Review of Comments on: Environment Agency Public Consultation Paper - Principles for Evaluating the Human Health Risks from Petroleum Hydrocarbons in Soils

Science Report P5-080/TR2

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Professor Mike Depledge Head of Science

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ABBREVIATIONS

CCME	Canadian Council of Ministers of the Environment
DRO	Diesel range organics
GRO	Gasoline range organics
ICRCL	Inter-departmental Committee on the Redevelopment of Contaminated Land
ID	Index Dose
MADEP	Massachusetts Department of Environmental Protection
MCERTS	Monitoring Certification Scheme
MTBE	Methyl tertiary-butyl ether
RIVM	Dutch National Institute for Public Health and the Environment
SCA	Standing Committee of Analysts
SEPA	Scottish Environmental Protection Agency
SSTL	Site specific target level
TDI	Tolerable daily intake
TPH	Total petroleum hydrocarbons
TPHCWG	Total Petroleum Hydrocarbon Criteria Working Group
UKELA	UK Environmental Law Association

1. INTRODUCTION

The Environment Agency is developing an approach for the evaluation of the risks to human health from petroleum hydrocarbon-contaminated soils. A public consultation was undertaken to solicit views on the principles that will underpin the framework within which these risks will be assessed.

Petroleum contamination in soils is currently evaluated in the UK using a wide variety of approaches, ranging from the assessment of 'Total Petroleum Hydrocarbons' to the evaluation of individual substances and petroleum fractions. Differences in analytical techniques, data interpretation and risk assessment methods mean that there is the potential for considerable variation in the outcome of risk evaluations. This may give rise to inconsistencies and difficulties for regulators in determining whether or not a particular risk assessment is sufficiently protective of human health.

A significant change to current UK practice is to be developed to address these issues and also to take account of the risk-based approach embodied in Part IIA of the Environmental Protection Act 1990 (outlined in DETR, 2000) and the requirements of Town and Country Planning Acts, in which land contamination is a material planning consideration.

In order to inform debate and invite views on these important issues the Environment Agency prepared a Public Consultation Paper 'Principles for Evaluating the Human Health Risks from Petroleum Hydrocarbons in Soils (R&D Technical Report P5-080/TR1)'. This paper included:

- The need for change and the purpose of the consultation process;
- The context of and background to, the complex issues when assessing petroleum hydrocarbon contaminated land and the need for a revised approach;
- A brief review of approaches adopted internationally by various regulatory authorities; &
- The proposed UK approach and an outline of the key issues and particular questions on which the Environment Agency is inviting comment.

This report presents a summary of the responses to the various questions and issues raised in the consultation document. It will be used in conjunction with other materials and information sources to develop a framework for deriving human health risks from petroleum hydrocarbons in soils.

Consultation Procedure

The consultation process was managed by the MRC Institute for Environment and Health (IEH). In accordance with the Cabinet Office Code of Practice, the consultation was open for a three-month review period, from 1st July to 3rd October 2003. The consultation paper was made widely available by means of a targeted mail-shot, a general release to the written media and through posting of notice of the consultation process on the Environment Agency and IEH websites. The consultation document was available electronically as a downloadable pdf file from the Agency website and also as a printed copy, which was available on request from IEH.

2. RESPONDENTS TO CONSULTATION PAPER

Comments on the consultation paper and the specific questions raised within it were received from a wide range of respondents, including Local Authority contaminated land officers, environmental professionals/consultancies, analytical laboratories, UK regulators, representatives of the petroleum industry and interested parties from abroad. A full list of the respondents is detailed below. It is indicated whether the response was that of an individual or on behalf of an organisation.

Table 1 Individuals and organisations submitting comments

1. UK Accreditation Service (UKAS)	14. Graeme Risby, TES Bretby
2. Dr Kevin Privett, SRK Consulting	15. Raw Consulting
3. Paul Ramsden, OSS Group	16. Delft Geosystems
4. David Alford, West Somerset District Council	17. North Wessex Contaminated Land Liaison Group
5. Jonathan Smith, Environment Agency National Groundwater & Contaminated Land Centre (NGCLC)	18. Thames Water Utilities Ltd
6. Gerard Madden, South Gloucestershire Council	19. Arcadis
7. Hun Seak Park, Washington State Department of Ecology	20. British Waterways
8. Greater Manchester Geological Unit	21. Dr Chris Collins, Imperial College
9. ALcontrol Laboratories	22. Merseyside Contaminated Land Officers Group
10. Contaminated Land Working Party of the United Kingdom Environmental Law Association (UKELA)	23. RIVM
11. SEPA	24. Energy Institute
12. Nick Marks, Newham Borough Council	25. BP International Limited
13. Standing Committee of Analysts (SCA)[1]	26. URS Corp.

[1] Including individual responses from Scientific Analytical Laboratories Ltd (SAL) and Severn Trent Laboratories.

