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Options for a Strategy for Economic Assessment of the Benefits of Contaminated Land Remediation

Final Report

AMEC Environment & Infrastructure UK Limited
August 2012

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Executive Summary

Project Objectives

The primary purpose of the study was to develop a methodology for establishing the benefits from remediating contaminated land, particularly those sites attracting central government expenditure through funding of Part 2A schemes. The objective was broken down as follows:

- To identify benefits that could arise from contaminated land remediation and methods of quantifying and monetising these benefits;
- To identify relevant national and international data, and its availability;
- To critically review the alternative existing methods and data and identify candidate feasible and meaningful methodologies;
- To test candidate methodologies against selected groups of sites;
- To collate and develop an evidence base.

Conceptual Approach

The need for strategic options is itself a response to a set of circumstances and strategic objectives which were not specified in detail for this project though the project outputs - the material presented - is believed to be applicable to a range of circumstances and objectives.

In general terms, specifications of strategic options for economic assessment can differ in their conceptual and philosophical approaches as well as in their qualitative and quantitative characteristics and assumptions. This report proposes the use of Total Economic Value (TEV) as a conceptual approach for all options with an alternative ecosystem services approach applicable in some circumstances.

TEV is a concept used to characterise and capture values at the level of society and includes components for financial values expressed in markets as well as more intangible values relating to un-priced individual preferences. TEV includes what might otherwise be seen as different forms of benefit (such as amenity benefits and financial benefits) within a single framework. TEV has two main sub-categories:

- *Use values*, which are the benefits of bringing land back into general use, for industry or housing, as well as amenity value from new parkland created at the site.
- *Non-use values,* which are benefits derived from knowledge that a particular resource is maintained. Non-use values are independent of any use, present or future that people might make of those goods.

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An example of a non-use benefit is the pleasure someone might take in knowing that less land is contaminated, even if they never visit the site.

While the methods described here can be used to evaluate use and non-use values, the focus of the report is on use values because they are the most common topics in valuation studies of both contaminated land and other environmental studies addressing the characteristics of specific locations. They also reflect the primary concerns of public bodies and their reasons for conducting valuation studies. In comparison, non-use benefits are difficult to assess although increasingly included in policy assessments. For example, they are part of the Environment Agency's Benefits Assessment Guidance.

Types of Benefit

The report identifies the following types of benefit which may show increases in value as a result of remediation:

- *Site value* - due to an increase in the opportunities for alternative more valuable uses of the land;
- *Neighbouring property values* - as a result of direct impacts or indirect association with the site (e.g. removal of blight);
- *Environmental benefits* - for example, benefits associated with reduced negative ecosystem impacts such as loss of biodiversity and improvements in water quality;
- *Amenity benefits* - for example, improved public access or environmental appearance;
- *Health benefits* - from reduced health risks and/or improved health outcomes from reduced exposure to contaminants;
- *Levels of property transactions* - which are no longer impeded by concerns or uncertainty of contamination;
- *Productivity benefits* - due to reductions in averting behaviour, such as a reduced need for protective equipment and reduced levels of fines;
- *Greenfield development savings* - due to avoided loss of ecosystem elsewhere, as remediation may allow brownfield development instead; and
- *Agglomeration benefits* - which arise from greater brownfield development and consequent urban density.

Assessment Methods

The assessment methods can be grouped as follows:

1. Those depending on observation of current behaviour (Revealed Preference) as revealed in house prices and other market prices;

2. Those which use surveys to elicit views about future change (Stated Preference), such as the declared willingness to pay for improvements resulting from remediation;

3. Use and adaptation of values from previous studies (so-called Benefit Transfer); and

4. Expert judgement.

The advantage of Stated Preference methods is that they can address the benefits of any potential change by putting forward specific proposals and questions to a survey population. Revealed Preference methods have lower costs but require pre-existing data such as records of local house prices and, depending on data availability, may be more inaccurate. Benefit Transfer methods draw on a wider set of studies to reduce research costs for assessments with sufficiently comparable circumstances. Typically, more than one method can be used to value a particular benefit, with strengths and weaknesses dependent on circumstances and study design.

Stated Preference methods involve questionnaires using descriptions of hypothetical situations. They include the *Contingent Valuation Method* and *Contingent Choice Experiment Method*. Well designed surveys are shown to provide robust estimates. In the context of contaminated land stated preference methods have particular relevance as they provide the basis for assessing non-use environmental benefits and estimating the value of reductions in risk of premature deaths or non-fatal injuries which are a form of harm attributable to contaminated land.

Revealed Preference methods have the underlying assumption that people's values are revealed by the choices they make in purchasing or consuming marketed goods and services and these can be used as proxies for information about their probable attitudes to environmental goods or services. Methods include the *Travel Cost Method,* which uses travel expenditure as a proxy for the price of enjoying a recreational or amenity resource and the *Hedonic Pricing Model*, which assumes that degradation in environmental goods and services reduces the price of marketed product (a house) affected by these goods and services. Prices revealed in markets may also be used directly as in the *Market Price Method* which assumes a change can be valued "at market prices". Other methods include the *Production Function Method* which values environmental goods and services as an input to the production of a marketed good. It requires data linking environmental goods and services to costs of production for the final good as well as to the demand for and supply of the final good. The *Avoided Damage Cost* and *Substitute Cost Methods* also comprise direct methods and are applied where investment or costs result from the loss of an environmental resource.

Data Sources

The data sources cover statistical information relating to the sizes of potential effects as well as valuation information. The quantitative statistics of most relevance are primarily those characterising populations such as the Small Area Population Estimates from the government's Office of National Statistics. Valuation information is more diverse. It includes databases of Benefit Transfer values, such as the provided in the BeTa source from the European Commission and the well established Environmental Valuation Reference Inventory (EVRI) database. Valuation information also includes market prices such as databases of house prices from the proprietary Price Paid

Dataset. These sources supplement various registers including those of potentially contaminated sites such as the National Land Use Database from the Homes and Communities Agency as well as those addressing the underlying physical processes of contamination such as borehole data from the British Geological Society and Environment Agency.

Case Studies

Three case studies provide information on the application of the valuation methods to assess completed remediation programmes. Their aim is to demonstrate workable methods that could be fitted to a number of different study designs. The three case studies are:

1. **Mirvale Chemical Works**, a former creosote plant in West Yorkshire used for chemicals manufacture for over 100 years. Contamination included a tarry slick on the river Calder arising from seepage of industrial residues to the soil. It was selected to illustrate methods for assessing environmental benefits and primarily used Benefit Transfer methods. One of the information sources was a national survey of attitudes towards improvement in water quality standards.

2. **Ince Central Estate in Wigan** comprises housing built in an area previously used for industry. It has a resident population and exhibited contamination which could have resulted in significant risks to their health. The site was remediated in 2010 and was chosen as a case study as there is information on the potential health impacts which were a primary justification for remediation work. The predominantly urban character of the location contrasts with that of the other two case studies.

3. **Phoenix Park**, now an area of open access to the public, is the result of the remediation of the former Hickleton Colliery site near Thurnscoe, South Yorkshire. The new Phoenix Park has generated significant social and economic benefits within surrounding areas due to its beneficial position between population centres. Its new use as parkland provides increased amenity value from the remediation.

There is an emphasis in the case studies on methods used for assessing Site value and Neighbouring Property benefits as these are likely to be relevant to a number of different types of benefit study. A simple hedonic price model is defined to provide an ex-post assessment of remediation at the three case study sites. Sub-models are estimated for each case study independently which formulate the question as to whether property prices near the study area have risen, relative to those in the wider area, after the remediation period and controls for movements in house prices due to other factors. This method has the benefit of being based on market prices, using standard property market datasets and being readily transferable to other sites.

Applying the house prices impacts identified to all houses within an area of approximately one kilometre around each site gives an aggregate increase in value of £43.9m at Mirvale, £54.4m at Ince and £52.6m at Thurnscoe, all relatively large compared to the probable costs of remediation. Of particular interest is that at all three sites, a method using analysis of the price of the same houses before and after remediation shows a statistically significant effect.

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Conclusions

In general terms, this report comprehensively identifies and categories the conceptual approaches, types of benefit and assessment methods in a way that allows them to be applied to a range of future studies with different strategic objectives.

Although primarily illustrative, the case study results indicated that remediation is associated with benefits substantially in excess of probable costs. The methods using house price data were applied in a similar manner at all three sites including controlling for underlying property prices in their relevant wider areas. It is difficult to attribute shifts in house prices to remediation despite their apparent relationship because correlation does not imply causation. However, against the general housing market background the changes observed represent significant improvements and the fact that increases were observed across all three sites lends weight of evidence to the hypothesis that remediation results in significant benefits to the local housing market through a positive impact on house prices. These results are consistent with a view that past government funding of remediation programmes addressed a market failure and support the hypothesis that remediation programmes can and do provide net benefits.

While demonstrating a possible link between remediation and house price movements, the methodology did not investigate possible underlying causes or indicate whether the same result would be obtained at other sites. Research relevant to supplementing the results here and to supporting forward looking estimates of currently unremediated sites includes:

- Application of the methodology used here to more case studies, as this would reduce the probability of a ‘false positive’ (even though it would not help directly identify causes); and
- Investigation of possible causes directly using a more detailed version of the methodology used here or survey techniques.

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1. Introduction

1.1 Purpose of the Report

This purpose of this report is to present methodological options for valuing the remediation of contaminated land and to discuss their use. It covers two main areas:

- The benefits arising from remediation of contaminated land; and
- The methods of valuing benefits.

1.2 Structure of the Report

The sections which follow this introductory section are:

2. Overview and Summary This can be read as a standalone document. It describes the overarching issues relating to study design, includes subsections which summarises the other main sections, and also presents conclusions.

3. Types of Benefits resulting from Remediation and Identification of Methods and

4. Critical Assessment of Methods together provides a detailed assessment of the benefits available, the methods available to assess them, the supporting literature and the data sources.

