,000 sites (Franken et al., 2008). Hence, the scale of response is substantial. The 2004 EU market for "remediation and cleanup of soil and groundwater" was estimated to be €5.2 billion (Ernst and Young, 2006). The UK market alone is thought to be worth in the region of £1 billion per annum (2009 prices) (Contaminated Land: Applications in Real Environments [CL:AIRE], 2010a). The scale of land-contamination problems and of the responses to them makes achieving sustainability in contaminated land remediation an important debate. There is now an active international debate across Europe, North America, and Australia about how best to ensure that land contamination is managed in a sustainable manner.

For some, "sustainable remediation" may be a relatively new idea, while for others, it has been in discussion in some shape or form since the late 1980s. Sustainable development appraisals are commonly undertaken for large developments and have begun to be applied to remediation projects (Bardos et al., in press). Consideration of remediation issues alongside other relevant factors in wider sustainable development appraisals will result in projects that are "better by design," and it constitutes part of a wider debate about sustainable brownfield regeneration (Dixon et al., 2007).

The UK Sustainable Remediation Forum (SuRF-UK) is a focused group of remediation practitioners and regulators from the United Kingdom interested in providing sustainable approaches to the management of land contamination. Its goal has been to develop a framework to embed balanced decision making in the selection of a remediation strategy to address land contamination as an integral part of sustainable development. SuRF-UK was established in 2007, is coordinated by an independent not-for-profit contaminated land organization, Contaminated Land: Applications in Real Environments, and actively collaborates with similar initiatives elsewhere in the world. Around 50 public- and private-sector organizations have taken part in SuRF-UK from 2007 to 2010. The approach taken was in line with practice suggested by Donnelly et al. (2006, 2007) and used by other sustainability assessment initiatives (Haughton et al., 2009) but encompassed a wider range of stakeholder interests, including site owners and managers, service providers, regulators, planners, local authorities, and the research community.

This article summarizes the historical and international context of sustainable remediation and presents the new UK framework for sustainable remediation developed by SuRF-UK.

INTERNATIONAL CONTEXT

Sustainability concerns have already had a major influence on historically contaminated land management policy across Europe. There has been a broad shift from

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"multifunctional" policies for land remediation, where remediation was required to be sufficient for *any* future use (Denneman, 1999), to "end-use-related" remediation, in particular in the Netherlands. Although the environmental benefits of the more stringent treatment required for any use, rather than a specified use, it was ultimately the economic and social costs of multifunctionality that were found to be politically unsustainable and an obstacle to the reuse of brownfield land (Veraat et al., 2005).

The use of risk-based land management (RBLM) and questions of sustainability were both crystallized in 2002 by the pan-European project CLARINET: the Contaminated Land Rehabilitation Network for Environmental Technologies in Europe (Vegter et al., 2002). RBLM integrates two key decisions:

1. The time frame, which requires an assessment of risks and priorities and the longer-term effects of particular choices, and
2. The choice of solution, taking into account its overall benefits, costs, and environmental effects; value and circumstances of the land; community views; and other issues.

CLARINET concluded that using risk-based decision making was consistent with sustainable development, as it provides a scientific rationale for the costs of remediation that society has to bear. However, CLARINET also found that this overarching philosophy did not mean that all remediation projects are necessarily sustainable. CLARINET suggested that considering the true contribution of remediation work to sustainable development was a challenge at least as great in its difficulty as the development of risk-based decision making, and with the same capacity to profoundly change how contaminated land is managed in the future. In 2004, Pollard et al. also identified a trend toward considering sustainability appraisal as a tool for decision making for the management of contaminated land (Pollard et al., 2004).

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At the same point in time, sustainability was emerging as a decision-making criterion in industry and consultancy in Europe. In 2003, NICOLE concluded that the meanings ascribed to terms such as "sustainable" or "sustainable development" varied widely (Bardos, 2003). It also concluded that there was no common language for discussing contaminated land management in the context of sustainable development: "Without clear definitions everybody can claim that they are acting sustainably when sometimes perhaps they are not." NICOLE decided that it would be both a major challenge and achievement to catalyze the development of a common framework, widely used across Europe for applying sustainability principles in contaminated land decision making. It subsequently established a sustainable remediation working group and held two further workshops on sustainable remediation (Bardos, 2008, 2010).

Hence, discussions of the role of sustainability in contaminated land remediation have been long-standing in Europe. Early discussions focused on wider environmental benefits and impacts (Environment Agency, 2000a; Interstate Technology & Regulatory Council [ITRC], 2006; NOBIS, 1995a, 1995b) and a number of remediation-selection software tools now include some consideration of wider environmental impacts, although awareness and use of these amongst practitioners is not widespread (Onwubuya et al., 2009). The need to also consider wider societal and economic benefits has now been more widely recognized (Harbottle et al., 2008a, 2008b; Hardisty et al., 2008).

In 2006, the Sustainable Remediation Forum (SURF) was established in the United States and rapidly grew into a cross-sectoral network that attempted to define concepts of sustainability from the bottom up (i.e., from the standpoint of remediation practitioners; US SURF, 2009). This has catalyzed other cross-sectoral sustainable remediation networks, including SuRF-UK, NICOLE's Sustainable Remediation Working Group (SRWG), and SuRF-Australia, listed in Exhibit 1. The situation is very fluid—for example, new initiatives are being discussed in Canada and the Netherlands (US EPA, 2010).

The broad goals of these initiatives are similar. All seek to improve the benefits of remediation while still achieving appropriate management of risks associated with land contamination. Where "sustainable remediation" has been defined, it is in terms of balanced decision making considering a range of sustainability criteria. These generally include environmental, economic, and social indicators of sustainability. The EURODEMO+ and the US EPA "green remediation" approaches are somewhat different, as they only consider environmental benefits and impacts.

The basic rationale behind contaminated land management retains its basis in risk assessment, but the means of managing those risks must in itself not place unreasonable demands on the environment, economy, and society, in either the short or long term.

While the SURF definition in Table 1 has an apparent focus on environmental aspects, SURF's overall approach, described in its 2009 "White Paper," is more rounded across environmental, economic, and social concerns (US SURF, 2009). The SURF approach in the United States is different from the other approaches in that it is more "bottom up," based on a series of aspirations that have emerged from its membership, rather than being directly linked to overarching sustainable development criteria. ASTM, under subcommittee E50.04, is in the process of developing a sustainable remediation standard guide.