3. RESPONSES TO SPECIFIC ISSUES

Section 4 of the consultation paper (Environment Agency, 2003) highlighted a series of specific issues and questions on which comments were invited. Key issues that were considered include:

- The approach to assessing threshold and non-threshold risk;
- Accepted approaches and philosophies of risk assessment and management;
- The availability and design of exposure assessment models for generating SGVs from toxicological criteria;
- The availability of standard analytical methods for the analysis of toxicologically relevant compounds and fractions in petroleum; and
- The cost of implementation and relative benefits in terms of improved decision-making.

The following section presents a summary of consultees' responses to the specific issues and questions on which comment was invited by the Environment Agency. These responses will be considered during the development of health criteria values and Soil Guideline Values (SGVs) for individual compounds and petroleum fractions through a staged, risk-based programme of research and development.

3a. Complexity of approach

Section 3 of the consultation paper summarised the various approaches adopted by national authorities for the assessment of risk to human health from petroleum hydrocarbon-contaminated soil. These vary considerably in sophistication and, in Section 4.4 of the consultation paper, the Environment Agency sought views on the level of complexity necessary to ensure scientific integrity in its approach, alongside practicality in implementation.

Issue 1. The Environment Agency welcomes views on whether the UK should adopt a combined indicator and petroleum fraction approach to the evaluation of petroleum hydrocarbons in soil.

It was agreed by the overwhelming majority of respondents that the UK should adopt a combined indicator and petroleum fraction approach for the evaluation of petroleum hydrocarbons in soil. This approach was thought to be the best way of demonstrating that the risks from all components of a complex mixture of petroleum hydrocarbons have been adequately assessed.

However, some consultees stated that they would welcome an emphasis on indicator compounds and there was a suggestion that petroleum hydrocarbon fractions should only be assessed during Tier 2 of an assessment.

A small number of responses warned that the suggested approach would entail excessive additional cost if required for all samples, possibly without a noticeable improvement in the risk assessment process.

Issue 2. What are consultees' experiences of applying these approaches in practice?

Respondents indicated that a wide variety of *ad hoc* approaches are used at present for the risk assessment of petroleum hydrocarbon contaminated soils. Clear, consistent guidance would therefore be welcomed as soon as possible.

Local Authority contaminated land officers noted that there were difficulties with the present situation and reported that inappropriate, outdated methodologies are still employed (e.g. measurement of the TPH parameter and comparison to ICRCL guidelines) and risk-based approaches are often not used.

Responses from environmental consultancies generally favoured the new risk-based approaches; one described the TPHCWG methodology as 'a leap forward' compared to the old 'TPH' approach. One respondent commented on some difficulties in dealing with regulators in the absence of a prescribed approach; problems were encountered as the concepts of indicators and fractions appeared to be poorly understood.

Some companies have been using risk-based fraction approaches for some time (although not necessarily with the aliphatic/aromatic split). One petroleum company has derived site specific treatment levels using the TPHCWG approach and discovered that regulators were uncomfortable with the calculated values because they were higher than those they were used to.

It was noted that for the purposes of groundwater assessment, the Environment Agency typically adopts a fractionation approach, generally based on the TPHCWG fractions; adoption of a different approach for soils could introduce inconsistency with risk assessment for other receptors.

Issue 3. The MADEP has selected petroleum fractions on the basis of the available analytical techniques and the toxicology of petroleum compounds. The TPHCWG has selected fractions based on transport properties.
If a petroleum fraction approach is favoured, what should be the basis for the selection of fractions?

Local Authority contaminated land officers favoured a toxicological basis for the selection of fractions, and one group suggested that the final guidance should consider integration with the assessment of other risks, such as for controlled waters.

Many respondents from environmental consultancies and the petroleum industry favoured selection on the basis of transport properties, as the 'pollutant-receptor-linkage' is the driver for risk assessment; practicality (i.e. availability and cost of analytical techniques) was also considered to be an important consideration. The TPHCWG approach was therefore favoured by these groups of respondents.

A response from a regulator involved in groundwater assessment stated that TPHCWG fractions (based on fate and transport) are employed for this type of assessment.

One respondent suggested that transport properties should be the greater influence for petroleum fraction selection, as toxicity is addressed by assessment of the separate, indicator compounds.

Overall, there was a preference for selection of fractions on the basis of transport properties.

Issue 4. Do consultees consider that a simplification of the TPHCWG approach is appropriate?

Most respondents favoured simplification of the TPHCWG approach.

Local Authority contaminated land officers favoured a simplified approach provided that all available toxicological data were taken into account and that the revised approach can be demonstrated to be protective of human health.

A number of respondents from environmental consultancies gave the view that the TPHCWG approach is not over-complicated and that grouping fractions and using conservative surrogates (i.e. those that are highly toxic) would be overly conservative.