5. Case Studies describe the identification of benefits and the application of the methods in three case studies.

Appendix B is a catalogue of important sources of data and information.

1.3 Use of the Report

To navigate through material which may have a different degree of relevance to a number of different audiences, the following guidance may be of help.

Nine types of benefit are identified and these are consistently identified throughout by the letters A to I. Summary descriptions of these are in Section 2.6 (Statement of Types of Benefit resulting from Remediation) and fuller explanations in Section 3 (Types of Benefits resulting from Remediation and Identification of Methods) . The types of benefits are:

(A) Benefits of Increased Site Value;

(B) Benefits of Increased Value of Neighbouring Property;

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(C) Property Transactions;

(D) Productivity Benefits;

(E) Environmental Benefits;

(F) Amenity Benefits;

(G) Greenfield Savings;

(H) Benefits of Reduced Health Risks;

(I) Agglomeration Benefits.

The evaluation methods are summarised in Section 2.7 (Statement of Types of Valuation Methodologies) including the specification of acronyms. The use of the methods to evaluate specific benefits is covered in Section 3 (Types of Benefits resulting from Remediation and Identification of Methods) and an assessment of them is covered in Section 4 (Critical Assessment of Methods).

There is a **Checklist of Factors affecting Study Design** in Section 2.5, which should be consulted before any particular analysis.

The mapping of the benefits of E**cosystem services** to the **Total Economic Valuation** framework used here is summarised in Section 2.4 (Strategic Options for Valuation) and has more detail in Appendix E.

Results and Conclusions, including commentary on the results of the quantitative assessment of neighbouring property values from the case studies are in Sections 2.8 and 2.9.

A **Glossary** is provided in Appendix D.

Cross-references to the more detailed sections are included in the Overview and Summary.

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2. Overview and Summary

2.1 Project Objectives

The primary purpose of the study is to develop a methodology for establishing the benefits from remediating contaminated land, particularly those sites attracting central government expenditure through funding of Part 2A schemes.

In the specification for this work, the overall objective is broken down into the following more specific objectives:

- to identify benefits that could arise from contaminated land remediation and methods of quantifying and monetising these benefits;
- to identify relevant national and international data, and its availability;
- to critically review the alternative existing methods and data and identify candidate feasible and meaningful methodologies;
- to test candidate methodologies against selected groups of sites; and
- to collate and develop an evidence base.

2.2 What is Contaminated Land?

From an economic perspective, contaminated land is like all other land except that it has been altered in some way, often seen as negative, which:

- may restrict its use; and
- has specific effects on the site and its surrounding environment and populations.

The differences in potential uses directly affect the value of the land compared to neighbouring land. The specific effects may include those on health, property values, ecosystems and biodiversity, amenity, and landscape.

In the UK, "contaminated land" is defined at section 78A(2) of the /Environmental Protection Act 1990 as:

> *"any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land, that –*
> *"(a) significant harm is being caused or there is a significant possibility of such harm being caused; or*
> *"(b) pollution of controlled waters is being, or is likely to be caused; ..."*

As regards the assessment of economic benefits, the key issue is the nature of harm. The document "Contaminated Land Statutory Guidance"[1] which supports interpretation of the Act, provides clarification of key concepts as follows:

> *Section 78A(4): "Harm" means harm to the health of living organisms or other interference with the ecological systems of which they form part and, in the case of man, includes harm to his property.*
> *Section 78A(5): The questions - (a) what harm or pollution of controlled waters is to be regarded as "significant", and (b) whether the possibility of significant harm or of significant pollution of controlled waters being caused is "significant" shall be determined in accordance with guidance issued for the purpose by the Secretary of State*

Further clarification identifies the possibility of physical harm to human beings and ecological systems as well as to property in the form of buildings, crops and animals.

This definition of "harm" takes into account direct effects on damage to property but does not take in to account the full potential economic impacts which are wider in scope, and so do not affect determination of whether land is contaminated or not. Factors such as the value of blight are excluded and, more generally, this leads to a decoupling of the processes for determination and assessment of contaminated land. This in turn can lead to "market failure" in that a difference arises between the costs of remediating the site and the levels of possible benefits that might result. If market failure did not exist, then the market would provide a mechanism so that sites would be remediated where benefits were greater than remediation costs.

2.3 Valuing Contaminated Land

The development of economic thought has always been closely connected with the development of land ownership and management. The value of land is a fundamental component in the economics of agriculture, one of the earliest areas in which the discipline was developed, in the theory of the definition of public and private goods as well as to the economics of property rights.

Today, the value of contaminated land is increasingly affected by the ideas of the environmental movement and the development of corresponding legislation. Contaminated land, which fifty years ago was seen predominantly as a useless waste from industry, is now managed within a more formal structure of obligations which promote reuse where possible. Now, the impact of the land on surrounding areas and even on parts of society who might never use it can now be included in a more extensive valuation framework which goes beyond financial and market values.

Even without the introduction of new ideas, the approach used to assess contaminated land depends inherently on society's appreciation and value of land more generally. For example values may be affected by the relative scarcity of certain types of land resulting from factors such as population growth and government policy. At one time England's woodlands were seen as a natural resource essential to defence as they provided the timbers for warships. Now their overuse and loss can be seen as a form of environmental damage - loss of a unique resource -

[1] This Statutory Guidance was issued in April 2012. It can be found at http://www.defra.gov.uk/publications/2012/04/10/pb13735contaminated-land/

though this could, in principle, be remediated. The value from doing so is in fact rarely calculated and the "value" of land in practice is normally understood to be its just its market value based on its market price in its current state. This measure of value is predominantly an "instrumental value" reflecting an anthropocentric view of current needs and uses.

This anthropocentric value of land can be contrasted with a wider concept of value which includes more "intrinsic values" such as the value of a habitat for species which benefit neighbouring land (e.g. bees through pollination). "Ecosystem Services" is the overarching term increasingly used to describe these benefits of which some can be valued using existing methods (such as surveys), while others which are more intrinsic remain difficult to value (such as the support ecosystem service of soil formation).

One important aspect of valuation is the method of accommodating irreversible change such as changes in interdependent habitats or pollution of deep groundwaters. As an example of the complication in assessing this, sites may host unique ecosystems due in part of the contamination for which the destruction through remediation would also be a form or irreversible change. Natural processes are always ongoing and may be an effective method of restoring or managing a contaminated land site without remediation programmes requiring human intervention.

As a result, the range of issues and corresponding literature that is potentially relevant to the assessment of benefits is large, covering society's approach to land and the environment generally, new and developing methodologies addressing aspects such as ecosystem services, the specific characteristics of sites and substances, and the nature of the impacts of contamination. Furthermore, a particular study may also draw on literature from other fields, to address uncertainty or risk thresholds for example, and may also take account of attitudes of the local population as well as the historical evidence relating to the site and its previous uses.

2.4 Benefiting from Remediating Contaminated Land

Each site is unique and the benefits available from remediation depend on local characteristics and circumstances as well as on general attitudes towards contamination. Local factors in particular will affect the degree to which stakeholders participate in the costs of remediation and benefit from it. A highly contaminated site may be costly for the owner to remediate but may provide substantial benefits to residents particularly in areas with a high population density. One direct benefit is a reduction in the possibility of exposure to hazardous materials. In addition, the benefits of health and amenity improvements may lead to a change in the perception of the quality of the area and also lead to an increase in the desirability of properties and changes in house prices.

Establishing a mechanism to link the costs of remediation and the resulting benefits may be difficult in practice, even where total benefits are expected to outweigh total costs substantially. While remediation may increase the value of neighbouring properties, the developer of the contaminated site may not themselves benefit unless they own the surrounding properties (and bought them before expectation of remediation caused any pre-emptive price rises). Unless there is a mechanism for participating in the benefit, the developer may choose not to remediate and, even if they do so, it may only be to a level sufficient for a lower value economic activity rather than to a level which would maximise overall benefits for all stakeholders.

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The lack of a market mechanism which both permits the best overall outcome for society and also provides the right incentives by rewarding relevant parties in a fair proportion reflecting their contribution to the costs is known as market failure. The solutions to market failure include making agreements between developers and beneficiaries before undertaking the remediation and establishing dedicated funds to cover the costs of a specific project. Government may participate directly in these solutions at either local or national level or act as an enabler.

Although the greater part of the benefits of remediation are likely to be experienced by local populations, stakeholder groups with wider perspectives (such as UK targets for biodiversity) may also benefit and contribute to specific remediations with skills or financial support. Overall, an actual remediation will need to balance all these factors according to the circumstances. The administrative costs of enabling a particular solution will need to be included in the overall costs.

2.5 Strategic Options for Valuation

2.5.1 What is a Strategic Option?

In practice, a strategic option amounts to a selection of the types of benefits to be valued and a choice of methodology for valuing them. The differences between options will depend on the:

- philosophical approach - such as which framework of economics is relevant;
- the economic assessment framework - including the types of benefits, and also more aspects such as the time period for assessment and which parties should be involved; and
- practical constraints, such as dataset availability, timescales and resources.

The need for strategic options is itself a response to a set of circumstances and strategic objectives which were not specified in detail for this project however the project outputs - the material presented - is believed to be applicable to a range of circumstances and objectives.

The nature of the ‘economic assessment’ referred to in the project title is implicitly general in scope. In practice, the meaning is of a ‘better’ or ‘more appropriate’ economic assessment as, for most sites, some form of assessment will already exist or is relatively easily available (e.g. estate agent valuation). Establishing an ongoing process of improving assessments way can be assumed as a strategic objective. Supporting actions focused on the long term include implementation of monitoring programmes of both the site and neighbouring area. Actions focused on the short term include identification of specific methodologies for studying sites of a certain type. In each case, the costs of a strategic option will need to be compared with the advantages of meeting the strategic objectives it addresses.

This report does not formulate the strategic objectives and define specific strategic options against them. Rather it raises relevant issues, establishes the context and explains the material appropriate to such decisions and choices, including its availability.

