Special Sessions

SPS 9. COMMON THEMES AND PRACTICE IN ACHIEVING SUSTAINABLE REMEDIATION WORLDWIDE, WITH CASE STUDIES AND DEBATE

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Abstract

All over the world Sustainable Remediation Forums are paving the road for sustainable development of contaminated land. In a combined session these forums would like to demonstrate and discuss their approach through short presentations of case studies and discussion.

1 Introduction

In the past decade or so, 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.

SPS9 included two special sessions which incorporated presentations and discussion periods. This paper provides a written précis for each of the presentations given at the special session.

2 Worldwide listing of sustainable and green remediation initiatives and how they collaborate

A number of networks worldwide are now regularly meeting to share their common understanding of achieving sustainable development when remediating or regenerating damaged sites or land area. They aim to share progress and learning amongst the different networks and develop opportunities for collaboration. It is hoped that by communicating on a regular basis it will help raise the awareness of the work that each group is undertaking in their different countries and help drive consistency between the different initiatives where appropriate. Further information is available at www.claire.co.uk/surfinternational.

The established national initiatives include Sustainable Remediation Forum (SURF) in the USA, SuRF-UK, SuRF-NL, SuRF-ANZ, SuRF-Canada as well as more recently developed initiatives in other countries including Italy, China and Brazil. The two major European stakeholder networks, NICOLE (industries and services / technologies providers) and COMMON FORUM (regulators and policy makers) are also active in this field. It is remarkable the degree of consensus across these initiatives about what a vision of "sustainable remediation" might be. In broad terms concepts of sustainable remediation are based on the achievement of a net benefit overall across a range of environmental, economic and social concerns that are judged to be representative of sustainability.

In the past decades or so management of historically contaminated land has largely been based on prevention of pollution ('stand still principle) and 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 for risk management. 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.

Sustainable remediation covers a wider range of sustainability impacts and benefits; and also integrates with ideas of sustainable regeneration (e.g. UK) sustainable land use (e.g. COMMON FORUM, UK) and sustainable soil management (e.g. NL). A related concept is "green remediation" being advanced by the US Environmental Protection Agency (US EPA), which focuses on minimizing or mitigating the environmental impacts of remediation activities in mature site clean-up programs and regulatory frameworks.

Sustainable remediation has become an area of intense development across the world. Public and private sector organisations have become involved in a number of projects and networks, with the intention to improve remediation practice and make it more sustainable. These initiatives are described in more detail in ThS E3 Sustainable use of the subsurface: Bardos *et al.* SUSTAINABLE AND GREEN REMEDIATION – GLOBAL UPDATE, *ibid*.

3 SURF's "Global Perspectives on Sustainable Remediation" White Paper

Over the last six years, the Sustainable Remediation Forum ("SURF") has evolved from an *ad hoc* organisation with just a few members to becoming a registered non-profit with several hundred active participants. During this time, the group has inspired like-minded people internationally, resulting in the formation of SURF groups across five continents, from the United Kingdom to Australia and New Zealand, and from Brazil to Taiwan.

Leveraging the enthusiasm generated from the proliferation of sustainable remediation thinking across the globe, SURF organised an international meeting in Washington DC in December 2012 at the National Academy of Sciences. SURF representatives and partners from all over the world travelled to the meeting to represent their various sustainable remediation organizations and to share their experiences and lessons learned. The overarching objective of this meeting was to gather information on the state of development of sustainable remediation around the world to develop a White Paper summarising best practices and case studies in the representatives' respective countries.

The creation of this White Paper is a true international collaboration effort with each country with a SURF affiliate or partner providing contributions to the paper. The paper will provide a background to the synthesis of this document. Each sustainable remediation organisation across the globe will then be introduced. These groups' structure, membership and mission will be summarised. Each organisation will also share how they balance the three facets of sustainability (i.e. environmental, social and economic). Currently available, country-specific and international frameworks, guidance documents, and tools will be presented. Barriers to sustainable remediation, lessons learned and opportunities to improve the practice will also be documented. International case studies will be provided in order to demonstrate the real-life cross-border applicability of sustainable remediation.