The view was also given that simplification is justified, based on data and the work of the RIVM[2], and that it would be desirable to keep analytical costs low.

Issue 5. The Environment Agency invites the views of consultees on the merits and practicalities of separating the aliphatic and aromatic class components (e.g. MADEP, TPHCWG), compared with an approach based on carbon number alone (e.g. CCME).

Consultees generally agreed that it would be beneficial to separate the aliphatic and aromatic class components because of their differing chemical and toxicological properties.

A response from one environmental consultancy considered the split appropriate as the toxicological properties of the two fractions are markedly different and over-generalisation at any level is likely to result in over-conservatism and unnecessary actions being taken.

Conversely, the opinion was expressed that the resulting extra cost of analysis may not be justified given the large uncertainties in the toxicological and fate/transport characteristics assigned to different bands (and a large number of fractions suggests an unrealistic accuracy and certainty).

Analytical laboratories supported the separation of aliphatic and aromatic hydrocarbons and consider this split relatively easy to achieve. A large number of analytical laboratories offer this service already, but a response from the petroleum industry noted that an internal review of this issue had indicated that it is not a trivial exercise. This opinion was based on the finding that there was an increased level of inter-laboratory variability because there is not a clean cut-off between the aliphatic and aromatic fractions (this is due to aromatics with long alkyl side chains behaving more like aliphatics than aromatics).

[2] RIVM report 711701025 *Re-evaluation of human-toxicological maximum permissible risk levels*. Written by AJ Baars, RMC Theelen, PJCM Janssen, JM Hesse, ME van Appledorn, MCM Meijerink, L Verdam, MJ Zeilmaker (March 2001)

The Environment Agency has proposed the separate toxicological review of individual substances for which there are particular concerns in Stage 1 of their work to derive health criteria values for petroleum hydrocarbons. These individual chemicals are generally non-threshold, genotoxic carcinogens and compounds frequently present in contaminated soils and are to be termed 'indicator compounds'.

Issue 6. The Environment Agency welcomes views on the proportions of sites where remediation is driven by the risks from non-threshold substances or threshold substances or both (and/or other assessment criteria).

Responses indicated that remediation of petroleum hydrocarbon contaminated sites is driven by risks from both threshold and non-threshold substances and also considerations of aesthetics and risk to controlled waters.

Non-threshold substances, e.g. benzene & PAHs, generally drive risks at sites such as old gasworks and petrol filling stations, respectively.

Slightly more of the consultees reported that risk was driven by non-threshold substances. However one respondent from the environmental consultancy sector stated that, in their experience, it is generally a 50:50 split but that only 20% of remediation is driven by risk to health.

Local Authority officers pointed out that remediation through re-development under the planning regime considers significant harm (as defined by Part IIA) but that remediation can also be driven by other factors, i.e. liability, aesthetics, perceived risk and financial considerations.

For kerosene or diesel contamination at residential or commercial sites, remediation is usually driven by the concentration of threshold substances where exposure is via inhalation or ingestion.

A groundwater regulator pointed out that 45% of designations of contaminated sites have been on the basis of pollution of controlled waters.

Stage 2 of the Environment Agency's proposed approach is the toxicological assessment and derivation of health criteria values for petroleum hydrocarbon fractions, based on surrogate compounds or mixtures representative of each fraction. The basis for the selection of surrogates for each fraction will have considerable influence on the derivation of SGVs. The Agency sought views on a number of issues relating to the assessment of the toxicology of the fractions.

Issue 7. If petroleum fractions are to be adopted, what should be the toxicological basis for the selection of surrogate compounds or mixtures?

One group of Local Authority contaminated land officers stated that they would favour a precautionary approach whereby the petroleum fraction was represented by the most toxic representative surrogate compound or mixture.

The view was also expressed that surrogates for fractions should have environmental relevance, i.e. surrogates should be chosen that are actually encountered at contaminated sites. This approach has been suggested by RIVM, who considered data on quantitative presence and available toxicological information. This approach was further endorsed by a number of other respondents.

A number of consultees asked that data on mixtures be used where possible. If data on individual substances were used, account should be taken of their fate/transport and abundance in the final selection (i.e. based on risk, not hazard).

A number of respondents suggested that surrogates should reflect threshold risk only, as non-threshold risks are addressed by indicator substances.

Issue 8. How many petroleum fractions do consultees consider to be toxicologically relevant?

Few respondents commented on this issue but most of those who did were of the opinion that the final framework should use as few fractions as possible that are environmentally and toxicologically relevant and provide meaningful results in terms of petroleum hydrocarbon risk.

The point was repeated that grouping fractions and using conservative surrogates would lead to the setting of overly conservative SSTLs.

The opinion was given that heavier end fractions may not be toxicologically relevant at some sites due to their low volatility and mobility.