DEFINING "SUSTAINABLE REMEDIATION"

Sustainable remediation is the application of the principles of sustainable development, as described by the Brundtland Report, to risk-based contaminated land management. As such, sustainable remediation encompasses four broad aims: achieving risk-based land management; ensuring that the wider effects of this risk management action are acceptable; ensuring the engagement of stakeholders and the transparency of decision-making processes; and supporting balanced outcomes in terms of the environmental, social, and economic elements of sustainable development, as illustrated in Exhibit 2.

The basic rationale behind contaminated land management retains its basis in risk assessment, but the means of managing those risks must in itself not place unreasonable demands on the environment, economy, and society, in either the short or long term. In some cases, generic (and necessarily conservative) approaches to risk management are not sustainable, and a site-specific risk management approach allows for a better design of the remediation strategy and/or remedial technique selection.

SuRF-UK has defined sustainable remediation as "the practice of demonstrating, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than its impact, and that the optimum remediation solution is selected through the use of a balanced decision-making process" (www.claire.co.uk/surfuk). It encompasses sustainable approaches to the investigation, assessment, and management (including institutional controls) of potentially

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Exhibit 1. International initiatives exploring sustainable remediation (Bardos et al., in press; NICOLE, 2010; US EPA, 2010)

Name	Geographical Coverage	Outputs and Web Links	Comment and Current Working Definition of "Sustainable Remediation"
Air Force Center for Engineering and the Environment Sustainable Remediation Tool	Focused on United States and US Air Force bases (Forbes et al., 2009)	Sustainable Remediation Tool; www.afcee.af.mil/resources/technologytransfer/programsandinitiatives/sustainableremediation	No formal definition
Department of Defense (US)	US armed forces	www.ert2.org/t2grsportal.drivers.aspx	US government memorandum instructing armed forces to consider sustainability in remediation decisions
EURODEMO+	European Union	EURODEMO (2007); www.eurodemo.info	No formal definition but proposes that sustainability can be assessed across a range of indicators, with eco-efficiency indicators being particularly useful
Interstate Technology & Regulatory Council	United States and Canada	http://www.itrcweb.org/teampublic_GSR.asp	Working group on "green and sustainable remediation" established; no definition to date
NICOLE Sustainable Remediation Working Group	European Union	Bardos (2003, 2008, 2009), NICOLE (2010); www.nicole.org/sustainableremediation	"An approach which the stakeholders involved with a project have agreed has a broad balance of beneficial environmental economic and environmental consequences"
Sustainable Remediation Forum (SURF)	Largely US-based	SURF (2009); www.sustainableremediation.org	"In fulfilling our obligations to remediate sites to be protective of human health and the environment we will embrace sustainable approaches to remediation that provide a net benefit to the environment"
SuRF-Australia	Australia	http://www.crccare.com/working_with_industry/surf.html	Early drafts of the Australian approach draw heavily on the principles, definitions, and approaches described in the SuRF-UK framework
SuRF-UK	Largely UK-based	CL:AIRE (2009, 2010b); www.claire.co.uk/surfuk	"The practice of demonstrating, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than its impact, and that the optimum remediation solution is selected through the use of a balanced decision-making process"
US EPA Green Remediation	United States, US EPA-led, linked with other initiatives	US EPA (2008, 2009); www.clu-in.org/greenremediation/	"Green Remediation: The practice of considering all environmental effects of remedy implementation and incorporating options to maximize net environmental benefit of cleanup actions."

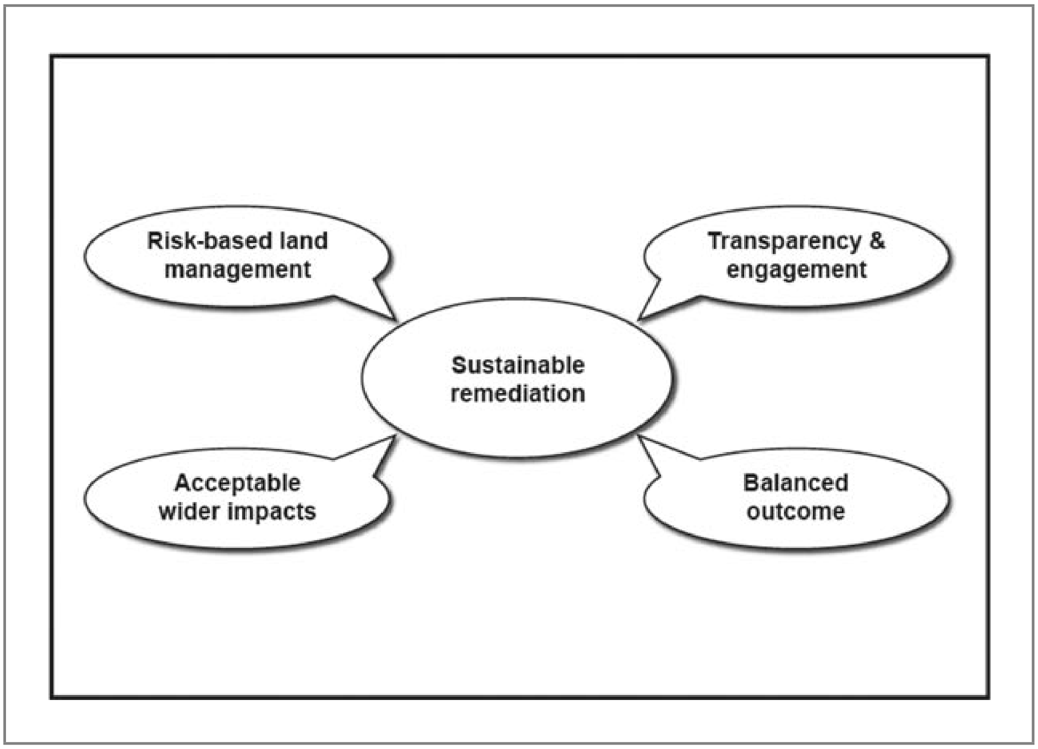

Exhibit 2. Broad aims of sustainable remediation

contaminated land. This balance is based on a set of underpinning principles (listed in Exhibit 3) within which the balancing of criteria such as environmental, social, and economic costs and benefits occurs.