It is expected that the White Paper will be published in 2013. It is anticipated that this paper will further tip the balance to sustainable remediation becoming intertwined with the wider sustainable development movement.

4 Progress towards an ISO standard

Sustainable remediation seeks to eliminate and/or control unacceptable risks in a safe and timely manner, whilst maximising the overall environmental, social and economic benefits of the remediation work. The worldwide interest in the concept of sustainable remediation has led to the formation of many trans-national initiatives, national groups and projects. While information is widely shared, its national provenance means that there is substantial duplication of effort among these groups and the information, whether in the peer review or grey literature, has little regulatory visibility and hence little impact on everyday practice. An International Standards Organisation (ISO) document on sustainable remediation would be 'visible' in all countries and would therefore allow an international collaboration to take place to ensure maximum benefit is gained from the volunteer time available. The ISO standard is being developed by a working group (12) of the Technical Committee 190 (Soil Quality) Sub Committee 7 (Soil and site assessment). See: www.iso.org/iso/home/standards_development/list_of_iso_technical_committees/iso_technical_committee.htm?commid=54408

The document is intended to be an informative or guidance document rather than a standard specification or normative document. It will seek to establish a common internationally accepted terminology and understanding of the components of sustainable remediation. The detailed working out of what is and is not sustainable remediation will be influenced by local factors to such an extent that greater prescription is inappropriate at this time. The document will provide guidance on sustainable remediation. In particular, a standard terminology and information about the key components and aspects of sustainable remediation ought to help the implementation of the practice. Sustainable remediation will be contrasted with the related concepts of sustainable brownfield redevelopment and sustainable reclamation as well as the distinct and separate concept of green remediation. In addition it will provide a document that distills available information in a place that has regulatory visibility and therefore encourage the take up of sustainable remediation principles in ways that grey or even peer reviewed literature cannot.

Anyone interested in keeping in touch with general developments in sustainable remediation should consider joining their local sustainable remediation forum and for wider news the sustainableremediation email forum (go to https://www.jiscmail.ac.uk/cgi-bin/webadmin?SUBED1=SUSTAINABLEREMEDIATION&A=1)

5 An international state of the art technical reference

A thematic issue on "sustainable remediation" is underway for a well-known journal. This is being coordinated by Prof Paul Bardos for the University of Brighton's involvement in an EU funded project on low input ("gentle") remediation called Greenland, www.greenlandproject.eu. The expected date of publication is mid to end 2014. The coordination will be supported by a technical committee, including:

- Andy Cundy (University of Brighton),
- Dominique Darmendrail (COMMON FORUM, BRGM)
- Nicola Harries (SuRF-UK and CL:AIRE)
- Karin Holland (SURF, Haley Aldrich, USA)
- Dietmar Müller (EAA),
- Carlos Pachon (US EPA),
- Jonathan Smith (SuRF-UK, Shell Global Solutions).

The original rationale for this publication had two principle elements:

1. At present the large volume of recent information and know-how available on "sustainable remediation" has yet to be gathered in one place, such as a book where it can be used by key user groups such as the consultancy sector and land managers, training providers and research establishments.
2. A significant amount of the information and know-how so far produced could benefit from publication following an independent peer review process, which would also maximise the interest of the academic sector in providing supporting R&D.

Experience in other sectors has shown that thematic issues of existing technical journals can bridge this gap and provide a suitably robust platform for the information collected. This approach also benefits from the use of existing systems for managing papers and their peer review. At this point in time the main concern is to find an approach where the journal publication is free at point of use and available on-line.

The aims of this publication are to collect the outputs of the various sustainable (and green) initiatives in an overarching way, and subject them to a common standard of peer review. It will provide a definitive statement of the technical state of the art for sustainable and green remediation, along with the perspectives and concepts that underpin sustainable/green remediation and a view of future direction of travel.