Issue 9. How, if at all, should additivity of health effects across the fractions be taken into account?

[Opinions on this issue varied between and within the different groups of respondents].

Local Authority contaminated land officers favoured the approach taken by MADEP, which is based on the addition of hazard quotients across fractions, but stressed that recommendations must be consistent with other UK guidance.

Some respondents from environmental consultancies reported that they currently include additivity in their assessments. Other consultees from this sector consider the assumption of additivity to be too conservative and that it is inappropriate because compounds have different health effects.

It was generally thought that consideration of additivity is appropriate and scientifically justifiable where there are sufficient data to indicate a common mode of action or target organ for toxicity.

One respondent pointed out that in the TPHCWG approach, indicator substances are not subtracted from the corresponding fraction, since the criteria used in the fractions is the non-carcinogenic index and the indicator compounds' contribution with respect to this criteria is not considered double counting. A number of other respondents had requested that results for individual compounds and fractions be treated separately to avoid 'double counting' [NB. this may only apply for indicator compounds that have threshold toxicological effects].

3b. Practicality – staged frameworks

The different approaches adopted internationally for the human health risk assessment of petroleum hydrocarbon-contaminated soil have a number of similarities but vary in their practical application. The approaches of the TPHCWG (1999) and ATSDR (1999) give precedence to non-threshold risks from individual compounds whereas the MADEP (2002) approach explicitly assesses risks from both individual compounds and fractions concurrently. The Environment Agency has proposed the use of an approach similar to that of MADEP in which the risks from indicator compounds and fractions are assessed concurrently. Views were invited on such an approach and its application in a tiered risk assessment framework.

Issue 10. The Environment Agency welcomes views on the concurrent assessment of all risks from both indicator compounds and petroleum fractions.

Nearly all consultees that commented on this issue thought that risks from both indicator compounds and fractions should be assessed concurrently. This was thought to be useful as it provides a representative picture of the contamination at sites, particularly as the origin of historic contamination is often unclear.

This proposal is in line with the requirement to identify all pollutant linkages specified by Part IIA.

One environmental consultancy expressed the opinion that fractions should only be considered where indicator compounds are inadequate to characterise the impacts (e.g.

fractions should be used if concentrations of indicator compounds add up to less than x% of the whole 'TPH' concentration). The opinion was also given that this approach would be too expensive and should only be undertaken at Tier 2 or above.

Issue 11. However, if an approach were adopted that gave precedence to the non-threshold risks (e.g. TPHCWG) over threshold risks, what are consultees' views on the practical application of such a staged approach in the context of identifying Part IIA pollutant linkages?

Similar views were expressed as for Issue 10 above. That is, there was a general consensus that all risks should be assessed concurrently, in line with the requirements of Part IIA. An approach that gives precedence to non-threshold risks may mask other significant pollutant linkages (including risks to ecological receptors) or necessitate a site being re-visited. It was also pointed out that threshold risks might be equally important as non-threshold risks.

Representative responses from the petroleum industry indicated that they would also welcome ecological risk assessments and human health risk assessments being conducted in parallel; the Energy Institute has worked with the Agency to align these two different types of assessment within a tiered framework.

A small number of respondents supported an approach such as that of the TPHCWG, with the proviso that there were checks in place to ensure that significant risks are not overlooked (e.g. where the risk from threshold substances may exceed that associated with non-threshold substances).

RIVM described how the Dutch approach evaluates carcinogenic substances first, because in general the risks from exposure to carcinogens are expected to be greater than the risks from non-carcinogenic compounds.

Issue 12. The Environment Agency seeks comments on the application of a tiered approach in the context of identifying the significance of Part IIA pollutant linkages.

All respondents that addressed this issue supported the use of a tiered approach as this was consistent with the requirements of Part IIA and is in line with existing UK guidance on risk assessment.

Many consultees suggested that the final framework should include a definition of the tiers and the way in which they shall be applied and should include guidance for site-specific risk assessments.

Representatives of the petroleum industry supported a tiered approach, with the proviso that it was not necessary to fractionate all samples. They suggested an initial screen by GC fingerprint, with only selected samples that showed different types of contamination requiring fractionation.

SEPA specified that Tier 1 should describe the minimum information required for an assessment and that this could be bypassed in cases where that level of information was already available (e.g. spill of known volume and defined product).

3c. Analytical feasibility and approach

The limitations of approaches previously (and to some extent, currently) used to assess levels of petroleum hydrocarbons are widely acknowledged (e.g. Gustafson 2002). Petroleum hydrocarbons form an extremely complex mixture and no universal method exists for their analysis. It is important to develop analytical strategies and reporting conventions that are capable of accurately measuring indicator compounds and fractions and that are also practical enough to apply in any risk assessment framework that is finally recommended. Views were sought on issues such as the application of the available methodologies, their costs and implications for site investigation.