In applying sustainable remediation to contaminated land decision making, management decisions need to be supported by assessments of sustainability (Network for Industrially Contaminated Land in Europe [NICOLE], 2010). Consequently, this article distinguishes:

- *sustainability management* as the discipline of integrating sustainability assessment in contaminated land management decision making, and
- *sustainability assessment* as the process of gaining an understanding of possible outcomes across all three elements (environmental, social, and economic) of sustainable development.

This approach mirrors the use of "assessment" and "management" in risk-based decision making for contaminated land management.

Related to sustainable remediation are concepts of sustainable brownfields regeneration that have been explored at a European level by the RESCUE (2003) and CABERNET projects (www.cabernet.org.uk), and in the United Kingdom by the SU:BRIM project (CL:AIRE, 2006, 2007a, 2007b). These all used the RESCUE project definition of project, which defined *sustainable brownfield regeneration* as "the management, rehabilitation and return to beneficial use of the brownfield land resource base in such a manner as to ensure the attainment and continued satisfaction of human needs for present

Exhibit 3. Underpinning principles guiding sustainable remediation identified by SuRF-UK

The balancing of environmental, social, and economic costs and benefits in identifying the optimal remediation solution needs to be carried out while complying with this set of key principles, which should be considered by practitioners in the design, implementation, and reporting of sustainable remediation schemes.

1 **Protection of human health and the wider environment.** Remediation (site-specific risk management) should remove unacceptable risks to human health and protect the wider environment now and in the future for the agreed land use, and give due consideration to the costs, benefits, effectiveness, durability, and technical feasibility of available options.

2 **Safe working practices.** Remediation works should be safe for all workers and for local communities, and should minimize impacts on the environment.

3 **Consistent, clear, and reproducible evidence-based decision making.** Sustainable risk-based remediation decisions are made with regard to environmental, social, and economic factors, and consider both current and likely future implications. Such sustainable and risk-based remediation solutions maximize the potential benefits achieved. Where benefits and impacts are aggregated or traded in some way, this process should be explained and a clear rationale provided.

4 **Recordkeeping and transparent reporting.** Remediation decisions, including the assumptions and supporting data used to reach them, should be documented in a clear and easily understood format in order to demonstrate to interested parties that a sustainable (or otherwise) solution has been adopted.

5 **Good governance and stakeholder involvement.** Remediation decisions should be made with regard to the views of stakeholders and following a clear process within which they can participate.

6 **Sound science.** Decisions should be made on the basis of sound science, relevant and accurate data, and clearly explained assumptions, uncertainties, and professional judgment. This will ensure that decisions are based upon the best available information and are justifiable and reproducible.

and future generations in environmentally non-degrading, economically viable, institutionally robust and socially acceptable ways" (RESCUE, 2003). Sustainable brownfield regeneration is an overlapping concept; for example, remediation may be a part of brownfield redevelopment. However, brownfield regeneration would not encompass, as a concept, the remediation of operational sites, and may not necessarily address the remediation of undevelopable contaminated land for softer end-uses such as for biomass or nature areas. The overall significance of soil and groundwater remediation to the sustainability of a scheme will vary depending on its relative contribution to a project.

SUSTAINABILITY MANAGEMENT

A conclusion recorded from the SuRF-UK meetings and consultations has been that decisions that affect sustainability are likely to be highly specific to local circumstances and stakeholder interests, but will also be affected by corporate and governmental sustainable development policies and objectives, which may be related to land but also a wide range of broader considerations. Hence, even with a consistently used definition, sustainability management could be a complex process. It is against this background that SuRF-UK's goal was set: "to develop a framework to embed balanced decision-making in the selection

Exhibit 4. Reducing complexity in sustainable remediation management

Idea 1: Using structured approaches	There are three types of structured approach: (1) Levels of decision making: decisions made at one level may well affect the range of actions that are possible at a subsequent level (Pollard et al., 2004). The use of a framework clarifies the points at which decisions are made, and how these affect subsequent decisions. (2) There are differing degrees of complexity: in how sustainability might be assessed and compared—for example, the range of factors that might be considered, or whether to use simple qualitative tools or a more detailed quantitative approach. Different levels of complexity may be appropriate for different types of decisions, but generally the simplest approach that yields a transparent, robust, and consensus-based decision is preferable (Therivel, 2004). A tiered approach to sustainability assessment is one that uses the simplest techniques first and advances to more detailed approaches only where necessary. (3) Assessing sustainability encompasses a wide range of considerations and (depending on the stakeholders involved) a range of viewpoints. Breaking the assessment procedure down into a stepwise approach means that judgments are made in a more controlled way, clarifying the assumptions and information used and allowing a more transparent reporting of the sustainability assessment process and findings.
Idea 2: Applying consistent boundaries to decision making and sustainability assessment	For any sustainability assessment, there are three types of boundaries: (1) The principles in Exhibit 3 affect the way in which individual economic, environmental, and social considerations should be balanced; (2) The range of factors being considered within sustainability; and (3) The boundary conditions that apply to a project or other concern whose sustainability is under scrutiny.
Idea 3: Assessing sustainability is subjective and needs to be accepted as such	There is no absolute “unit of sustainability.” Assessing sustainability is subjective for a number of reasons. The principles of the “balancing” approach and the scope of what is to be considered all need to be broadly acceptable to the stakeholders involved in the decision as suggested by Pediaditi et al. (2005; also CL:AIRE, 2007a, 2007b). If this consensus does not exist, then the assessment of sustainability will not be accepted as a basis for decision making. Important criteria may not be readily quantifiable (for example, impact on a landscape), while others may be directly related to perceptions (for example, access to amenities or the presence of odors). Embracing this subjectivity does not pose a problem for decision making; indeed, it allows decisions to be made in a way that is customized for the particular issue being considered and the stakeholders active in its consideration.

of a remediation strategy to address land contamination, as an integral part of sustainable development” (www.claire.co.uk/surfuk).