What this publication will not seek to do is to provide frameworks for harmonisation and standardisation, nor for policy development and regulation. These are developments that are already underway, e.g.

- SURF International White Paper
- ISO proposal
- COMMON FORUM / ICCL

However, it could support these initiatives by providing consolidated source material.

A resource that is free at point of use, well promoted and in a well established journal is intended to improve access for organisations which hitherto may not have been fully engaged in our discussions (e.g. SMEs and organisations with limited access to the existing system of networks).

The provisional scope of the thematic issue will be to cover:

- Scene setting
- Overarching principles
- Tools, techniques and applications
- Domains (e.g. operational sites, brownfields etc)
- Measures (e.g. “gentle remediation”)
- Future direction of travel.

The likely approach will be to combine an invited paper in each segment with an open call for additional papers, with a target of 15-20 papers across the thematic issue.

6 Key findings of the Vienna Sustainable Remediation Conference, 2012

As a successor to a series of events since the Green Remediation Conference Copenhagen 2009 the 2nd International Conference on Sustainable Remediation (SustRem 2012) was held in Vienna (November, 14 – 16). The event was organized by the Environment Agency Austria in cooperation with the U.S. Environment Protection Agency, the CL:AIRE and the University of Natural Resources and Life Sciences (BOKU), Vienna. 120 participants (4 continents, 23 countries) discussed following a plenary track and in several workshops how projects may successfully contribute to sustainable development. The main thematic blocks at the plenary of the conference concerned theoretical and practical strategies for the sustainable remediation of contaminated sites as well as the environmental policy framework. The conference was closed by a Round Table discussion of representatives of SuRF US, SuRF UK, SuRF ANZ, NICOLE and COMMON FORUM along the following key questions:

1. Are sustainability management and risk management in conflict?
2. Can the environmental footprint of remediation projects be reduced?
3. Will sustainability be widely accepted as a tool in remediation decision making?
4. How closely are sustainable remediation and regeneration related?

The panellists concluded that implementing sustainability into remediation may not be seen as a concept to replace but to complement the commonly used risk based approach. Experiences up to now indicate that involving all key stakeholders, establishing clear definitions and practicing intensive communication are the most crucial issues in the process towards a common understanding on sustainable remediation and towards the implementation of conceptual frameworks.

When assessing sustainability, it should be kept in mind that ‘‘sustainability’’ is a relative term relying on values to be defined and accepted by each society. Consequently, ‘‘sustainability’’ – or better: the question whether an action is referred to as ‘‘sustainable’’ –, necessarily, has to be variable in space and time. “Sustainability’’ in its entirety is not measurable. Instead, indicators need to be defined reflecting specific aspects of sustainability. By measuring or assessing and processing these indicators in an appropriate way and by comparing the results relatively to each other, a ranking of options according to their ‘‘sustainability’’ may be achieved (e.g. option A is ‘‘more sustainable’’ than option B). The selection of an assessment methodology and the selection of criteria or indicators as well as their weighting and the way to handle and process them should be as transparent as possible and preferably be organized as an open and consensus based procedure including all relevant stakeholder groups. Reliability of input data, including a sound and comprehensive conceptual site model (CSM) and appropriate handling of uncertainties, as well as transparency of data processing, i.e. avoiding a “black-box”, are crucial in perspective of a commonly accepted and robust result.

As for practical experiences more than half of platform presentations reflected the broad variety of possible ways to apply the concept of sustainable remediation in practice. For the majority of the case studies stakeholder involvement was reported, albeit in different project phases and with varying intensity, extent and focus. Most of the case studies still focused on the environmental perspective of sustainability and on costs. Accordingly panellists of the final Round Table Discussion emphasised that the environmental footprints of remediation should be considered and mitigated, but future challenges will be to do it in concert with efforts to improve the social and economic performance of remediation projects. Actually the presentations at the conference indicated some new and promising attempts to include the social dimension of sustainability by developing appropriate indicators.