Issue 13. In devising its approach, the Environment Agency wishes to ensure that analytical methods can be suitably matched to the needs of the risk assessment.
Consultees are invited to express their views on experiences in using these complex analytical techniques (as described in paragraph 4.10 of the consultation document) and related analytical methods for characterising petroleum in environmental samples.
What are the costs and requirements of these methods?
What are the implications for site investigation soil sampling, analysis and analytical reporting?
What levels of uncertainty in analytical measurement are typically experienced in applying these methods?

A common response from consultees to this issue was that it is essential for the assessment approach to be compatible with available analytical methodology and to be easily incorporated into a standard suite of analyses.

Responses from Local Authority contaminated land officers indicated that, currently, there is considerable inconsistency in the reporting of petroleum hydrocarbon concentrations at contaminated sites and also some degree of confusion.

There was general agreement from the various consultees that no one current method will describe all forms of petroleum hydrocarbons in soils. Thus, for example, different methods would be required for low boiling point fractions and highly weathered hydrocarbons. There may also be a requirement to adapt methods or develop specific techniques on a site-by-site basis.

Consultees from the environmental consultancy sector reported that significant inter-laboratory variability had been encountered with both the old methods of hydrocarbon analysis (i.e. TPH, DRO &TPH), and also with analysis of fractions; this was thought to be due to inconsistency in extraction and use of sample clean-up. One respondent had encountered variations of up to several orders of magnitude for the same sample when analysed by five laboratories. It is thought that this could be because laboratories are often working at the limits of detection and that some of the 'data' simply represent 'noise' in the methodology. It was recommended that the final framework should provide advice on how to interpret values close to the detection limit. The observation was made that it is important that errors introduced through the analytical process do not outweigh the perceived advantage of toxicological assessment using the hydrocarbon fractions. Field spiking with a non-petroleum hydrocarbon reference standard was suggested as a possible aid for quality control.

Responses from the SCA and individual analytical laboratories clearly stated that they possess the analytical capability to undertake the analyses required by a risk assessment framework incorporating a combined indicator and fraction approach. It is important, however, that the final framework specifies clearly and unambiguously what is required in terms of results; terminology also needs to be well defined and consistent.

Within the SCA, a committee has been set up to produce guidance on methodology relating to the analysis of hydrocarbon compounds in soils; this statement of 'UK best practice' will be published on the Environment Agency's website as a "bluebook" which will specify performance criteria rather than prescribed methodology. Analysis to these standards will meet MCERTS requirements[3]. Individual laboratories disagreed over whether there should be a performance standard or a specific prescribed methodology for what they considered to be a complex area.

Analytical laboratories considered that the most appropriate requirement to specify will be defined carbon number ranges.

A number of consultees stipulated that for any methodology it is essential to state to which matrix it applies to, since most methodologies are not transferable between matrices. It was also suggested that a number of suitable soil reference materials should be established in order to test performance standards.

Analytical costs were anticipated to increase by varying amounts following implementation of a combined indicator and fraction approach, although there was general agreement that as method usage increased costs would reduce. Estimates of the 'cost per sample' using the analytical methodology required for a combined indicator and fraction approach (with aliphatic/aromatic split) were said to vary with laboratory, batch size and turnaround time required. Estimates of cost per fractionated and split sample, reported by environmental consultancies and an analytical laboratory, ranged from £50 to £100 [this is compared to current costs of £25-30 for TPH, GRO or DRO analysis]. Much higher estimates of £150-350 per fractionated and split sample were provided by representatives of the petroleum industry.

Guidance on methods for representative soil sampling would be welcomed, as contamination is not homogenous. It was pointed out that there is often more uncertainty in sampling than in analysis.

[3] MCERTS is the Environment Agency's Monitoring Certification Scheme which specifies performance standards for laboratories undertaking chemical testing of environmental media.

3d. Weathered petroleum contamination in the soil

Heavy and highly weathered oils are found at many petroleum-contaminated sites and present a particular challenge in terms of their analysis and health risk assessment due to their high boiling point, the effects of weathering and extreme chemical complexity.

Issue 14. The Environment Agency seeks views on appropriate methods for the chemical analysis of heavy, weathered and residual oils and on the approach to their toxicological evaluation.

In order to ensure consistency, it was suggested that heavy-end hydrocarbons should be analysed using the same approaches as for lighter hydrocarbons. However, sample clean-up is necessary to avoid overestimating petroleum hydrocarbons and very heavy hydrocarbons can clog a GC column, requiring an additional column clean-up stage to fully characterise the material.

A respondent from an analytical laboratory suggested use of a higher temperature GC column (e.g. the Restek RTX-1 metal capillary column), which can reach C_{110}.
Alternatively, heavy, weathered and residual oils can be extracted separately and analysed specifically, if their presence is indicated by observation, or analysis of soil for 'extractable petroleum hydrocarbons' demonstrates that most of the hydrocarbon is concentrated in the heavier end.