Three fundamental ideas have helped SuRF-UK reduce this level of complexity to the extent that a robust and reproducible approach to sustainable remediation decision making is possible (Exhibit 4):

1. Decisions and assessments should be considered in a structured way.

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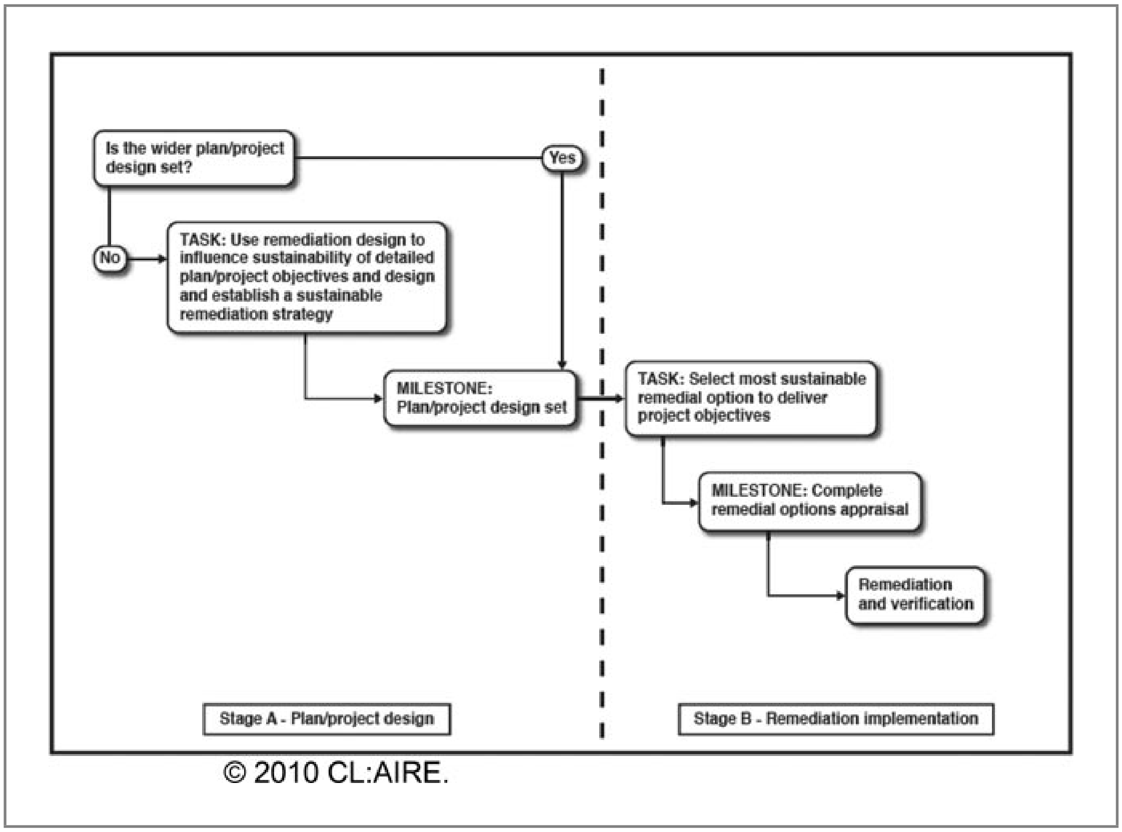

Exhibit 5. The SuRF-UK framework in simple outline

2. Consistent boundaries must be used in decision making and sustainability assessment.
3. Assessing sustainability is essentially a subjective process; it needs to be accepted as such.

These ideas have allowed SuRF-UK to develop its framework and facilitated linkage to existing UK good practice for contaminated land management, as set out in the *Model Procedures for the Management of Land Contamination* (Environment Agency & Department of Environment, Food, and Rural Affairs, 2004) and related ideas of wider environmental value and cost-benefit assessment (Environment Agency, 1999a, 1999b, 2000a, 2000b).

Exhibit 5 provides a simplified overview of the SuRF-UK framework (CL:AIRE, 2010b). This framework identifies two fundamental stages at which sustainability can be considered: (1) at the planning/project design stage (which SuRF-UK calls "Stage A") and (2) during the selection and implementation of remediation techniques ("Stage B").

The SuRF-UK framework is sufficiently flexible that it can be applied to these various remediation decision-making scenarios within a property life cycle and for different sizes of project or site. The framework provides several illustrative scenarios considering remediation for redevelopment projects, managing operational sites, and land restoration to "soft" end-uses, as shown in Exhibit 6.

The SuRF-UK framework for managing sustainability in remediation describes *when* sustainable remediation decisions should be made, *how* they should be taken, and *what* they should be based upon.

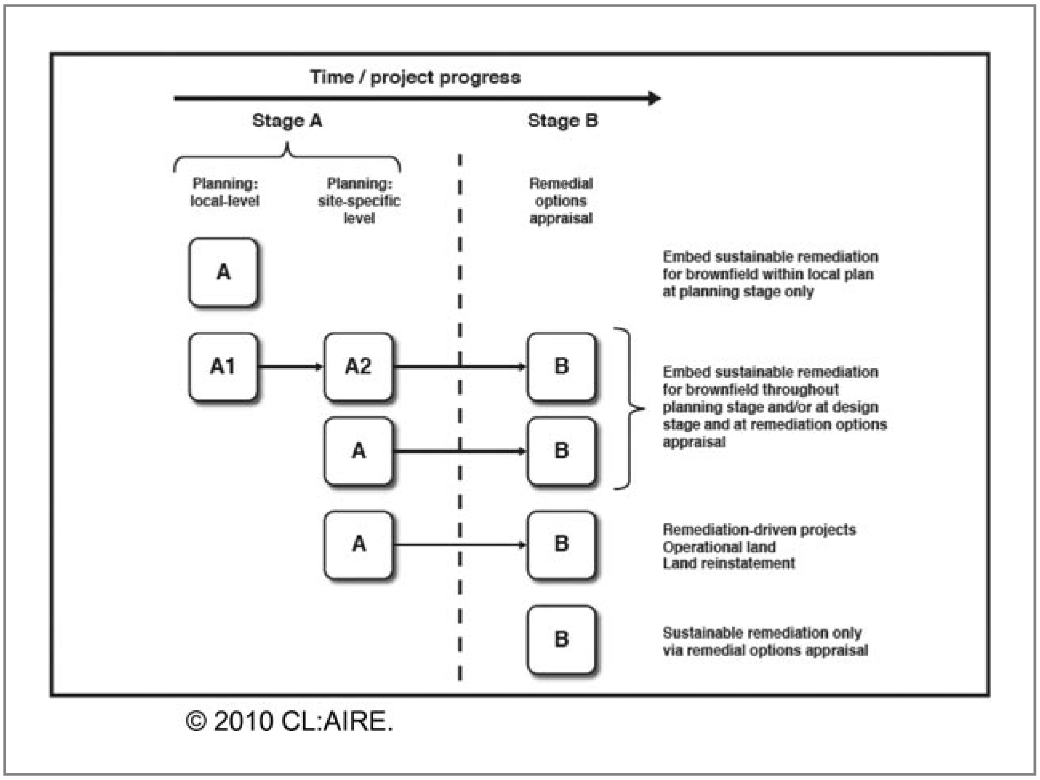

Exhibit 6. Use of the SuRF-UK framework for different remediation scenarios

Different groups of practitioners will apply the SuRF-UK framework to different decision-making contexts. The discussions that took place at the SuRF-UK open-forum meetings indicated that many contractors and consultants will focus on “Stage B,” using the framework to help them deliver more sustainable solutions for fixed remediation goals.