Discussions on whether sustainability will be widely accepted met a balance of pro and cons. Practitioners, whereas it seemed obvious that (re)development of brownfields is closely related to sustainable remediation and will in many cases trigger the implementation of socio-economic and social issues into the remediation contaminated sites.

As a general conclusion the comparision to the first conference back to back to the UN Climate Summit in Copenhagen in 2009 (COP 15) the second conference four years later showed that significant progress in rehabilitation practices can be reported in some countries. Particularly in the U.S., the UK, Belgium, the Netherlands and Sweden, policy and project operators have designed innovative approaches and implemented them in various projects.

The presentations and a summary report of the conference are available for download (http://www.umweltbundesamt.at/en/news_events_reports/events_eaa/sustainable_remediation2012/) And from 2014 via www.eugris.info.

7 Case Study: Sustainability assessment of interactions between groundwater and surface water systems, a case study in the Netherlands

7.1 Introduction

The interaction between surface water and groundwater systems is complex and taking effective and sustainable measures to protect surface water quality for soil contamination can be a challenge. Besides technical issues addressing surface water quality issues requires cooperation between stakeholders: water quality managers, soil policy makers and problem owners. Local situations may vary strongly and practical solutions need to be tailored. In this project a sustainability assessment was an important tool in the evaluation of a groundwater pump and treat system.

7.2 Case

On an industrial site in the Netherlands, the production of pesticides in the fifties led to a complex and extensive contamination of soil and groundwater. The area surrounding the production site is also contaminated with chlorinated pesticides. The site is situated along a canal, which is divided into several sections by sluices, managed by Dutch water authorities (Rijkswaterstaat (RWS)).

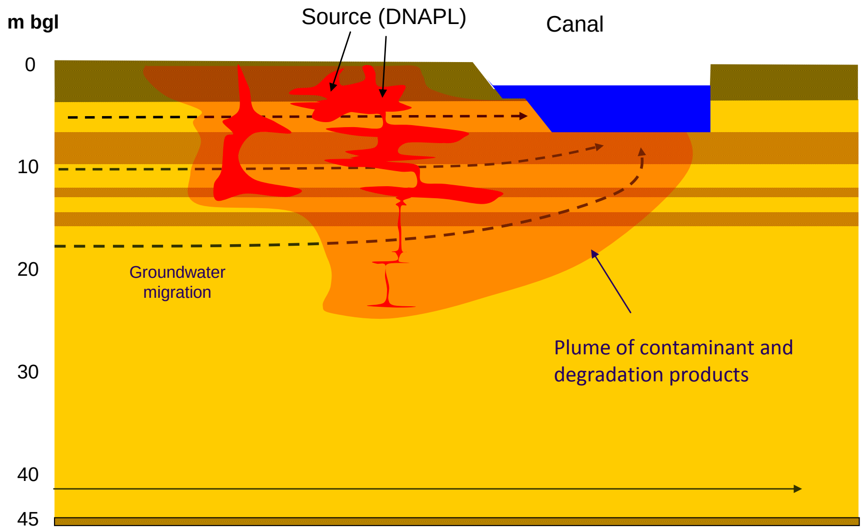


Figure 1 Conceptual model of the contaminated site

The presence of pesticides and degradation products was confirmed in surface water and sediments. The analysis of the quality of the surface water and sediments demonstrated that in the present situation there is no unacceptable actual environmental risk in the canal. However, at downstream monitoring points the pesticide contaminant levels in surface water were above yearly average quality criteria established in the Water Framework Directive (WFD). The water quality board RWS seeks to improve the quality of surface water at the location of the WFD points. Authorities urged the problem owner to undertake remedial action towards the emission of the contamination on the Canal. At the same time plans were developed to transfer the site into a container terminal.