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2.5.2 Philosophical approach

A set of principles for economic assessment is established in the Treasury 'Green Book', 2003 (with updates 2011). A particular benefit is the standardisation they provide across government assessments. For the consideration of contaminated land, these principles, as well as other approaches are applicable.

The main approach used here is that of Total Economic Value (TEV). The main advantage of TEV is that it categorises different types of value, including those used in the Green Book, and organises them within a common framework. Different kinds of value can therefore be seen as complementary and in relation to each other, rather than as alternatives. TEV is implicitly a 'philosophical' approach in that it considers some kinds of value, such as market values, but not others, such as intrinsic values and overall, reflects an anthropocentric view.

A different approach is that of Ecosystem Services which begins from a starting point which is more focused on preserving and using the environment. In this approach, services provided by ecosystems are used by society, but also are recognised as part of the environment itself, such as those for soil formation.

Some other approaches have fundamentally different philosophical or cultural bases with, for example, societal models which have no concept of ownership. These are not considered further, though their potential insights for understanding long term issues is noted.

How temporal issues are addressed is particularly important to all forms of long term environmental change, including contamination of land. The main approach used in the Green Book is the use of discounted values for future years with different rates for different periods of effect. This approach values an impact less highly the further it is into the future. Such an approach is relevant if remediation is seen as an investment in comparison to other investments that society could make.

Total Economic Value

TEV is a concept used to characterise and capture values at the level of society. Its components include financial values expressed in markets as well as more intangible values relating to individual preferences. TEV includes what might otherwise be seen as different forms of benefit (such as amenity benefits and financial benefits) within a single framework. Although comprehensive, TEV has inherent difficulties in use, such as establishing certain types of value. In practice it is broken down into components which are valued singly or in combination using a variety of methods to construct a working value appropriate to the valuation context.

At the highest level, TEV is broken down into two sub-categories:

- *Use values*: the values placed on resources that are currently used directly or indirectly. For land these include property development and amenity (e.g. recreational) use; and
- *Non-use values:* benefits derived from knowledge that a particular resource is maintained. Non-use values are independent of any use, present or future, that people might make of those goods and include existence, bequest and option value. An example is the value of the pleasure someone might take in knowing that less land is contaminated, even if they never visit the site.

Although non-use values are difficult to assess, they are increasingly included in policy assessments. They are covered in the Environment Agency's Benefits Assessment Guidance (BAG)[2] focused on the water sector and in the US Environmental Protection Agency's assessment of natural resource values[3].

The methods described here can be used to evaluate non-use values of contaminated land. However, the focus of this report is on use values as they:

- Are the most common topics in valuation studies of both contaminated land and other environmental studies with an intrinsic focus on location;
- Give rise to differences which are site-specific and can support processes of comparison;
- Interface well with the concerns of public bodies and reasons for conducting valuation studies; and
- Depend on a range of real-world issues, including comparability, accuracy and data limitations.

Ecosystem Services and TEV approaches

"Ecosystem Services" (ES) is an approach to assessing the value provided by the environment which has a fundamentally different starting point compared to TEV. The ES approach begins with a scientific description of the environmental context and the activities within it whereas TEV begins with the different types of value that humans have used historically, of which environmental value is just one.

TEV works on the premise that if something had value (for whatever reason) then estimating impacts of its change will allow assessment of benefits. It does not decide how things come to have value. The ES approach instead needs techniques to translate an underlying physical description of changes and use of a particular resource - the environment, into a measure of value. Despite having different starting points, TEV and ES approaches can use some of the same techniques. For example, they both recognise recreational benefits and can use the Travel Cost Method to value them[4].

ES approaches do not easily include some types of value. An example is the impact on house prices of unfounded fears of damage caused by a contaminated site (a form of blight). Furthermore, separating out the movements in prices due to changes in ecosystem services from other changes is very difficult, particularly as features resulting from ecosystem services (e.g. a nice park) may not be understood by users as resulting from underlying individual ecosystems services and attributing value to each of these is a difficult and potentially arbitrary process.

A more detailed comparison of the components of TEV with the components of the ES approach is provided in Appendix E.

[2] http://www.environment-agency.gov.uk/business/sectors/37305.aspx

[3] See http://www.epa.gov/superfund/programs/nrd/faqs.htm

[4] Using the Travel Cost Method, the value depends on observations of the cost and time people are prepared to pay to enjoy a particular amenity.

Effects of Time

Many methods, including those in the Green Book and the different component parts of TEV all need to address the basic problem which is the need to value the difference between the land in its contaminated and remediated states. This implicitly requires the definition of a possible world in which the land is not remediated and may also require definition of a hypothetical world in which the land did not become contaminated. The first is required to assess remediation benefits, the second to define a 'pristine' state to which remediation, which could be only partial, may aspire.

Furthermore, the points in time when these occur may affect valuation both in the short and long term. Using common short term financial horizons, a study which compares a two remediation programmes, one over 20 years and one over 5 years will need to take an approach to discounting (the relative value of future benefits) which will favour one or the other. Only with a discount rate of zero would remediation have perpetual value, and this is not used in public policy making.

In the long term, the value of perpetual non-remediation could be seen as change that becomes 'established' like other one-off environmental changes, such as the harvesting of established woodlands. The relevance of this is that remediation work becomes just one other action that society could take and one that would be normally be valued not only in comparison to hypothetical states but prioritised with respect to *all* other actions that would produce future benefits. The implication is that remediation should only be undertaken if it is part of the best overall use of society's resources.

Time may also play a part in the removal of expected benefits. For example, remediation may improve amenity benefits in terms of visual appearance, but this improvement may only last for a short period if the site is subsequently redeveloped.

2.5.3 The Economic Assessment Framework

Whichever philosophical approach is used, an economic assessment framework will be required which meets the needs of the specific study and context. These include the need for and possibility of achieving a certain level of accuracy, the selection of the types of benefits requiring evaluation, and assumptions for study parameters such as the level of discount rate to use.

The purpose of the valuation is likely to be the primary determinant of the framework. For example, a simple price agreed between buyer and seller might be a sufficient valuation methodology to enable a change of ownership. Different methodologies may be required according to whether the need is to identify one site from three, to rank a much larger number of sites, or to make detailed assessments of individual sites.

Underlying all valuation exercises are themes of relative value. These may be internal to the study, such as site comparison studies, or external as when total impacts are calculated and then implicitly compared to external values, such as local authority budgets or to the costs of the health service. More generally the framework design will be affected by two main considerations: the parties involved (explicitly or implicitly), and the type of assessment required.

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Parties involved

Public bodies representing society's wishes are most likely to need to seek to understand all the possible benefits that may arise. These include wider benefits, such as those arising from environmental change and sustaining ecosystem services. Parties with more specific interests will often need just a subset of these values or wish to calculate them in a certain way. Private companies will seek the highest value for shareholders, in comparison to public authorities who have more complex responsibilities and obligations, including those to future generations. Both kinds of owner will implicitly compare values with market values, but also with other benefits such as tax benefits for a private company or the contribution the remediation can make to a local urban regeneration programme for a local authority.

Type of Assessment

Although it appears that the assessment of a single site might be the simplest, some types of benefit are difficult to calculate with accuracy and total benefits (which depend on their sum) correspondingly uncertain. In comparison, an assessment of a single type of benefit at multiple sites might be easier and more accurate. Some studies may need the collective value of a group of sites rather than individual results. The objectivity of the assessment may be a concern requiring the agreement of parties involved in the design. Such factors affect the detail in the design of the type of the assessment.

Some aspects are nevertheless particular to certain types of assessment. For example, in comparative studies, the methodology will always have two parts: (i) the valuation methodology(s) for individual sites and (ii) the methodology for comparing or ranking sites. While both parts are required, they could be developed together as a pair or separately, even by different teams.

Ranking systems may be used as an alternative to expressing results in monetary terms for parts of the analysis or when applying overall judgements although monetising results always has the advantage of avoiding the need to develop a weighting scheme for results expressed in other terms.

An actual study may use the following techniques:

- More detailed studies at some sites than others;
- Screening of sites before undertaking a fuller benefit assessment study (e.g. according to features, practical constraints or topics of interest);
- Screening of benefit types (e.g. to prioritise those affecting certain parties);
- Explicit methodologies for resolving types of uncertainty; and
- Calculation of results for groups of sites (e.g. where sites close together are all remediated at the same time).

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2.5.4 Practical constraints

More practical issues may also play a part as valuation may need to be performed within a certain time, or with limited information. In these cases, an acceptable level of scope and error may be agreed between parties.

Where timescales are an issue, the level of existing data may be a primary consideration (as may be the time to establish the level of data). Other constraints, particularly in comparative studies, may lead to a need to use a more limited set of types of data which are already consistent to some degree across different sites. A key database for site valuation is the records of property transactions. As well as their use in local valuation exercises, property prices also provide a pre-existing reference framework for comparisons across the UK.

2.6 Checklist of Factors affecting Study Design

The following is a check-list of aspects to consider in study design.