However, at earlier stages there are wider opportunities to influence management decisions on sustainability. Notionally, the earliest stage considered in this framework is at local spatial planning. Remediation-related considerations are only one small component of a spatial strategy for a region, as, for example, demographics, flood risk, and transport are other key factors that need to be considered. Therefore, the impact of sustainable remediation decisions may have a relatively minor impact on the overall sustainability of a scheme.

If the SuRF-UK framework begins at the project-design stage (“Stage A”), there may be a range of possibilities to maximize the sustainability gained by considering remediation and ongoing site use in an integrated manner (for example, looking at synergies between remediation and development processes), ensuring risk management objectives have been optimized in a site-specific manner for an operational site, or looking for synergies between different types of activities for a soft end-use (for example, combining remediation, bio-energy, and organic matter recycling). In addition, many organizations manage a portfolio of sites, some or all of which may need risk assessment and, possibly, remediation. In this case, sustainable remediation considerations may be an important component of strategic planning, along with other issues of corporate governance. Operators of industrial processes could use “Stage A” to ensure that risk management goal setting is carried out in a sustainable manner, taking into account the specific context of individual sites.

At a project-specific level, such as a brownfield redevelopment, the remediation process becomes more significant in the overall project sustainability, and during the remediation of operational land (i.e., where there is no change of use proposed), the sustainability of the remediation approach selected defines the project sustainability, because remediation is the entirety of the project.

Decisions made at "Stage A" have a controlling influence on decisions made at "Stage B." The completion of the remediation plan or design is typically a point of limited return. This occurs because, for example, contracts, regulatory agreements, conditions of a permit, or a planning consent are finalized. In contractual terms, the break point is often the point of signing a contract, irrespective of the form of agreement under consideration. Revisiting these decisions is effectively a project-failure situation given the large foregoing investment in time and money that would then have to be redone. If remediation has not been considered in Stage A, there is a finite probability of finding that any of the remediation options available will have limited appeal from a sustainable development point of view. This emphasizes the importance of early assessment of remediation on sustainability to deliver a project that is "better by design."

Sustainability assessment underpins these management decisions. Determining an assessment approach requires consideration of two broad questions: how is the assessment carried out? and what are the factors that together will constitute a view of sustainability? There is no absolute measure of sustainability, and each decision is specific to a project site and its context. Hence, a sustainability assessment process should be:

Determining an assessment approach requires consideration of two broad questions: how is the assessment carried out? and what are the factors that together will constitute a view of sustainability?

1. *Based on consultation (ideally consensus)*: Engagement with the stakeholders who will need to be convinced of sustainability benefits should take place from an early stage.
2. *Transparent*, so that it is fully understood by all those taking part (and those who may need to refer to it in the future). Transparency and early engagement of stakeholders in sustainability assessment will greatly improve the chances of achieving an agreement between all stakeholders and, hence, the chances of an acceptable, robust, and durable decision.
3. *Reproducible*, so that the process is capable of being used reliably for different sites, projects, and stages.
4. *Verifiable*, so that the performance of the remediation during its implementation can be compared with the expectations that led to it being selected.
5. *Documented*, with the assessment process and any consequent decisions linked to evidence, with all assumptions and valuations clearly explained.
6. *Appropriate*, so that the level of decision-making effort is the minimum that is needed to achieve a robust (including consensual, transparent, reproducible, and verifiable) management decision. A tiered approach to assessment may help avoid wasting money and effort beginning with simple qualitative methods and focusing more complicated assessments only on aspects of sustainability where there is a failure to reach clear consensus.

These suggestions are in line with recommendations made elsewhere about brownfields and contaminated land remediation (Pediaditi et al., 2005; Pollard et al., 2004; Slenders et al., 2005).

 Remediation DOI: 10.1002/rem

SUSTAINABILITY ASSESSMENT

The key steps in sustainability assessment noted by both SuRF-UK and NICOLE are identifying the need, identifying the stakeholders to be consulted, agreeing on the scope of what the assessment is to cover, agreeing on the assessment approach, executing the assessment, and testing its findings.

Sustainability assessment is a consultative process (Pediaditi et al., 2005) that seeks to find consensus between the different project stakeholders. As such, stakeholder workshops and facilitation may be important (Franz et al., 2007). If any stakeholder does not agree with the underlying assumptions or method on which a sustainability assessment is based, they are also unlikely to support its findings. Consequently, both SuRF-UK and NICOLE strongly endorse early engagement with stakeholders from the inception of the assessment procedure when its objectives are agreed upon (CL:AIRE, 2010b, NICOLE, 2010). There are circumstances when a single assessor may undertake a sustainability appraisal. For example, these might be for small projects where there are no major external stakeholder interests, for internal purposes perhaps as part of process development, or as a "feasibility study" to guide a wider sustainability assessment. However, given the subjective nature of sustainability assessment, it is a validation of assumptions and methods by a wider group of stakeholders that can increase confidence in its findings.

In line with suggestions for good practice in sustainability assessment (Pollard et al., 2004; Therivel, 2004), SuRF-UK suggests a tiered approach in carrying out assessment using simpler techniques first—and also a stepwise procedure for carrying out the sustainability assessment. These suggestions are broadly in line with the views of other international working groups such as NICOLE, EURODEMO+, and SURF in the United States (EURODEMO, 2007; NICOLE, 2010; US SURF, 2009). It is also in line with published guidance for environmental impact assessment and sustainability appraisal: *a sustainability assessment need not be done in any more detail, or using more resources, than is useful for its decision-making purpose* (Office of the Deputy Prime Minister [ODPM], 2005).