The problem owner decided to contain the groundwater contamination at the former production site by an interception pump and treat system to prevent groundwater emissions to the canal. In 2007 a groundwater extraction system consisting of 30 deepwells and a groundwater treatment system (based on active carbon adsorption) was constructed and started operation.

7.3 Evaluating the remediation approach

A detailed analysis of the yearly evolution of the surface water quality in the period before the pump and treat and during the pump and treat was performed by analyzing a monitoring database provided by RWS. Contaminant levels in the canal water were strongly influenced by several processes.

Analyses of the available data demonstrated that the concentration level in the surface water was influenced by seasonal fluctuations of the surface water flow direction. In dry periods surface water is contained in the canal to obtain a sufficient water level to maintain navigability. The water management results in high concentrations of contamination in the surface water at the site in dry periods. In wet periods water is drained from the canal into a river resulting in low concentrations.

Comparison of the contaminant discharge into the canal in a natural situation before the pump and treat operation and the emission during the groundwater pump and treat demonstrated the importance of natural processes in the soil system. No improvement of the surface water quality was observed during the pump and treat. The contaminant emission under natural conditions appeared to be comparable to the emissions of the effluent of the groundwater emission. The groundwater system and the natural barrier at the interface of groundwater and surface water apparently is an important reactive system that reduces the level of contamination before it reaches the surface water.

Based on these data the effectiveness of the hydrological containment was evaluated. A multi criteria analysis of the effectiveness of the groundwater extraction, taking sustainability aspects into account with the REC framework, was established in close cooperation with the stakeholders. The REC model was developed in the Netherlands in 2000 as a sustainability assessment tool to evaluate soil remediation alternatives. The REC model is an excel-based assessment tool that consists of elements: Risk reduction, Environmental Merits, Cost. The analysis was focused on the environmental impact of the activities. In figure 2 the result of the analysis is presented.

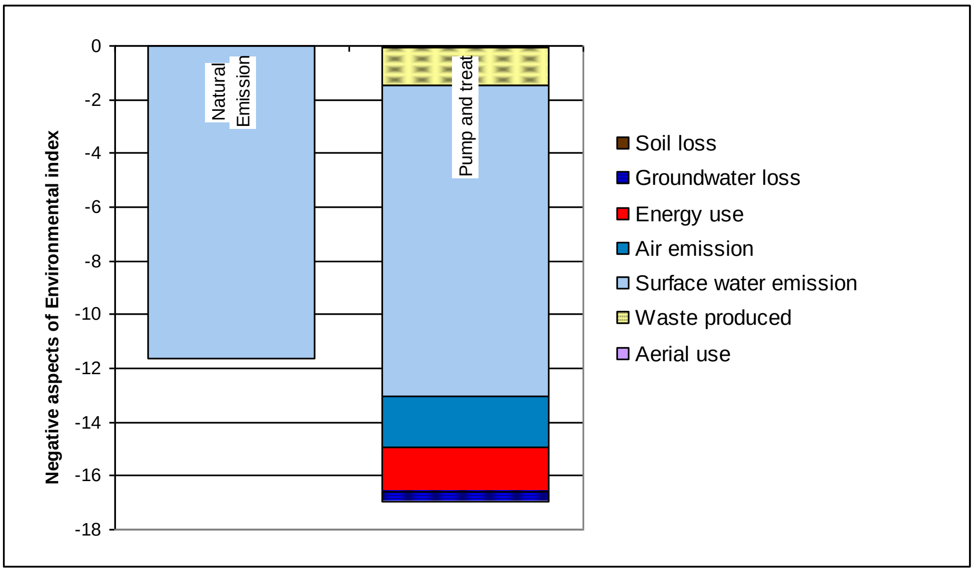


Figure 2 **Result of the negative environmental impact analysis with the REC model**

The REC analyses demonstrated that the contaminant emission on the surface water was the most important aspect. Based on the observation that in both cases the emission of contamination was comparable, any additional remediation action will lead to an increased negative impact.