- **Categories of benefit:** A particular study may not need to consider all categories of benefit, or may choose to concentrate resources on key categories of benefits (see Section 3);
- **Level of benefits:** The size of benefits or expected benefits may affect how the methodology is applied. Early identification of overriding benefits may help when, for example, an initial filtering process is needed to compare a number of test sites;
- **Ex-ante or ex-post assessment:** Benefits may be assessed before or after remediation. More generally, benefits may be estimated based on current data, then the estimate used to guide remediation action and/or further data gathering, followed by a re-estimation which could look backward, comparing with previous estimates, and/or forward, to revise future estimates. The techniques for ex-post evaluation of benefits will be different from those for an ex-ante evaluation. There may be a reason to apply ex-ante techniques to /circumstances *in the past* if there is historical data that allows these to be recreated. This would, for example, test the accuracy of a forecasting technique (see Section 4);
- **Data adequacy:** The availability of data will have particular impacts in studies which compare different sites and obtaining additional data may be required as part of a process of reducing uncertainty. Trade-offs between the time and cost of obtaining additional data and the impact of potential error may need to be addressed in some studies;
- **Medium of contamination:** Contamination is usually unevenly distributed across a site with corresponding variation in impacts through soil, surface water and groundwater pathways. Impacts through airborne pathways will begin from either soil or water although in practice are unlikely to need separate identification;
- **Location:** Benefits in a number of categories are affected by a broad characterisation of the size and distribution of receptors. For human receptors, the urban/rural characterisation is often used as it captures a range of features that help focus a benefit assessment study;
- **Previous and future use:** Remediation which produces a wider range of potential uses is a clear benefit (subject to remediation costs) and is captured as site value and productivity benefit. Selection of possible end-use may be an important assumption in valuation exercises and sometimes this will be

known, but otherwise assessments of post-remediation and market judgement as to demand from different sectors may be required;

- **Risk level**: The risk from contaminated land results from a number of potential sources of uncertainty from the level of contamination to the effectiveness of mitigation measures. Risks may need to be grouped into their different types as part of the assessment; and

- **Existing knowledge and research**: Previous work on benefits is often very site-specific and may have been undertaken as part of studies with different objectives (See Appendix B).

2.7 Statement of Types of Benefit resulting from Remediation

Although remediation may need precise definition in some circumstances (for example, in contracts specifying management procedures for land cleanup), from an economic perspective a broader definition is sufficient and all remediation by definition is expected to produce benefits.

The types of benefits are discussed under the categories below, grouped by direct and indirect benefits. Categories are a convenience rather than a necessity used to help develop and catalogue a comprehensive set of causes and effects related to an individual site or set of sites. The first five in this list reflect topics that are commonly found in the literature as important in addressing contaminated land. The following four are referred to in the specification for this work and covered in some of the literature surveyed. They are discussed in detail in Section 3.

The direct benefits of remediation are understood to result from changes in:

- **(A) Site value** - An increase in the value of the previously contaminated land as a result of increased opportunities for alternative more valuable uses of the land;

- **(B) Neighbouring property** - Increased value of neighbouring land and properties;

- **(E) Environmental Benefits** - for example, benefits associated with reduced negative ecosystem impacts such as loss of biodiversity and improvements in water quality;

- **(F) Amenity benefits** - for example, improved access or improved environmental appearance; and

- **(H) Reduced Health risks** - Reduced health risks and/or improved health outcomes either from direct exposure and ingestion to soil-borne contaminants or exposure to soil-borne contaminants transported into groundwater or air.

Remediation may also result in indirect benefits in terms of:

- **(C) Property transactions** - Property transactions not impeded by concerns or uncertainty of contamination;

- **(D) Productivity benefits** - Improvements to productivity arising from the cleanup of contaminated land including reductions in averting behaviour, less need for protective equipment for exposed workers, and less damage to plant and machinery as well as reduced administration costs (e.g. reduced levels of fines);

- **(G) Greenfield development savings -** Greenfield savings (and avoided loss of ecosystem), as remediation may allow brownfield development instead; and
- **(I) Agglomeration benefits -** which arise from greater brownfield development and consequent urban density.

Benefits are not all mutually exclusive. For example, the benefits of reduced health risks may be reflected in an increase in neighbouring property prices as people respond to the change in health risk and are therefore willing to pay more for neighbouring properties than previously. Similarly, some amenity benefit may be capitalised into local house prices once the land has been remediated and also into the rents and capital values of commercial and industrial premises.

Where not mutually exclusive, benefits, once distinguished, are usually additive, regardless of their cause. As an example, remediation of a site such that public footpath can be reinstated would potentially result in:

- Amenity benefits, as the footpath would add to the sum of footpath resources; and
- Productivity benefits, if workers could use it to save time moving between factories.

This illustration shows that in specific cases, possible benefits can be relatively easily identified, and assessed for likelihood. Here, productivity benefits will only occur if workers need or would need the footpath. The size of the benefit would be calculated in terms of time saved.

Double counting in a particular study can be avoided by breaking down the benefits according to their underlying causes. However, if aggregated values from one site with known benefits is used to values at another then categorisations need to match to avoid double counting.

2.8 Statement of Types of Valuation Methodologies

Typically, more than one method can be used to value a particular benefit, with strengths and weaknesses dependent on circumstances and study design. Experience of the use of these methods outside the context of contaminated land is common and can also provide insight to a particular study.

A summary of these methods is presented here. Section 4 contains more detailed descriptions which are included as cross references below.

Revealed preference methods are based on observation of current behaviour. The underlying assumption is that people's values are revealed by the choices they make in purchasing or consuming marketed goods and services. Revealed preference methods rely on identifying goods and services which provide good proxies for information about their probable attitudes to the environmental good or service under investigation (See Section 4.2)

The methods are based on evidence from real market transactions such as correlations between noise disturbance and house prices. As such, they are based on real actions by people that incur real actual costs.

Methods include the **Hedonic Pricing Model (HPM)** and the **Travel Cost Method (TCM)** (See Sections 4.2.1 and 4.2.2).

TCM can be used to estimate value of recreational use by using travel expenditure as a proxy for the price of enjoying a resource such as a lake or forest. One way it can be implemented is to observe the number of visitors to a site and to question them as to their costs of travel.

HPM is based on changes in house rent or land prices and is used to value local environmental quality, such as air pollution, water or noise pollution, and environmental amenity, such as the aesthetic value of the view from a property or its proximity to recreational sites. It is based on the notion that degradation in environmental goods/services would lower the price of a marketed product (a house) with a relationship to these.

Stated Preference (SP) methods involve questionnaires and interviews with people which include a description of a hypothetical situation (sometimes involving a market) and ask how they value a given outcome. In particular, these are based on asking people to state their willingness to pay (WTP), contingent on a specific hypothetical scenario and a description of the environmental goods and services (See Section 4.3).

This group of methods includes the **Contingent Valuation Method (CVM), Contingent Choice Experiment Method (CE)**[5], and (less commonly) the Stated Reference Gamble (SRG) (discussed in Section 4.3). The methods are very versatile and can be applied to all kinds of environmental goods and services and all types of uses but also have a number of limitations. However, well designed surveys are shown to provide robust estimates. In the context of contaminated land stated preference methods have particular relevance as they provide the basis for assessing non-use environmental benefits and estimating the value of reductions in risk of premature deaths or non-fatal injuries (which are a form of harm attributable to contaminated land);

Direct or market based methods include **Market Price, Production Function and Avoided Damage/ Substitute Cost Methods**[6] (See Section 4.4).

The Market Price Method uses prices from existing markets. The concept is that this price captures the direct value of a particular change, which can then be valued “at market prices”.

The Production Function (PF) Method can be applied when environmental goods and services are an input in the production of a marketed good. It requires data that shows how changes in the quantity or quality of the environmental resource affect - (i) costs of production for the final good, (ii) demand for and supply of the final good, (iii) demand for and supply of other factors of production.

The Avoided Damage Cost and Substitute Cost Methods[7] also comprise direct methods and are applied where investment or costs result from the loss of an environmental resource.

[5] The method has a number of alternative formats: (a) Contingent Ranking (b) Discrete Choice and (c) Paired Rating

[6] See Environment Agency (2007), Mishra (2003), Görlach and Interwies (2003) for a detailed discussion on the methods and their selection.

As well as these groups of distinct methodologies a further technique called '**Benefit Transfer**' (BT) relies on reusing results from previous studies. This technique has more recently become known as '**Value Transfer**' (See Section 4.5).

Expert judgment may be considered a further method which can be used independently or to supplement others (See Section 4.1).

Table 2.1 shows the applicability of methods to the different types of benefits arising from remediation of contaminated land. Note that BT is not shown as it is a way of reusing other methods.

Table 2.1 Main Methods for Assessing the Benefits of Remediation of Contaminated Land

Benefits	Methods							
		Direct Methods		Revealed Preference		Stated Preference		
	Expert Judgement	Market Price	Avoided Damage Cost /Production Function	Hedonic Price Models	Travel Cost Method	Stated Reference Gamble	Contingent Valuation	Choice Experiment
		MP	ADC/PF	HPM	TCM	SRG	CV	CE
(A) Site value	●	●		●			●	●
(B) Neighbouring property	●	●		●			●	●
(C) Reduced Health risks				●		●	●	●
(D) Environmental Benefits			●			●	●	●
(E) Amenity benefits	●			●	●	●	●	●
(F) Productivity benefits	●	●	●					
(G) Property transactions	●			●				
(H) Greenfield development savings			●				●	●
(I) Agglomeration benefits				●				

[7] In some sources, Averting Cost Method is discussed as part of Revealed preference methods;

2.9 Case Study Summary Description and Results

Case studies are chosen to illustrate use of valuation techniques rather than fitting a single hypothetical study design. Their aim is to demonstrate workable methods that could be fitted to a number of different study designs.

The three cases are:

1. Mirvale Chemical Works, a former creosote plant in West Yorkshire used for chemicals manufacture for over 100 years. The works are located close to the river Calder and the contamination arising from disposal of industrial residues to the soil has resulted in impacts on surface waters. It is proposed as a case study as it illustrates techniques for assessing environmental benefits (See Section 5.1).

2. Ince Central Estate in Wigan comprises housing built in an area previously used for industry. It has a resident population and exhibited contamination which could have resulted in significant risks to their health. The site was remediated in 2010. It was chosen as a case study as there is information on the potential health impacts which were a primary justification for remediation work. Also, the predominantly urban character of the location contrasts with that of the other two case studies (See Section 5.2).

3. Phoenix Park, now an area of open access to the public, is the result of the remediation of the former Hickleton Colliery site near Thurnscoe, South Yorkshire. This site has been chosen as a case study as it is possible that Phoenix Park has generated significant social and economic benefits within surrounding areas. Its position between population centres results in impacts on the neighbouring area and its new use as parkland illustrates increased amenity value from the remediation (See Section 5.3).