Exhibit 7 sets out the SuRF-UK tiered approach, which is that decision making should be based on the simplest assessment that provides a basis for a robust decision, starting with a qualitative approach and then moving to more time-consuming semiquantitative or quantitative methods only where there is a need for better information. The tiered approach also allows stakeholders to identify where greater informational effort is required, by allowing points of already existing consensus to be identified, thus avoiding greater detailed effort on those points. It should also be considered that not all factors important in sustainability are readily quantifiable, and not all stakeholders respond well to quantitative and valuation-based tools.

The reason for a stepwise procedure to carry out the sustainability assessment process (at any given tier) is to provide a better opportunity for consultation and consensus building, by breaking discussions into discrete components, thereby making the process of agreeing assumptions and precedents more transparent, and by reducing the chance that assumptions and precedents will be confused and influence each other in a way that is not transparent. The key steps in sustainability assessment noted by both SuRF-UK and NICOLE (CL:AIRE, 2010b; NICOLE, 2010) are identifying the need, identifying the stakeholders to be consulted, agreeing on the scope of what the assessment is to cover, agreeing on the assessment approach, executing the assessment, and testing its findings. These are presented in Exhibit 8, with a commentary on each step following.

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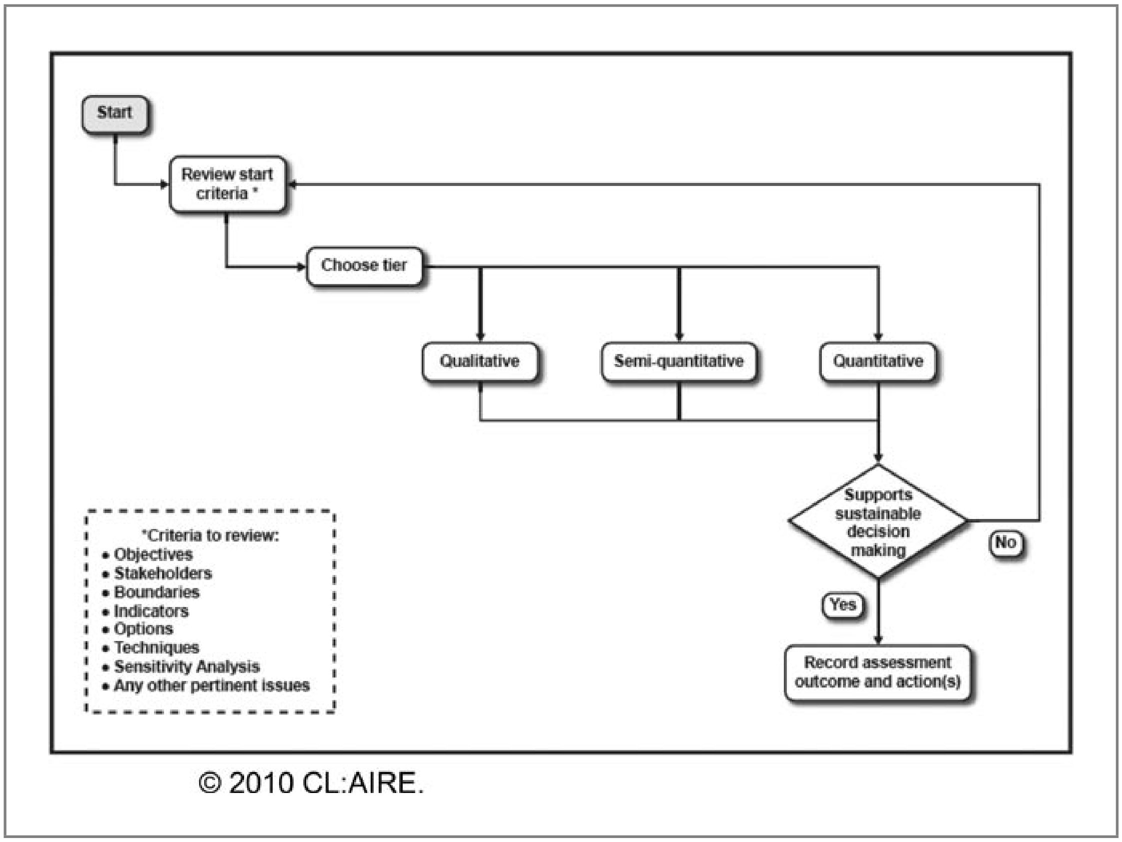

Exhibit 7. The SuRF-UK tiered approach

Step 1: Identifying a Need

The identification of need for a sustainability assessment is linked to the sustainability management goals of a project. Assessments may be needed to compare different options at different points in a land-use management process—for example, "Stage A" or "Stage B" in the SuRF-UK Framework. While the approach to sustainability assessment is essentially similar, including the same procedure and tiered approach, its context will define both the objectives for the sustainability assessment and the stakeholders who need to be involved.

Step 2: Identifying Which Stakeholders to Involve

Whoever is commissioning a sustainability assessment will be using it to support a decision and, therefore, those involved in making that decision ought to be involved in, or be able to comment on, the assessment procedure so that its findings represent a shared point of view. As a rule of thumb, where the findings are to be used to influence a stakeholder (for example, a planner or a regulator), that stakeholder should also have an opportunity for involvement or comment to ensure the approach taken is acceptable to the stakeholder.