The cost of the actual treatment of the pesticide containing groundwater was determined form the field data at EUR 2.900 per kg contamination. This is beyond the threshold value of EUR 2.250 per kg that has been defined to determine cost effectiveness of groundwater treatment plants (CIW Richtlijn) in the Netherlands.

Based on the result of the REC analyses and cost effectiveness threshold all parties decided to terminate the active containment by groundwater extraction after three years operation and study the development of the surface water quality under natural conditions. Up to now two years of monitoring has demonstrated a gradual decrease of contamination concentration in the surface water at the site. Natural processes are gradually decreasing the emission. In the down gradient official WFD monitoring point the concentration is also decreasing, but is not yet below the threshold value.

Case Study: A live assessment undertaken as part of remediation options appraisal during competitive tendering

8.1 Introduction

The decision making process for contaminated land remediation is influenced by many factors which include sustaniability factors as well as the more traditional technical and commercial aspects. There are many stages to progressing a remediation project from concept to delivery in the field and these involve, as well as investigation, risk assessment and design, consultations with the relevant regulators and stakeholders gaining planning permission and other regulatory approvals. In addition it is essential that one selects the most appropriate, cost effective and practical solution to the problem. This process can be clouded by clients requiring a competitive element to tendering the works and it is easy to lose sight of the purpose of the project when focusing on costs alone. This case study highlights when, where and how the SURF UK framework can be used to aid the sustainable redevelopment of previously developed sites and in particular highlight how this can be used at tender stage before award to influence decisions early as well as being followed through to the project. There are key benefits to all stakeholders including the client and contractor undertaking the work as is demonstrated below.

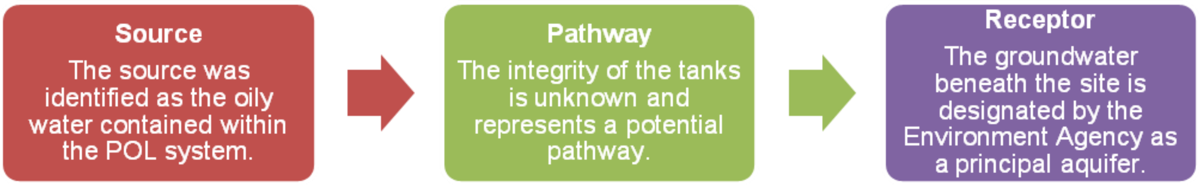
8.2 The Site

RAF Upper Heyford is located 7 km northwest of Bicester, Oxfordshire (United Kingdom) in a rural location, within the parishes of Upper Heyford, Somerton and Ardley. The site extends over 505 hectares, and has been designated as a conservation area in view of its heritage as a former airbase. A Remediation Options Appraisal was undertaken to determine the scope of work required. Planning consent, an overriding planning policy and planning conditions were already in place for the site. Although the remediation options appraisal was undertaken at Stage B of the assessment, there were only a few limiting factors to consider as part of the options appraisal which allowed a varied number of options to be considered as part of the SuRF assessment. Following redevelopment the site is to provide a new settlement of approximately 1000 homes and associated infrastructure and amenity. As well as requiring remediation the heritage interest of the site as a military base with Cold War associations was also to be conserved, compatible with achieving a satisfactory living environment.

The Petroleum, Oil and Lubrication (POL) system comprised a network of circa 13km of pipework and approximately 71 tanks, with a capacity of approximately 30 million litres. Historically, it was used for the storage and distribution of aviation fuel, petrol and diesel above and below the ground. During the 1990s, it is understood that all fuels were removed and the system was filled with water and reportedly an alkaline substance to prevent corrosion. With the exception of isolating the POL system from the UK fuel distribution system little further work was done. “Oily” water is known to be contained within the system and asbestos containing materials are known to remain in parts of the POL system.