There is an emphasis on techniques used for assessing Site value and Neighbouring Property benefits as these are likely to be relevant to a number of different types of benefit study. This technique has the benefit of being based on market prices, uses standard property market datasets and is readily transferable to other sites. It defines a simple hedonic price model to provide an ex-post assessment of remediation at the three case study sites. Models are estimated for at each site independently. It is implicitly 'backward-looking' and formulates the question as to whether property prices near the study area have risen, relative to those in the wider area, after the remediation period. The design of an alternative model which could be used for 'forward-looking' prediction of site and neighbouring values would be based on representing the features of each site including the nature of the local area and effects of different possible end-uses of the site as well aspects related to the local property market.

The cases studies also include commentary on the preparation of independent estimates for Health and Amenity benefits but here they are assumed captured within property values and are not added as a separate item.

The results of the assessment of neighbouring values used two methods: a 'before and after' comparison of *all* house price transactions within a certain distance of the site; and a similar comparison of transactions just for the houses which were sold twice, one before and one after the remediation (a 'repeat sales' method). The second method standardises for the locational and neighbourhood effects of the property.

Applying the impacts identified relating to house prices to all houses within an area of approximately one kilometre around each site gives an aggregate increase in value of £43.9m at Mirvale, £54.4m at Ince and £52.6m at

Thurnscoe, all relatively large compared to the probable costs of remediation. Of particular interest is that at all three sites the 'repeat sales' version of the relationship explicitly shows remediation having an effect[8] . For one other site (Thurnscoe) the 'before and after' analysis also shows an explicit effect, while for the other two it gives inconclusive results from a formal statistical perspective.

2.10 Conclusions

Specifications of strategic options for economic assessment can differ in their conceptual and philosophical approaches as well as in their qualitative and quantitative characteristics and assumptions. This report proposes the use of Total Economic Value as a conceptual approach for all options. An alternative approach based on ecosystem services is not currently considered sufficiently comprehensive for general use though applicable in some circumstances.

Following this approach, the report identifies the following types of benefit which may increase in value as a result of remediation:

- The site itself;
- Neighbouring property;
- The surrounding environment;
- Local amenities;
- Health of local communities and others;
- Number of property transactions;
- Productivity of land and labour;
- Greenfield savings from avoided loss of ecosystem; and
- Agglomeration benefits from greater urban density.

The need for strategic options is itself a response to a set of circumstances and strategic objectives which will also ultimately determine which option is best. For example, option design may depend on interest in:

- The types and levels of benefit;
- Whether an ex-ante or ex-post assessment is required;
- The medium of contamination;
- The type and number of locations;

[8] i.e. rejects the null hypothesis that remediation has had no effect

- Types of receptors;
- Previous and future site uses; and
- Risk and uncertainty levels.

Practical option design will also be constrained by actual or expected availability of data and research resources.

Each strategic option may assess one or more types of benefit and each benefit can be estimated using a range of possible methods grouped as follows:

1. Those depending on observation of current behaviour (Revealed Preference), such as house prices and other market prices;

2. Those which use surveys to elicit views about future change (Stated Preference), such as the declared willingness to pay for improvements resulting from remediation;

3. Use and adaptation of values from previous studies (so-called Benefit Transfer); and

4. Expert judgement.

The advantage of Stated Preference methods is that they can address the benefits of any potential change by putting forward specific proposals and questions to a survey population. Revealed Preference methods have lower costs but require pre-existing data such as house prices in the locality and, depending on data availability, may be more inaccurate. Benefit Transfer methods extend the use of pre-existing data by drawing on a wider set of studies of other situations and permitting further reductions in research costs for assessments with comparable circumstances.

All methods draw on data sources which cover statistical information on the size of potential effects as well as valuation information (See Appendix B). The quantitative statistics of most relevance are primarily those characterising population sizes such as the Small Area Population Estimates from the Office of National Statistics. The valuation information is more diverse. It includes databases of Benefit Transfer values, such as the provided in the BeTa source from the European Commission and the well established Environmental Valuation Reference Inventory (EVRI) database. Valuation information also includes market prices such as databases of house prices from the proprietary Price Paid Dataset. These sources supplement various registers including those of potentially contaminated sites such as the National Land Use Database from the Homes and Communities Agency as well as those addressing the underlying physical processes of contamination such as borehole data from the British Geological Society and Environment Agency. These and others are listed in Appendix B.

The three case studies provide information on the application of the valuation methods to cases where remediation programmes have been completed. They illustrate the Stated Preference methods through discussion of the use of survey data to value health and environmental impacts. They illustrate Revealed Preference methods through the analysis of house price data in the surrounding area.

The health impacts are illustrated in the case study for Ince Central Estate where there was potential exposure to residents from contamination in garden soil. Environmental impacts were assessed at the Mirvale Chemicals Works

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site where remediation stopped the occurrence of a tarry slick on a local river. Resulting benefits were based on Benefit Transfer values for improvement in water quality standards obtained from a national survey. The Phoenix Park site provided an increase in amenity from new recreational facilities and the value was assumed to be captured in local house price increases.

Although primarily illustrative, the case study results indicated that remediation is associated with benefits substantially in excess of probable costs.The methods using house price data were applied in a similar manner at all three sites including controlling for underlying property prices in their relevant wider areas. It is difficult to attribute shifts in house prices to remediation despite their apparent relationship because correlation does not imply causation. However, against the general housing market background the changes observed represent significant improvements and the fact that increases were observed across all three sites lends weight of evidence to the hypothesis that remediation results in significant benefits to the local housing market through a positive impact on house prices. These results are consistent with a view that past government funding of remediation programmes addressed a market failure and support the hypothesis that remediation programmes can and do provide net benefits.

The methodology demonstrated indicated a possible link between remediation and house price movements, but did not investigate possible underlying causes or indicate whether the same result would be obtained at other sites. This could be addressed by looking at more sites, which would reduce the probability of a ‘false positive’ (even though it would not help directly identify causes) or, dependent on data availability, by investigating possible causes directly using a more detailed version of the methodology used here or survey techniques. This type of evidence would supplement the indicative results here and could be used in forward looking estimates for other currently unremediated sites.

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3. Types of Benefits resulting from Remediation and Identification of Methods

3.1 (A) Benefits of Increased Site Value

Remediation of contaminated sites aims to result in an increased value of the land. The legal requirement under Part 2A is to make the site suitable for its current use, however remediation may also enhance the prospects for alternative more valuable uses.

Use of Methods

Increases in value of the remediated site can be determined with reasonable accuracy by experts in land and property valuation. A valuation expert has knowledge of local market conditions, and regularly deals with property valuations and sales, and would be expected to have good information on the market value of different types of land in their local area.

The problem with this approach is that the method is not particularly transparent. No information is provided on the weights attached to different attributes of the site in forming the valuation. The estimated values of environmental impacts provided by valuation experts can be higher than those derived by HPMs.

HPMs are more transparent, and have been used over many years to provide reasonably accurate estimates of the impact of environmental externalities on house prices. However, HPM can be subject to omitted variable bias, multicollinearity, and coefficients and estimates of WTP for marginal changes in an environmental attribute are dependent upon the functional form of the model adopted. HPM will not to able to estimate the environmental impact of different contaminants where the impacts are not separable. Thus HPM may not be able to estimate the value of remediation at all contaminated sites.

Choice experiments have been used to assess developers' responses to remediation incentives. Alberini et al (2005) found that developers in the USA viewed contaminated sites as less attractive, and that they valued liability relief as a remediation incentive. Developers with prior contaminated site experience were very responsive to government subsidies, whereas inexperienced developers were more responsive to liability and regulatory relief.

Data

The key data for valuing the site include information from Land Registry on property transactions, information on remediation and development costs, including in particular, finance charges, the time and costs of cleanup and consulting and transaction fees.

Valuation Methods

Experts in land and property valuation commonly use two site valuation methodologies: the comparison method and the residual method. Most frequently, the two methodologies inform one another and are both used to establish and sense-check a value.

The comparison method compares the site to those nearby with equivalent development potential. Traditionally, the comparison is based on common units, such as site area, developable area or habitable room. In principle it is a form of benefit transfer which reuses values from one location at another benefit while adjusting for certain differentiating factors. These factors include location, regulatory context (e.g. planning obligations, density limits), tenure, site condition, development costs and time costs.

The approach is favoured in simple cases, where these adjustment factors normally make up a minority of the general local value being transferred. This technique is unlikely to be suitable where there are few or comparable transactions or where "per-unit" comparison may not be the most significant factor influencing prices. It is most applicable in cases where recent similar transactions have taken place and per-hectare values can be adapted easily.

The following are important concerns:

- values may differ considerably within a small geographical area;
- the condition of the site and associated remediation costs are very site specific and could differ significantly between greenfield and brownfield, and between brownfield, sites;
- site and construction costs, for example, in terms of infrastructure and service requirements differ;
- the type of the development will vary and may reflect a requirement to provide affordable housing. In the case of residential developments the density achieved can also affect the price;
- the price may be affected by planning obligations; and
- in a rapidly changing market, the date of the sale of the comparable is relevant.

Differences between comparable sites are dealt with through heuristics, making it important to gather a variety of informed perspectives.

The **residual valuation method** can be used in relatively more complex cases which have, for example, high development costs or lack of comparable data. It also helps when isolating the value gain solely attributable to remediation. The residual method begins once a developer has an understanding of the development potential of a site, and is based on the relationship:

Land value = (value of completed development) – (development costs + developers' profit)

This formula can be applied at pre- and post-remediation stages, to understand the way in which land value is affected by the remediation process. At both stages the value of the completed development, the developers' profit, holding costs of capital, construction costs and professional fees are considered constant. All that changes due to

remediation is to remove the costs of remediation (which comprise part of the 'development costs') from the right-hand side of the formula which then increases the land value on the left-hand side by the same amount.