Several consultees emphasised that analytical methodology should be employed that is capable of distinguishing between hydrocarbons, polar breakdown products and naturally occurring organic materials such as humic acids.

Several consultees raised questions as to whether it was necessary to consider the toxicological properties of heavier oils if there was no probability of exposure due to their low mobility.

Aesthetic concerns are considered likely to be the main issues for heavy end hydrocarbons.

3e. Aesthetics, costs and socioeconomic considerations

Issue 15. The Environment Agency welcomes views on the implementation costs and implications of the various approaches described in section 3, specifically with respect to site and risk assessment.

Most respondents envisaged an increase in costs following implementation of the type of risk assessment framework proposed in the consultation document. Most were of the opinion that this was justified by the improvement in the quality of risk assessment. It was also anticipated that implementation of this type of approach would lead to increased confidence in the decision making process and reduce the amount of unnecessary remediation.

A respondent from an environmental consultancy stressed that care should be taken to ensure that the UK doesn't make risk-based investigation and remediation too expensive, thus deterring development of brownfield sites. They reported that some clients were of the opinion that the risk-based approach is too conservative and increases their clean-up costs and requirements. However, other companies in this sector have adopted similar approaches and reported that no drastic changes to current practice would be necessary on implementation of the final framework.

It was requested by consultees that the final framework should strike a balance between practicality and sufficient protection of human health.

It was suggested that the costs of analytical and risk assessment requirements are greatly outweighed by the site investigation and sampling costs, and that any increase is still likely to be insignificant compared to these elements.

Issue 16. Aesthetic impacts are not covered by Part IIA of the Environmental Protection Act 1990. However, the Environment Agency wishes to take this opportunity to consider separately views relating to aesthetic impacts of oil at contaminated sites.
The Environment Agency invites practitioners to summarise their experiences of the influence that aesthetics currently play in risk management at petroleum-contaminated sites and their considered opinions on the influence they might play in the future.
What typical concentrations of petroleum hydrocarbons remain in the soil after remediation? Please relate concentration data to remedial techniques.

Aesthetic considerations were acknowledged to be an extremely important issue for contaminated sites. A number of consultees requested that guidance on aesthetic impacts should be provided by the Agency. Others questioned whether this should be part of a risk-based framework that is the primary consideration of this consultation. One respondent noted that aesthetic impacts fall under the jurisdiction of Local Authorities/environmental health officers that could require landowners to address aesthetic impacts.

It was reported that aesthetics are often of more importance than calculated risk drivers, particularly where sites go for redevelopment. The opinion was given that a developer was unlikely to sell a property affected in this way and, therefore, more often than not the material

is excavated, irrespective of health or environmental risk.

Staining and odour in particular are important considerations as they give rise to a perception of pollution/contamination even if there is no actual health risk. The public is quite likely to perceive unacceptable risk due to a smell. Odour has been found to be a particular problem with certain compounds, such as the petrol additive MTBE (not a hydrocarbon).

A respondent with experience of applying risk-based approaches stated that for diesel range petroleum hydrocarbons and above, SSTLs are so high that aesthetic issues (i.e. sight, smell) are often the driver rather than risk to human health.

Typical concentrations of petroleum hydrocarbons post-remediation

Respondents from an environmental consultancy reported that bioremediation will typically achieve end point concentrations of 100 to 2000 mg kg^{-1} from initial concentrations of thousands of mg kg^{-1} of weathered diesel, dependent upon the degree of weathering that has occurred. For example, 22,600 mg kg^{-1} mixed hydrocarbon contaminated soils undergoing bioremediation were reduced to achieve around 2000 mg kg^{-1} and at a former terminal site (predominantly diesel range) hydrocarbons were reduced from 2500 to around 100 mg kg^{-1} over 6 weeks. Experience with 'lube oil' suggests that it is often difficult to achieve concentrations below 1000 to 1500 mg kg^{-1} using 'conventional' techniques.

One respondent from an environmental consultancy that provides services to petrol retailers indicated that, as a rule of thumb, 5 mg kg^{-1} benzene can be achieved after remediation. Post-remediation concentrations away from wells reach 400 mg kg^{-1} 'petroleum range hydrocarbons' and 1000 mg kg^{-1} 'diesel range hydrocarbons', particularly if the soil is less suitable to in-situ remediation. Where there are no practical constraints, sites for redevelopment can be remediated to a much greater extent.

4. ADDITIONAL COMMENTS

In addition to the specific issues and questions on which the Environment Agency invited responses, comments on a number of other issues were received.