8.3 Site conceptual model

A risk management plan had been prepared for the POL system looking at its current condition and investigating the contents of the decommissioned tanks. The risk management plan identified that the tanks all contained oily water and sludge that posed a potential risk to the environment. Each tank was given a risk rating dependent on the concentration of hydrocarbons identified and its proximity to groundwater (depth below ground level). The risk management plan identified that the POL system in its current condition represented an ongoing liability and that a potential source – pathway – receptor linkage was present. TPH contaminated water in the tanks (the source), could leak from the tanks and pipelines and migration through underlying ground (the pathway) leading to impact on the groundwater beneath the site (the receptor). The risk management plan concluded that that in order to remove the residual risk of the POL system it should be ‘cleaned and made safe’.



8.4 Remediation Objectives

The outline remediation objectives for the decommissioning of the POL system were:

- Objective 1 - The removal of any potential liquid, sludge, emulsion, solid, vapour and gaseous sources of contamination that are currently within and/or associated with the POL system;
- Objective 2 - Breaking of the internal and external potential pathways for contaminants to enter the environment that exist as a result of the presence of the POL system including the buried pipelines on site; and
- Objective 3 - Ensuring that the system cannot become a future source of contamination or a pathway for any contamination, be it contamination either related or unrelated to the existence and/or previous operation of the POL system on site.

There were a number of site constraints which had to be considered when choosing the remediation options, these included restrictions due to the ecological status of the site, restrictions due to the built heritage on site, the need to preserve the heritage of the POL system in accordance with English Heritages requirements, the need to minimise disruption to other site users and adjacent site users and to comply with all restrictions and recommendations related to the potential for Unexploded Ordnance (UXOs) on site.

8.5 Why did we assess sustainability?

The remediation options appraisal and sustainability assessment was undertaken as part of a competitive tendering process. Its objective was to provide commercial advantage at tender stage to show our understanding of the issues and also to inform the decision making process. It was also the intention to clearly demonstrate to regulators that our selections were the most sustainable. The outcomes resulted in us undertaking the project according to the choices made as part of the assessment. It informed decisions relating to refining the PFA stabilisation mix, treating water on site and to discharging treated water to land. The assessment suggested it was more sustainable for pipelines to be foam filled but the tanks decommissioned using PFA.

8.6 Sustainability Assessment

The assessment was undertaken in two stages with both qualitative and semi quantitative and quantitative elements. The assessment was based on the remediation objectives listed in above, these were used as the boundary conditions for the assessment, including timescales and restrictions to ensure protection of environmental and social aspects of the site. The initial stage of the remediation options appraisal was to identify potential remediation options which would meet the criteria for the works. Including breaking any source pathway receptor pollution linkages present on site. In light of the remediation options being identified, a semi quantitative assessment was made of the effectiveness and ease of implementation / practicality of the remediation option to meet these objectives. The remediation options were then assessed for their sustainability using the sustainability indicator parameters identified in the SuRF framework. A score was given for each group of parameters ENV, SOC and ECON. The scoring system was equally distributed between the Effectiveness and Practical Implementation of Remediation Technique vs the Sustainability, with a maximum of 15 being scored for each half of the assessment.

(	Effectiveness of Remediationx Technique	Practical Implementation of Remediation Technique	)	+	Assessment of ENV	+	Assessment of SOC	+	Assessment of ECON

Effectiveness of Remediation technique	Practical Implementation of Remediation Technique	Assessment of Sustainability
1. Ineffective, unlikely to meet remedial targets / objectives **2.** Partly effective, but still unlikely to meet remedial targets / objectives **3.** Effective, likely to meet remedial targets / objectives **4.** Very effective, very likely to meet remedial targets / objectives **5.** Entirely effective, will meet remedial targets / objectives	**1.** Impractical, requires significant enabling works significant impacts to cost, programme and the environment. **2.** Practical, requires some enabling works, some impacts to cost, programme and the environment. **3.** Very practical, with minimal impacts to cost, programme and the environment.	**1.** Unsustainable (no benefits to the following: ENV, SOC , ECON) **2.** Partly Sustainable (benefits one of the following: ENV, SOC , ECON) **3.** Sustainable (benefits two of the following: ENV, SOC, ECON) **4.** Very Sustainable (benefits three of the following: ENV, SOC , ECON) **5.** Extremely Sustainable (significant benefits to all three of the following: ENV, SOC , ECON)

Stage 1: Assessment included this semi Quantitative Assessment of all 14 of the indicator parameters. Uncertainties were assessed qualitatively as part of the conclusions and discussion for each remediation option. the following table summarises the outcome of this assessment with score for each of the options.