Since remediation costs are considered part of the development costs of the site, in the case of a typical private sector remediation project, the value added to the site by remediation equals the costs of remediation *by definition*. High remediation costs can make a development unviable, given that developers have more or less fixed appetites for expected profit and risk. If the value gained by remediation is lower than the costs, the private sector will not invest and therefore this formula will not be an appropriate model for understanding site value changes. In the absence of private sector development it is no longer appropriate to use the total real costs of remediation to infer the site value gained through remediation.

One way around this definitional issue would be to conduct a contingent valuation exercise among property developers in order to identify developers' willingness to pay for the remediation of a site. Given a particular end use, this defines how much developers would be prepared to spend on site cleanup prior to construction. Responses to this query would provide an estimate of the gain in land value regardless of the actual level of contamination and the actual remediation costs. No primary research has been undertaken for this report, and therefore no contingent valuation study has been conducted.

3.2 (B) Benefits of Increased Value of Neighbouring Property

Remediation of contaminated land may also result in an increase in the value of neighbouring land and properties including residential, commercial and industrial properties.

Use of Methods

Value changes to neighbouring properties can be determined with reasonable accuracy by experts in land and property valuation. However, the method is not particularly transparent.

HPMs have been used to provide accurate estimates of the effects of Locally Unwanted Land Uses (LULUs). In particular, studies (e.g. Smith and Desvousges, 1986; McClelland et al, 1990; Kiel and McClain, 1995) have demonstrated that the negative effects of LULUs, such as landfills and hazardous waste sites, declines with distance from the site. HPM underpinned the determination of the UK's Landfill Tax (see Brisson and Pearce, 1995; Cambridge Econometrics, 2003).

HPMs have also shown that prices of residential properties rebound after the stigmatised location is cleaned up, but that the price rebound may be slower in the nearest and lowest income neighbourhoods to a site (Dale et al, 1999).

HPMs using more sophisticated techniques than standard Ordinary Least Squares (OLS) methods have revealed that purchasers of homes in different house price brackets value attributes differently (Zietz et al, 2008) suggesting that the characteristics of the neighbourhoods surrounding contaminated sites are important in determining the aggregate value of remediation.

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CV and CE can be applied ex-ante to a particular site to value environmental improvements; and because of the experimental design underlying these methods, they can be constructed to avoid multicollinearity problems associated with HPMs. CV has been used to value the environmental externalities of quarries and this CV analysis underpins the Aggregates Tax in the UK.

For all these techniques, defining a perimeter within which property market impacts will be analysed cannot be an exact science and may invite errors of selection bias. In practice, the decision will often reflect both the need to capture a sufficient number of data points to enable robust analysis and professional judgement as to the locus of the community impacted by or able to access the site on a regular basis.

Data

The Land Registry holds a record of every residential property transaction involving a change of ownership, and their data is considered the most robust and comprehensive source of residential property market intelligence. Land Registry data are provided by month for all Local Authorities except where these are too small to permit confident averages. This data is made available via the Department for Communities and Local Government aggregated to Middle Super Output Area (MSOA) level and via some commercial operators for bulk download at individual address levels (see for example, The Property Database Ltd[9]). MSOA boundaries are likely to be too large to delineate the potentially affected area, but they can provide a basis for comparison against property values within them. In general, the quality and comprehensiveness of residential property transaction data falls the further the year of investigation before the year 2000.

Data for residential property transactions is collated in the Land Registry's Price Paid Dataset, a comprehensive archive of all residential sales since 1995. Extracts from the Price Paid Dataset are available from the Land Registry (fee payable), as well as several third-party providers, such as the website www.houseprices.co.uk (free access to transaction data since 2000) and The Property Database Ltd (http://www.property-database.com/company/). Indices, sales volumes and average prices for different types of property in each Local Authority are also made available by the Land Registry, without charge, for all months since January 1995.

Information on past transactions in commercial and industrial property markets is much more difficult to obtain as commercial and industrial property transaction records are not collected or maintained centrally by any government agency.

Proprietary datasets, assembled through the cooperation of many property agencies, are available to varying levels of detail and coverage while local commercial and industrial agents may be a relevant source of information to address specific gaps in the data. FOCUS (www.focusnet.co.uk) and EGi (www.egi.co.uk) both provide registers of known commercial/industrial transactions. There are numerous issues with the quality of data from these providers, who receive their intelligence from property agents on a voluntary basis. Of these issues the most significant is incompleteness of information for individual transactions, but there are also a number of duplicated entries and similar resolvable data quality problems. Nevertheless, these two sources constitute the best available resource on commercial and industrial property transactions.

[9] http://www.property-database.com/company/

Valuation Methods

In ex-ante assessments, one can construct an index of prices using comparables data drawn from transactions in the wider geographical area during the period of interest. Comparables should be selected on the basis of their similarity with key features of the property market in the affected area. This will establish a baseline against which to compare the current value of residences within a target proximity of the contaminated site. The hypothesis is that proximity to a source of contamination will stifle the natural level of house prices when controlling for other factors e.g. type of dwelling, freehold/lease, new/second hand. The advice of local agents and/or specialist valuation experts may be helpful in understanding and separating out the likely impact of other factors (e.g. access and accessibility) that may be correlated with proximity to the contaminated site.

In ex-post assessments, one could perform the same analysis and assess the degree to which the difference in value caused by proximity to the contaminated site has reduced due to remediation. An alternative approach would involve assessing price changes for individual dwellings, where such data exists, indexed against comparator areas and trends. This method relies on individual properties changing hands at least twice – once before remediation and once after which may not be the case for all sites. The increase in value of neighbouring properties as a result of remediation work can also be determined with reasonable accuracy by experts in land and property valuation. It should be noted that as health risks and amenity co-vary with distance from the contaminated site, the increase in the neighbouring property values after remediation has taken place will also reflect the associated amenity and health benefits and it will not be feasible to separate these values.

Data limitations may also affect the selection of a wider housing market bases for comparison to the subject site and surroundings. Housing market areas in their strict definitions do not follow administrative boundaries, and therefore this matching process cannot be exact. Two factors should guide the selection of a wider comparator area:

1. The wider comparator area should contain the site and the transactions being analysed; and

2. Consideration should be given to the urban/rural nature of the wider comparator area, so as to minimise the structural difference between the areas as far as possible.

The general principle behind selection of a wider comparator area is that the wider area should experience the same exogenous market forces as the study area.

3.3 (C) Property Transactions

Asymmetric information[10] regarding the extent of contamination may prevent or depress the frequency of land-market transactions resulting in a situation when the land is not necessarily used by the most productive owner or devoted to its "highest and best use" (Jenkins *et al*., 2006). Reduced numbers of transactions means that prices are less likely to match the levels in a more liquid market and this divergence is a potential welfare loss. Remediating contaminated land and providing communities with the best scientific and technical information about nearby sites could therefore result in indirect benefits.

[10] i.e. when one party has more information than another.

Use of Methods

Jenkins *et al*., 2006 note that potential as well as actual liability to exposure was found to prevent transactions and properties might exhibit lower prices due to actual and suspected contamination. They also identify that existing hedonic (HPM) studies might also provide indirect evidence of information asymmetry.

Studies are also available about the extent to which property transactions might be depressed due to asymmetric information regarding land contamination from Sementelli and Simons, 1997, Schoenbaum, 2002 and Howland, 2003. For example, Sementelli and Simons, 1997 found that the transaction rate of properties on which underground storage tanks are located which did not receive a "no further action letter" had a six percent lower transaction rate than the properties for commercial properties without underground storage tanks (4% and 10% respectively). However, the transaction rate for properties that *had* received a no further action letter was only 0.2%.

Data

The data relevant to property transactions is largely the same as that required to assess values of neighbouring properties and is covered in that section. In some cases, this may be supplemented by knowledge of property professionals in the area though this second source is unlikely to be sufficient for detailed quantitative analysis.

Valuation Methods

Using the data sources, transaction levels within a given distance from the contaminated site can be compared against those in wider or comparator areas at ex-post, to capture changes in the relative levels of activity in the residential market. However, particularly over the last two years, this approach will need to control for overall shifts in the housing market.

For commercial and industrial property, transaction records allow calculation of the length of time a premises has been on the market. It is possible to derive a measure of average days on the market before sale, and compare how this indicator varies with distance from the contaminated site. Again, the coverage of industrial and commercial property data is not thorough, but should permit some analysis dependent on the particular case.

In order to assess the likely anticipated change in property transactions before remediation of contaminated site has taken place, expert judgement or the BT approach can be utilised. In particular, in addition to expert assessment, the observed changes in transaction levels of residential, commercial and industrial properties before and after the remediation of different contaminated sites for a wider area across England and Wales can be used to provide insight on the potential changes in transaction levels for the sites under consideration.

3.4 (D) Productivity Benefits

Contaminated land as a source of soil, water and air pollution may affect factor productivity by making production of goods or services due to contaminated land more expensive. Such additional expenditures on, for example, workers health protection and securing products from contamination, may become obsolete once remediation has

taken place. In addition to direct expenditures, households and industries in the wider surrounding area may be subject to additional costs associated with the prevention of negative effects on health and the environment as well as on industrial production and amenities (Jenkins *et al*., 2006).

Remediation of contaminated land would therefore result in improvements to productivity at the site and its surroundings from a reduced need for averting behaviour, such as less need for protective equipment for exposed workers, less damage to plant and machinery, and reduction in site management costs.

Use of Methods

Bergstrom *et al*., 1996 and Rygaard *et al*., 2009 note that in order to evaluate the changes in the provision of different services as a result of remediation of contaminated sites, dose-response models describing outcomes as a function of exposure to a dose level of pollutant are required to link changes in contaminants with changes in services.

Averting and mitigating response estimates are increasingly being used to value environmental damages where government is required by law or international agreement to reduce pollution to a specified standard or environmental limit (see IGCB, 2010a). Where air quality is not met or where a decision is expected to exceed an air quality objective, then the use of marginal abatement costs to identify the least cost path back to compliance is recommended as the best practice approach to appraisal (IGCB, 2010a).