A large number of respondents stressed the need for publication and adoption of a consistent approach as soon as possible. Respondents from the petroleum industry suggested that a cost-effective approach might be to adopt one of the existing approaches in the short term and customise it as appropriate. This would ensure that there was no gap left in the interim, maintain confidence in the risk based approach, and build confidence in undertaking transactions involving brownfield land.

Local Authority representatives stressed that they particularly need advice on toxicological issues as this is outside the expertise of environmental health staff.

Current approaches to the assessment of petroleum hydrocarbons were noted as not considering the presence of 'hetero compounds' (i.e. those containing N, S or O), which may be more toxic than hydrocarbons. It was suggested that consideration should be given to the organometallics present in lubricating oils (comment from OSS Group). Environment Agency National Groundwater & Contaminated Land Centre (NGCLC) also noted that MTBE and other fuel oxygenates are not currently listed as 'indicator compounds', but are often drivers for water risk assessment. The SCA commented that the consultation paper did not consider the toxicology of alkylated PAHs (which are thought to be highly toxic) or the unresolved complex mixture (UCM), which is a common feature of chromatograms of weathered petroleum hydrocarbons.

Several respondents suggested that consideration should be given to the 'background levels' commonly encountered in soils when establishing guidance levels. Car exhaust fumes were considered a possible source of background concentrations.

NGCLC commented that it would be useful to ensure consistency in assessing risks to human health, the water environment and ecosystems (also property, crops etc.), which are listed as receptors in Part IIA. It was also suggested that it would be helpful if health criteria values (IDs/TDIs) for petroleum hydrocarbon constituents/indicators were established in parallel with development of Environmental Quality Standards (EQSs) for the same fractions.

Washington State Department of Ecology highlighted their approach to assessing risks from petroleum hydrocarbons, which includes an analytical protocol for generating fractionated data. A copy of a paper discussing their approach was included with their response (Park & Juan 2000).

The UKELA contaminated land working group commented relevant provisions of the Water Resources Act 1991 (particularly Section 161 and s. 161 A-D) should be addressed, in addition to the Town and Country Planning Act 1990 and Part IIA of the Environmental Protection Act 1990. UKELA suggested that the questions posed by the consultation were also of relevance to assessments carried out in relation to the Water Resources Act 1991, which the Environment Agency invokes in some instances to enforce remediation. UKELA also sought clarification on the status of the guidelines finally issued on petroleum hydrocarbons; i.e. whether they are guidance for assessments in general or form a benchmark to be used by Local Authorities and

the Environment Agency when assessing whether land is contaminated under Part IIA and other regimes.

A respondent from a water utilities company expressed disappointment that the risk to human health from leaching through pipelines and contamination of water supplies was not considered in the consultation document. The impact of hydrocarbon contaminated soils on pipeline integrity and material selection is often neglected by developers and regulators when assessing sites. United Kingdom Water Industry Research Ltd (UKWIR) is currently undertaking a review of the classification of contaminated soils for the purposes of pipeline selection, and the respondent was keen that this industry-led project is reviewed before finalising the new assessment methodology for hydrocarbon contamination of soils.

A consultee from an environmental consultancy requested that the final Soil Guideline Values (SGVs) resulting from this consultation process should be 'single screening numbers' with more detailed data only being required for site specific risk assessments.

Some contaminated land officers considered that it is essential that the publication of the guidance and Soil Guideline Values is supported by provision of appropriate training.

Representatives from the petroleum industry stated that their experience suggests that the exposure scenario often has the greatest influence on the risk / hazard estimate and this should be a consideration when selecting fractions.

5. SUMMARY

In total, twenty six responses were received to the consultation paper from a variety of consultees, including Local Authority contaminated land officers, environmental professionals/consultancies, analytical laboratories, UK regulators, representatives of the petroleum industry and interested parties from abroad.

It is clear from the responses to this consultation exercise that people working on the risk assessment of contaminated land are very keen for clear guidance to be issued on the human health risk assessment of petroleum hydrocarbon-contaminated soil. A variety of approaches are currently being employed in an *ad hoc* manner. A defined UK position that could be consistently applied and generate comparable results would be welcomed.

Most respondents favoured adoption of a combined indicator and fraction approach within a tiered risk-based framework (similar to the MADEP or TPHCWG methodologies). It was generally agreed that specific indicator compounds should be assessed because these are mainly well characterised substances that are often the main risk drivers at contaminated sites. It was thought that assessment of fractions would facilitate a more representative picture of risk at those contaminated sites where the origin of the petroleum contamination may be unclear.

The vast majority of respondents favoured the concurrent assessment of indicator compounds and fractions as this is in line with the requirement to identify all pollutant linkages specified by Part IIA. However, some involved in the production of risk assessments for contaminated sites would prefer a degree of flexibility in how the approach is applied. It was suggested that an assessment should only require consideration of those compounds/fractions that would be expected to be present based on initial observations/simple analysis or detailed knowledge of the composition of the contamination or spill. Some consultees would prefer precedence to be given to the indicator compounds, with the option to only consider fractions at higher tiers of the assessment framework.