Step 3: Agreeing on Objectives for the Assessment

In broad terms, sustainability assessment objectives have:

- a statement of the purpose of the sustainability assessment (e.g., to determine the most sustainable approach to deliver a particular goal);

Exhibit 8. Stepwise procedure for sustainability assessment (adapted from SuRF-UK and NICOLE SR-WG)

	Step	Description
1	Identifying a need	Triggered by a wish of those undertaking a project, or by a regulatory or planning request, for sustainability to be a decision-making criterion at "Stage A" or "Stage B"
2	Identifying which stakeholders to involve	The key criteria for involving a stakeholder in the sustainability assessment relate to *need* (i.e., does the stakeholder have a controlling influence in decision making?) and to *inclusivity* (i.e., is there a policy or wish for wider engagement with potentially affected parties?)
3	Agreeing on objectives for the assessment	From a pragmatic point of view, agreement of findings is unlikely if stakeholders fail to agree on objectives, including: • purpose of the sustainability assessment, • the goals under consideration, • the options being compared by which those goals might be reached, and • how the sustainability assessment findings will be used.
4	Agreeing on the scope of the assessment	These are part of the assumptions underpinning the sustainability appraisal. From a pragmatic point of view, agreement of findings is unlikely if stakeholders fail to agree on a scope. It includes: • boundary conditions, • range of issues (indicators) to be considered, and • any considerations of priority and importance and how these are to be addressed.
5	Agreeing on the sustainability assessment approach	These are also part of the assumptions underpinning the sustainability appraisal. From a pragmatic point of view, agreement of findings is unlikely if stakeholders fail to agree on a method, which includes: • how options are valued (e.g., ranked, scored, weighted, estimated, quantified, etc.), • how a tiered approach might be applied, • how valuations are compared (e.g., in absolute terms or in comparison to thresholds, benchmarks, etc.), • how individual indicator assessments are to be aggregated, • how the overall assessment will be visualized and presented, • how findings will be tested (e.g., with sensitivity analyses), • agreeing on the sustainability assessment reporting approach, and • agreeing on whether/how any assumptions and the assessment might be verified as the project is delivered.
6	Execution of the sustainability appraisal	• Carrying out the valuations • Carrying out the aggregation/visualization • Testing the findings (sensitivity analysis) • Agreeing on verification requirements • Reporting
7	Verification	Monitoring of any sustainability parameters identified as necessary for verification

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- a description of the overall goal being assessed (e.g., for "Stage B," the delivery of a particular set of risk management objectives required for a particular site);
- the options being compared to deliver that goal (e.g., for "Stage B," a list of different remedial approaches); and
- a statement describing how the findings will be used.

These points define the sustainability appraisal, and all other decisions are contingent on this definition. It is therefore important that all key stakeholders involved in a sustainability assessment are "signed up" to its objectives at the outset. SuRF-UK has set out guiding principles about how to consider sustainability in remediation decision making (set out in Exhibit 3) to facilitate reaching this consensus.

Step 4: Agreeing on the Scope of the Assessment

While the guiding principles set out by SuRF largely relate to objective setting, the range of issues to be considered as sustainability and the project boundary conditions set the scope of the assessment.

SuRF-UK believes that the range of sustainability issues to be considered is site- and project-specific. Pediaditi et al. (2006, 2007) point out that while there are a large number of sustainability indicator sets and assessment tools in existence, decisions need to be "owned" by the stakeholders making them. The use of pre-existing "top-down" systems limits this ownership and can limit transparency. They have developed a participatory system for the development of site-specific sustainability indicators for brownfield remediation projects (CL:AIRE, 2007b). Similarly, the European Commission's RESCUE project suggests that sustainability assessment should be based on site-specific metrics developed through a stakeholder process (Edwards et al., 2005).

While the guiding principles set out by SuRF largely relate to objective setting, the range of issues to be considered as sustainability and the project boundary conditions set the scope of the assessment.

Indicators can be used for sustainability criteria to provide a consistent approach to agreeing on the range of issues to be considered (Therivel, 2004). An indicator is a single characteristic that can be compared between options to evaluate their relative performance toward specific sustainable development concerns. A wide range of indicator sets has been developed for sustainability assessment for different purposes, including assessment of remediation (CL:AIRE, 2007b, 2009). Donnelly et al. (2007) suggest a number of factors to gauge the usefulness of particular indicators for environmental assessment, which also seem useful for sustainability assessment:

- How important is the indicator for environment (economy and society)?
- How relevant to the problem is the indicator and how well will it describe the trends from year to year?
- How much effort and money must be used to retrieve the data?
- How big is the uncertainty of any calculations?
- How good is the indicator to provide a basis for actions and plans?
- How well will the indicator perform to provide a basis for comparison across time and between different geographical areas?

Factors in sustainability can interact. For example, the impact of emissions of greenhouse gases may be a concern. But also, another sustainability concern might be the robustness of a remedial solution itself to future climate change (Al-Tabbaa et al., 2007).

Exhibit 9. Overarching categories for indicators of importance to sustainability assessment for remediation (CL:AIRE, 2010b)

Environmental	Social	Economic
1. Impacts on air (including climate change)	1. Impacts on human health and safety	1. Direct economic costs and benefits
2. Impacts on soil	2. Ethical and equity considerations	2. Indirect economic costs and benefits
3. Impacts on water	3. Impacts on neighborhoods or regions	3. Employment and capital gain
4. Impacts on ecology	4. Community involvement and satisfaction	4. Gearing
5. Use of natural resources and generation of wastes	5. Compliance with policy objectives and strategies	5. Life-span and "project risks"
6. Intrusiveness	6. Uncertainty and evidence	6. Project flexibility

The SuRF-UK framework has made a *preliminary* categorization of how indicators can be grouped across the three elements of sustainability, listed in Exhibit 9, as a benchmark of the breadth of issues that might be important for sustainability assessment for remediation. The framework points out that not all of these issues will be important for all sites. The categorization groups similar indicators under thematic "headlines" as suggested by Worrall et al. (2009). This thematic approach is also scaleable. At its simplest, a sustainability assessment might be finding a consensus between stakeholders about the relative merits of different options in broad environmental, economic, and social terms. This might be sufficient for small projects. However, comparison across headline categories in an overarching way allows a more detailed assessment, while the greatest degree of rigor follows from identifying individual indicators of importance within each category, and aggregating a view across all of these individual assessments. The degree of rigor is likely to be set by what is agreeable to the stakeholders in a decision (e.g., client, regulator, planner, service providers) for a particular site/project.

There are two fundamental boundary conditions in life-cycle assessment that SuRF-UK suggests are applied to sustainability assessment: the "system boundary" and the "life-cycle assessment boundary." The system boundary describes the project goals for which options are being compared. Each option needs to address the same system for a comparison to be fair. For example, the inputs and outputs of a biopile cannot be directly compared with an excavation and removal alternative; what needs to be compared are the complete sets of remediation options in one case, including use of a biopile, and in the other case without. An example boundary statement might be: "Delivery of the 'remediated site' including all benefits and impacts whether local or distant, temporary or permanent." The life-cycle assessment boundary in effect sets a limit to the inputs and outputs that will be included in the assessment. For example, a boundary statement might be "consumption by the project but not the impacts of manufacturing capital equipment (like an excavator)." There are two other sets of boundary conditions that *may* be of interest in a decision: a boundary related to a geographical area (for example, to allow a separate discussion of local impacts) and a boundary set in time (for example, to allow a separate discussion of temporary project-related impacts vs. long-term outcomes, and to define a planning horizon over which any costs and benefits may be accrued). Page et al.