In the case of household water abstraction, averting expenditures of most relevance include bottled water, installation of water filters or obtaining an alternative treated water supply source (see Box 2). By extension this could bring some further benefits in terms of improved human health and/or reduced human health risks[11]. For example, Sun *et al.*, 1992 and Abdalla *et al.*, 1992 discuss reduction in the risk of cancer and other illnesses as a result of protecting groundwater quality and reduced exposure to contaminants; Gurian *et al.*, 2001 discuss reduced risk of bladder cancer and related mortality as a result of arsenic exposure reductions; and Rygaard *et al.*, 2009 consider occurrence of dental cavities, cardiovascular diseases and atopic eczema among other impacts.

Data

The key information requirements are data on the current expenditures associated with management of contaminated sites and the costs to households and industries on and off site resulting from the contamination. In addition, information will need to be collected on the averting behaviour exhibited (or, for an ex-ante assessment, expected to be exhibited) by different sectors pre- and post remediation to determine the reduction in associated costs.

Valuation Methods

Taking water as an example, the remediation of contaminated sites could potentially benefit:

[11] See Gurian *et al*. (2001), Sun *et al.* (1992), Abdalla *et al*. (1992), Rygaard *et al.* (2009) for discussion on likely health benefits associated with improved quality of water abstraction.

- Industries, which depend on good raw water quality for their production purposes or incur costs associated with a reduced lifetime of equipment;
- Agriculture, which depends critically on the quality of the soil and of the water used for irrigation and livestock watering;
- Aquaculture and commercial fisheries, which may respond positively to the improved water quality through an increase in fish population, increased fisheries revenues and improved consumer safety;
- Public water abstraction, which depend critically on the quality of the raw water quality both groundwater and surface water and would benefit from withdrawal of water of improved quality available for supply. Potentially reductions in water contamination could result in changes in (the intensity of) treatment activities required by a water company and hence in the costs. In particular, in some cases improvements in water quality can allow for reduced treatment and subsequently for the reduced costs of chemicals, labour and energy as well as increased lifetime of filters and other equipment [12]; and
- Private households affected by water quality issues.

Although less common, productivity impacts from soil and air are also possible and should be included unless explicitly ruled out. An example would be the need for a factory at a neighbouring site to install special air filters as a result of potential wind-borne contaminated dust. Remediation would remove this requirement.

The first step is the quantification of the benefits arising from a reduction in averting behaviour by users at the site. The second step, estimating the wider impact on households, industrial and commercial sectors, including those which are off-site, will be more challenging and requires linking the remediation both to the reduction of contaminants in soil, water and air and then to changes in averting behaviour. This may require environmental and behavioural modelling.

In the absence of information on the averting costs pre and post contamination, dose-response models could be employed to link changes in contaminants with changes in services such as water provision, soil and air quality.

As an illustration, Box 2 shows the use of the averting expenditure approach.

Box 2 Using Averting Expenditure Approach for Costs to Households

The benefits of remediation of contaminated sites for households could result in a reduction of health risks and current expenditures associated with the risks of exposure, for instance through consumption of food and water.

The **Averting Behaviour (or Expenditure) approach** derives the value of clean water based on the cost that consumers incur in order to avoid contaminated water. Abdalla, 1994 highlights that the important factors influencing averting costs include: contaminant and its health risks, type of water supply, cost of averting actions, household and community characteristics. Crutchfield *et al.*, 1997 also discuss averting expenditure models - where the value of clean drinking water is measured by expenditures on less risky substitutes such as bottled water.

The method is based on estimating the costs of behaviours to prevent or mitigate adverse impacts of pollution. The benefits are inferred by measuring consumption of goods and services that substitute for the environmental change. Bartik, 1988 examines how the benefits of non-marginal (large) pollution reductions can be evaluated using information on households' defensive expenditures to alleviate pollution and suggests that the benefits of marginal pollution reductions are equal to defensive expenditure savings (i.e. the minimum expenditure

[12] Geering (2000) explored a reduction in filter surface area (thus enabling significant savings); Rygaard *et al.* (2009) considered corrosion of water distribution network; Koteen *et al.* (2002) on likely impacts for producers from reduced loads of different contaminants.

needed to reach target utility at certain pollution level and set personal environmental quality).

The examples of averting behaviour include among others[13]:

- Installing purification systems, e.g. filtration system;
- Purchasing and consuming bottled water. It should be noted, however, that drivers behind the increase in bottled water consumption are not always clear: risk avoidance, taste preferences, failure of trust in authorities' decisions, and lack of comprehensive and open information may all be causes for people not to use the local water supply;
- Obtaining water from other sources, e.g. importation from 'pure' wells;
- Connecting to the public water supply, avoiding, for example, their own wells;
- Using point-of-use/point-of-entry (POU/POE) technology at individuals' properties that can provide an affordable means for rural residents to remedy contamination;
- Physical relocation;
- Installing an urban water treatment facility.

The literature (referenced in the footnotes) suggests that the averting expenditure method is an alternative estimate of willingness-to-pay for risk reduction associated with water quality. It provides a lower bound estimate of benefits from changes in water quality[14], i.e. the change in defensive expenditure represents a lower bound estimate of benefits from a reduction in pollution. The method is best used where damage avoidance or replacement expenditures have actually been, or will actually be, made.

In order to use the method information on households' averting behaviour should be collected or assumptions made. The literature suggests that the ability of individuals to assess the safety level of their current exposure and the implications of anticipated change is fundamental in the context of averting behaviour.

Entec, 2009 Valuing the benefits of reduced drinking water treatment as a result of Water Framework Directive measures – PHASE 1. Report for the Environment Agency

3.5 (E) Environmental Benefits

Contaminated land can be a source of tainted soil, polluted water and airborne toxins negatively affecting the natural environment. In addition to adverse health and amenity impacts, contaminated land may, for instance, negatively affect biodiversity and habitats, water, air and soil quality. Therefore, remediation of contaminated sites may have a positive impact on natural environment and wildlife. Relevant environmental issues include, amongst others, eutrophication and pollution of water bodies with toxic substances, soil contamination and losses of habitats and species.

Use of Methods

To begin with, there is often considerable uncertainty about the precise impact of pollutants on biodiversity and wildlife. Overall, biodiversity benefits can be estimated, but biodiversity values have proven notoriously difficult to transfer between sites (see Hanley *et al.*, 2006). While numerous studies are available on assessing non-use environmental benefits associated with water quality and biodiversity, there is a lack of estimates of the ecological benefits associated explicitly with land cleanup (Jenkins *et al.*, 2006[15]).

[13] See Poe and Bishop, 1993; Quiggin, 1992; Abdalla *et al*., 1992; Poe, 1997; Barrett *et al.*, 1996; Klinko and Abdalla, no date; Rygaard *et al*., 2009

[14] See Barrett *et al.* (1996), Abdalla (1994) Quiggin (1992), Mishra (2003), Marbek (2007), Ribaudo and Hellerstein (1992) for discussion

[15] We note that the study by Jenkins *et al.*, 2006 was undertaken by the National Centre for Environmental Economics in the US Environmental Protection Agency. It describes the different categories of benefits or routes through which contaminated land affects social welfare: primary effects are identified as health, ecosystem and amenity effects; indirect effects on productivity and depressed property transactions; and there are potential Greenfield savings effects of redevelopment, and agglomeration effects. The Jenkins *et al.*, 2006 study evaluates the clean up of contaminated land in the USA under these categories. As these benefit categories were specified in the project brief, the reference to Jenkins *et al.* is correspondingly extensive.

On one hand, such analysis requires understanding and data on the anticipated ecological changes in physical terms (such as species and areas affected) and modelling of such linkages is extremely challenging. The Superfund Benefits Analysis Advisory Panel (2005), for instance, suggests that the various ecological consequences of cleanup and removal need to be fully described and then translated into descriptions of anticipated beneficial effects. The next step is to quantify the likely ecosystem impacts by estimating, for instance, the number of surface water bodies that will avoid or abate contamination or result in avoided contaminant concentrations in surface and ground water, potentially using physical fate and transport type models. There is however generally very little information on ecological and ecosystem indicators being collected at hazardous waste site cleanups.

Secondly, a choice on the valuation technique needs to be made with a range of methods being available, including CVM, CE, Averting Behaviour/Avoided Costs/Replacement Cost approaches among others.

Stated preference methods have an important role in assessing environmental benefits as these can capture non-use values associated with remediation of contaminated sites. However, not many studies assess environmental benefits of remediating contaminated land in practice. In 1992, the EPA commissioned a contingent valuation study to estimate non-use values from groundwater cleanup at contaminated sites (McClelland et al. 1992). Another study addressed cleanup of the partially remediated Waukegan Harbor Superfund site in Lake County, Illinois and compared survey- (conjoint choice approach) and market-based approaches to valuing further cleanup of asbestos and PCBs (Chattopadhyay et al., 2005). In particular, the elicited WTP in this study for continued remediation of the site was compared to the results of a HPM carried out in 1996-2001. The WTP results were comparable to HCM results ($535 million and $594 million for full cleanup respectively).

In the UK, CVM and CE approaches were used to assess the environmental (non-use) benefits associated with reaching good ecological and chemical status in the water bodies. A study by NERA, 2007 using CV and CE found mean WTP for an improvement in national water quality of 95% by 2015 ranged from £49.20 – £293.70 per household per year.

Data

The key information requirements include information on the site in terms of its environmental characteristics. In particular, information on air, water, soil quality, biodiversity prior and post remediation will be required. Data on anticipated ecological changes and the impact of different pollutants on biodiversity and wildlife will also be required.

Valuation Methods

The first step is to quantify the marginal changes in environmental quality as a result of remediation of the contaminated site in terms of its impacts, e.g. on biodiversity. Even with environmental monitoring data for soil, water and air quality, there is often considerable uncertainty about the precise impact of pollutants on biodiversity and wildlife and this complicates the assessment. In addition, the time taken for an ecosystem to recover or reach the desired state may mean that benefits are not immediately seen. .