A number of consultees warned that although the approach adopted in the UK should have scientific integrity, it must be practical in application and should not entail excessive costs that would deter development of brownfield land. The potential increased cost was highlighted by a number of consultees but it was noted that this would be offset by increased confidence in the results of risk assessments and that analytical/assessment costs were insignificant compared to site investigation and sampling. It was suggested that this should be emphasised to developers.

Some environmental consultancies are already applying approaches such as TPHCWG and MADEP. Results are variable due in part to inter-laboratory variability and unfamiliarity with these approaches. It is likely that such problems will diminish when clear guidance is available and methodologies become familiar.

Overall, most respondents thought that fractions should be selected on the basis of transport properties and practicality of analysis, as long as it could be demonstrated that the approach was protective of human health. With regard to choice of surrogates for the toxicity of fractions, a number of respondents stated that the surrogate compounds or mixtures should be environmentally relevant (i.e. frequently detected at contaminated sites). There was some support from Local Authority regulators for a precautionary approach that used the most toxic

representative surrogate compound or mixture. It was suggested that the fractions should only consider threshold health effects, as non-threshold effects are addressed by the indicator compounds.

There was a mixed response on the issue of additivity across the fractions. Some environmental consultancies are already using methods that adopt this approach. Others thought that it was too conservative and that additivity should only be assumed when there was evidence that compounds or fractions have the same target or mechanism of toxicity.

Differing opinions were offered on the need for an aliphatic/aromatic split of petroleum hydrocarbons. Some consultees thought that the adjudged refinement of the assessment was not justified by the additional costs, whereas others pointed out that it avoided adoption of overly-conservative surrogates for large fractions containing aliphatic and aromatic compounds. Respondents from analytical laboratories indicated that this requirement was relatively easy to achieve.

The same respondents pointed out that there is no one analytical method suitable for all components of petroleum contamination, but stated that the analytical requirements of the approaches discussed in the consultation paper were within their capabilities provided that clear guidance was provided on the results required. Some laboratories and other consultees requested that a specific prescribed methodology should be recommended. However, the SCA was of the general opinion that 'performance criteria' should be recommended, with freedom given for individual laboratories to apply or adapt existing methodologies to meet the standards. Analytical costs are expected to increase significantly following adoption of the final framework but these are anticipated to decrease once the techniques become common practice.

Aesthetic issues were highlighted as a major concern for those involved in the assessment and redevelopment of petroleum contaminated land. Issues such as staining and odour are the drivers for a large proportion of remediation. Guidance on how to assess aesthetics would be welcomed, but it was questioned if this was appropriate within a risk-based framework.

A large number of consultees requested that methods for human health risk assessment of petroleum hydrocarbons should be integrated with those for environmental risk assessment (including the risks to controlled waters). Some work has already been done in this area by the Energy Institute in conjunction with the Environment Agency.

6. REFERENCES

ATSDR (1999) Toxicological Profile for Total Petroleum Hydrocarbons, US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, Atlanta. Available at http://www.atsdr.cdc.gov/toxprofiles/tp123.html (March 2003).

DETR (2000) Circular 2/2000, Environmental Protection Act 1990 – Part IIA –Contaminated Land, Department of Environment, Transport and the Regions, London. Available at http://www.defra.gov.uk/environment/landliability/circ2-2000/ (March2002).

Environment Agency (2003) Principles for Evaluating the Human Health Risks from Petroleum Hydrocarbons in Soils' (R&D Technical Report P5-080/TR1)

Gustafson JB (2002) Using TPH in Risk-Based Corrective Action. Available at http://www.epa.gov/swerust1/rbdm/tphrbca.htm (March 2003).

MADEP (2002) *Characterizing Risks Posed by Petroleum Contaminated Sites:Implementing the VPH/EPH/APH Approach, Policy #WSC-02-411,* Massachusetts Department of Environmental Protection, Executive Office of Environmental Affairs, Commonwealth of Massachusetts, dated 31/10/02. Available at http://www.state.ma.us/dep/bwsc/vph_eph.htm (March 2003).

Park HS & Jaun CS (2000) A Method for Assessing Leaching Potential for Petroleum Hydrocarbons Release Sites: Multiphase and Multisubstance Equilibrium Partitioning. *Soil and Sediment Contamination*, 9 (6): 611-632

TPHCWG (1999) Human Health Risk-based Evaluation of Petroleum Contaminated Sites: Implementation of the Working Group Approach, Volume 5. Total Petroleum Hydrocarbon Criteria Working Group Series. Amherst: Amherst Scientific Publishers. Available at http://www.aehs.com/publications/catalog/contents/tph.htm (March 2003).