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Exhibit 10. Selected decision-support techniques with relevance to sustainable remediation assessments (amended from Bardos et al., 2010; CL:AIRE, 2010b)

Technique	Environment	Economy	Society	Type	CLM Application?
Scoring/ranking systems (including multicriteria analysis)	Narrow to Wide	Narrow to Wide	Narrow to Wide	Both	Yes
Best available technique (BAT)	Narrow to Wide	Narrow	-	Qual	Yes
Carbon footprint ("area")	Narrow	-	-	Quan	Yes
Carbon balance (flows)	Narrow	-	-	Quan	-
Cost-benefit analysis	Narrow to Wide	Narrow to Wide	Narrow to Wide	Quan	Yes
Cost-effectiveness analysis	Narrow to Wide	Narrow to Wide	Narrow to Wide	Both	Yes
Eco-efficiency	Narrow	-	-	Quan	-
Ecological footprint	Narrow	-	-	Quan	-
Ecosystem services (Vejre et al., 2009)	Wide			Both	Yes
Energy/intensity efficiency	Narrow	-	-	Quan	Yes
Environmental risk assessment	Narrow to Wide	-	-	Both	Yes
Human health risk assessment	-	-	Narrow	Both	Yes
Environmental impact assessment/ strategic environmental assessment	Narrow to Wide	-	-	Qual	Yes
Financial risk assessment	-	Narrow	-	Quan	Yes
Industrial ecology	Narrow to Wide	Narrow to Wide	-	Quan	-
Life-cycle assessment (based)	Narrow to Wide	-	-	Quan	Yes
Quality-of-life assessment	Wide	Wide	Wide	Qual	-

Notes:
Qual = Qualitative.
Quan = Quantitative.
Both = Qualitative and/or quantitative.
CLM = Contaminated Land Management.
- = Technique has no known coverage.

(1999) provide an example of boundary setting for life-cycle assessment of remediation options, explicitly considering system, time, and geographical boundaries.

Step 5: Agreeing on the Sustainability Assessment Approach

The sustainability assessment approach describes the tools and techniques used to aggregate the findings from individual considerations of indicator criteria into an overall understanding of sustainability. A wide range of sustainability assessment techniques and tools has been published (Building Research Establishment, 2004; Therivel, 2004), and a number have been applied to remediation work (e.g., Bardos et al., 2002; EURODEMO, 2006). Exhibit 10 summarizes the "techniques" most likely to be applied to sustainability assessment. It is important that any tools or techniques are used as an aid to decision making, and not to provide the final decision. Ultimately, the assessors make the decision, not the sustainability tool.

Step 6: Execution of the Sustainability Assessment

SuRF-UK suggests the use of sensitivity analysis for testing the robustness of assessment findings against changes in key assumptions, and also for reassuring stakeholders that the effects of diverging opinions on assumptions and priorities on the findings can be tested in a consistent and transparent manner.

DISCUSSION AND CONCLUSIONS

The efforts of SuRF-UK to apply sustainable development principles to contaminated land management have revealed an intuitive tendency on the part of contaminated land practitioners to focus on the environmental impacts of remediation methodologies.

The efforts of SuRF-UK to apply sustainable development principles to contaminated land management have revealed an intuitive tendency on the part of contaminated land practitioners to focus on the environmental impacts of remediation methodologies. The merits of this approach are well founded and represent an important step toward developing a zero-waste, low-carbon society. Where historical in its origin, contaminated land is an inherited problem that requires expense of energy and capital to remediate. In this context, to tackle this legacy sustainably and in a manner consistent with the principle of sustainable development is to do so in a manner such that the benefits of the activity outweigh the impacts, in environmental, social, and economic terms. This net-benefit approach is recognized by sustainable remediation initiatives throughout the world. However, the terms under which it is assessed do not have global consensus.

Assessing these environmental, social, and economic terms in a consistent manner is a key challenge to effective assessment of sustainability. Embracing and working with the subjectivity of the process needs to be accepted and the limitations of using an absolute unit of sustainability recognized.

One of the key conclusions of the SuRF-UK work to date was to recognize the significant sustainability gains that exist by considering contaminated land management options as early in the design process as possible. Practitioners are all aware of the value that can be added by remedial design optioneering early in the process, especially where site-specific risk-based criteria linked to an end-use can be used to define unacceptable risks and remediation criteria. Recognizing that, in practice, there is a point at which this design optioneering cannot be influenced any further and that a fixed design has to be agreed and taken forward is an important aspect of the SuRF-UK framework. The basic structure of the SuRF-UK framework is robust across different timescales, site sizes, and project types. It can support decisions at both a local land zoning and planning level and at a site level, in scale from a large brownfield development to a small operational spill cleanup.

The overlap of risk assessment and sustainability has emerged as a much-discussed issue in the role of contaminated land management. Site-specific risk assessment based around suitability for land use underpins sustainable contaminated land management but does not necessarily constitute a sustainable approach. Any risk-based assessment criterion is founded on assumptions of toxicity and acceptable levels of risk, and arguably these must stand as a non-negotiable point of reference. The means of achieving these criteria may be met using a variety of technologies with considerably different abilities to meet environmental, economic, and social performance standards—for example, of emissions to land, water, and air; energy consumption; waste generation; and impact on local transportation or amenities. These issues can only be collectively considered in a

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sustainability assessment. The SuRF-UK framework is the first of its kind to influence the design and implementation of such an assessment at a local or site level.

ACKNOWLEDGMENTS

The authors are grateful for funding for SuRF-UK from the Homes and Communities Agency (HCA), which is the national housing and regeneration agency for England. However, the views expressed are those of the authors and may not represent the views or policies of either the HCA or the authors' respective organizations. The authors are also grateful to SuRF-UK forum attendees who contributed to development of the framework. Further detail can be found at www.claire.co.uk/surfuk.

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