Remedial Technology Description	Effectiveness	Practical Implementation	Environmental	Social	Economic	Overall Score
Option T1 Clean and vent only	2	3	1	2	2	11
Option T2 Confirm absence of contamination outside the tanks, 'drill' tanks and allow groundwater equilibrium within tanks	2	4	2	2	2	14
Option T3 Fill with foamed concrete	5	4	3	4	3	30
Option T4 Fill with PFA Grout	5	4	5	3	4	32
Option T5 - Break into side of tanks and bulk fill with Fill with Crush	3	2	3	3	3	15
Option T6 - Break into side of tanks and bulk fill with conditioned PFA only	4	3	3	2	4	21
Option T7 - Foam fill (Bacel hard foam)	5	4	2	3	1	26
Option W1 - On site water treatment and disposal to foul sewer	5	0	N/A	N/A	N/A	0
Option W2 - Off site disposal via tanker to treatment facility	5	4	2	2	1	25
Option W3 - On site water treatment and disposal to controlled waters	5	4	4	4	4	32
Option P1 - Foam fill (Bacel hard foam)	5	4	4	4	4	32
Option P2 Fill with foamed concrete	4	3	3	3	4	22
Option P3 Fill with PFA Grout	4	4	4	3	4	27

EXTRACT TABLE FROM ASSESSMENT

Stage 2: Following the initial screening, the remediation options with the highest scores were taken to the next level of assessment, this included a detailed qualitative assessment of the key indicator parameters identified in the initial screening process, including an assessment of the uncertainties identified. In addition a quantitative assessment of the carbon footprint of the different options was undertaken. As part of this assessment, alternative working methodologies and materials were considered that could improve the sustainability of the project. As part of the Stage 2 assessment a cost benefit analysis of the remediation options was undertaken. A basic carbon calculation was undertaken, based on the embodied carbon of the materials (where data could be obtained), fuel consumption of the plant and transport distances for materials. The embodied carbon data was sourced from ICE database, Environment Agency carbon calculator and data sourced from suppliers. These were then factored to provide overall decisions for elements of the project. A full life cycle analysis of the options was not undertaken as this assessment as reliable information was difficult to find and the assumptions that would have to be made were considered to broad to provide valid data. This assessment concluded that the the most sustainable option for the filling of pipelines was the foam filling option (whilst not the most cost effective), the tanks were most appropriately addressed using a PFA grout mix the mix design also assessed via the same methodology. It was most sustainable to treat water on site and discharged to land and following initial reluctance the Environment Agency were supportive given the strong sustainability argument.

8.7 Summary

In summary overall the most sustainable remediation solution was adopted for the site and the SuRF assessment was an essential part of this aiding and informing these decisions and also in communicating them to other stakeholders. At the tender stage it allowed us to have confidence in our decisions and to communicate to the client that we could provide cost effective technical solutions which demonstrated and met the projects sustainability objectives. Following award it allowed us to engage with stakeholders on an informed basis allow the Environment Agency to make quick informed decisions on permitting and acceptance of the chosen remediation methods. The use of PFA grout over other solutions offered sustainability wins as well as a cost effective solution. The use of on site water treatment over off site saved lorry movements and provided other environmental benefits. The assessment also identified the fact that the other factors outweighed the economic factors for the pipeline decommissioning resulting in a more sustainable but more expensive option being selected this ultimately provided a well balanced and sustainable approach to the whole project.