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The next step will be to quantify the likely environmental impacts estimating, for instance, the number of surface water bodies that will avoid or abate contamination as well as the avoided contaminant concentrations in surface and ground water. This can potentially use physical fate and transport type models.

Stated preference methods which survey the expectations of local people regarding environmental improvements and their perceptions of potential changes in value are considered the most suitable to assess the value of the environmental benefits arising from the remediation as other methods (such as comparison with other sites using BT) may be more difficult due to issues of site-specificity. Stated preference methods also have the advantage of being able to capture non-use values associated with remediation of contaminated sites.

3.6 (F) Amenity Benefits

Remediation of contaminated sites may result in amenity benefits, for example improved access to recreation or improved environmental appearance. In some instances, remediation of contaminated sites may result in an open access development, such as new public parks or nature sites with specific amenity values. Relevant recreational activities include bird and wildlife watching, bathing, angling, water-related sports, forest visits, camping, hiking, and hunting.

It should be noted that care needs to be taken to avoid double counting of benefits. For example, the value of reduced health risks may be partly capitalised into house prices (as with radon risks, and as observed with studies of PCB contamination in the USA[16]) and so changes in house prices are likely to reflect changes in health risk and the amenity value of contaminated land remediation. Evidence needs to ensure that health and amenity values are not confounded in HPMs.

Use of Methods

Professional judgement by property valuers can be used to assess the impact of visual amenity improvements on neighbouring properties.

There are a significant number of HPM studies of the effect on property prices on LULUs (Locally Unwanted Land Uses) in terms of the amenity effects of landfill and contaminated land sites. A literature review of the effects of environmental contamination on real estate prices is provided by Jackson, 2001; whilst Brasington and Hite, 2005 review the application of HPMs to point-source pollution points such as contaminated sites.

The TCM and CVM methods are also used to value landscape related impacts. For instance, Bergin and Price, 1994 valued different levels of landscape quality using TCM, while Hanley and Knight, 1992 valued greenfield benefits (landscape and recreation) using CVM.

CE has also been applied to assess local residents' WTP to reduce environmental externalities and improve amenity in relation to landfill sites. Garrod and Willis, 1998 used a CE to assess local residents' WTP increased Council

[16] Mendelsohn, R., D. Hellerstein, M. Huguenin, R. Unsworth and R. Brazee, Measuring Hazardous Waste Damages with Panel Models, Journal of Environmental Economics and Management, 1992, 22:3, 259-71; Söderqvist, T., 1995, "Property Values and Health Risks: The Willingness to Pay for reducing Residential Radon Radiation" *Scandinavian Housing & Planning Research*, Vol. 12, pp. 141-153.

Tax to reduce the number of days with noise disturbance, smells and odours, and windblown dust and litter. WTP varied between 20p and 32p per day to eliminate the externalities. Such values will vary between sites, and with distance from the site.

Remediation of contaminated land may result in improved access and recreation to the site and/or surrounding areas. Recreation experts, with experience in managing priced recreational sites, can also provide estimates of the value of improved assess after remediation work in terms of existing recreational trips and any new trips likely to be generated.

Recreational amenity value can also be evaluated using TCMs. For instance, Hanley, 1989 assessed recreational value of forest visits (landscape, bird watching) using a range of different methods including TCM. Fadali and Shaw, 1998 and Johnston et al., 2002 valued a wide range of recreational use of bird and wildlife watching while O'Neill, 2001 assessed the WTP for maintaining the quality of bird watching sites. Furthermore, Needelman and Kealy, 1994 and Wade *et al.*, 1989 employed TCM to value open water bathing. The method has been also applied widely to assess the benefits associated with changes in recreational sports (water-related sports) (see Bowker *et al.*, 1996, Hynes *et al.*, 2005, Jay, 1996 and Rollins and Wistowsky, 1997 and angling (Wade *et al.*, 1989; Curtis,2002).

CVM is also being widely used to value recreation related benefits. Cooper and Loomis,1992 and La Rouch,2001, for instance, estimated WTP using CVM for bird watching while Shrestha and Loomis,2001 compiled studies on all types of outdoor recreation (hunting, fishing, bird watching, camping, hiking, canoeing). Eftec, 2010 assessed WTP to avoid a decrease in water levels and a change in bird species.

CVM is also widely used in assessing bathing related benefits (Bateman *et al.*, 1999; Day *et al.*, 2001; Georgiou *et al.*, 1998 and 2000), benefits associated with recreational sports (Siderelis *et al.* 2004 and Rollins *et al.,* 1997) as well as recreational angling (ERM Economics, 1997; Peirson *et al.* 2001; Spurgeon *et al.* 2001).

The recreational use of forests has also been valued extensively (see Willis and Garrod, 1991, 1999; Hanley and Ruffel, 1993).

Data

The key information requirements include information on the site in terms of its landscape and recreational activity uses together with primary valuation studies on recreational uses and landscape values.

Valuation Methods

To address potential double counting, an approach using the judgement of professional property valuers and recreation facilities experts can be used. Also, a BT approach can also be used as there are a significant number of TCM, CV, CE, HPM studies addressing amenity impacts associated with remediation. For more specific primary valuation studies, the most common and suitable methods are TCM and CVM.

Future amenity benefits are unlikely to be included in current property prices, though this could be the case where, for example remediation is planned and there is a high expectation of it being completed. Hence, in general, for ex-

ante assessments, there will be a need to assess amenity benefits explicitly. For these, as with ex-post assessments, primary surveys are a suitable method though design needs to account for biases, particularly if respondents believe their answers will influence the nature of the remediation. For such reasons a complementary BT approach can be used to provide a validating component to any analysis.

3.7 (G) Greenfield Savings

Greenfield savings occur where contaminated land remediation allows brownfield development instead. The saving results from avoiding factors such as habitat fragmentation and may contribute positively to environmental benefits including the levels of ecosystem services and conditions of habitats, biodiversity, and access. The underlying assumption is that "Greenfield" land is an environmental asset and that benefits result from its preservation. However, it may be of variable quality, as has been suggested in the case of Green Belt land[17], and this would reduce the benefits of avoiding development on it.

Use of Methods

According to Jenkins *et al.* (2006) when industry reclaims "brownfields" it may reduce pressure for the conversion of more "greenfields" however, the empirical evidence on the land-saving effects of brownfield reclamation seem to be limited. In particular, Jenkins *et al.* (2006) discusses two studies: that by Deason *et al.*, 2001 and the Atlantic Steel Project XL benefits study which estimated the reuse impacts of remediation of brownfield sites. Deason *et al.*, 2001 argues that contamination (factual or perceived) can accelerate new development of greenfield areas so causing further undesirable impacts especially if the greenfield land hosts biodiversity or provides other public goods such as ecosystem services and amenity.

Deason *et al.* estimated the land area required for inner city developments on brownfield and suburban greenfield areas. Using the data from brownfield redevelopment projects and published land regulations for the identified greenfield counterparts, they concluded that, on average, each redeveloped brownfield acre would have required a minimum of 4.5 acres had the same project been located in a greenfield area. In other words, developing one acre of a brownfield site would save 4.5 acres of greenfield. The underlying notion was that greenfield development uses more land than does brownfield redevelopment because of common planning regulatory factors in outlying areas. Such factors include among others requirements and limitations on building density, i.e. maximum number of buildings per acre, building height, parking requirements, buffer zones and landscaping.

The ratio of 4.5 might no longer be valid if restoring brownfield land to productive use changes economic and political equilibria. If more land is made available at the urban centre this could motivate even a larger ratio on properties that are developed away from the urban centre. The issue is further complicated by the lack of understanding of the dynamics of urban expansion.

[17] The standard and value of Green Belt land is discussed in Newey, G. and Less, S. (2012) "Nuturing Nature", Policy Exchange (2012)

Data

A range of data sources can be used to provide information on the area of the brownfield development (actual or anticipated) per site, including, for instance, the Public Register of Contaminated Land and submissions related to potential remediation (e.g. CL1/CL2 forms). However, no information exists on the avoided area of greenfield development and, although when industry reclaims "brownfields", pressure on greenfield land would be expected to be reduced, there is little empirical evidence.

Valuation Methods

In order to assess greenfield savings, expert judgement and/or BT approach using information gathered from different studies are the practical alternatives. The steps are to first quantify the savings and then to monetise these depending on the location and value of the sites considering the biodiversity, habitat and other differences between the brownfield and greenfield options.

3.8 (H) Benefits of Reduced Health Risks

Depending on the nature and location of contaminated sites, remediation of contaminated land may result in benefits from reduced health risks or improved health outcomes. Contamination affecting health could result from direct exposure to contaminants in the soil or in an indirect exposure via pathways through ground water, surface water or air. The exact nature and extensiveness of adverse effects will depend on the contaminants (e.g. toxicity) and exposure levels. Overall, the relevant adverse health-related impacts could vary between mild illness with or without hospital admissions up to (preventable) fatalities. Typical parameters used to assess human health benefits are:

- Effects on rates of hospital admissions due to illness;
- Effects on day to day mortality (deaths brought forward);
- Effects on long term life expectancy;
- Chronic effects – life years gained; and
- Carcinogenic effects – numbers of cases of cancer avoided.

Use of Methods

According to a study (Defra, 2009[18]) that aimed to provide an overview of the direct and indirect impacts of contaminated land on human health, the current state of knowledge is insufficient to quantitatively estimate overall impacts, if any, of contaminated land on human health. In particular, there seem to be no evidence for widespread impacts of contaminated land on human health; but equally such potential can not be dismissed. The literature provides some evidence of a plausible linkage between proximity of residence to a landfill site and birth defects

[18] Defra (2009). Potential health effects of contaminants in Soil - SP1002

and substantial research is available on cadmium. The main sources of uncertainty are the lack of comprehensive information on types and concentrations of contaminants present on a site and on the routes of exposure to the general public and lack of conclusive evidence for impacts on human health for European conditions.

Several methods have been used for quantifying and monetising health-related benefits. Most of these are applicable generally and do not relate specifically to the impacts of contaminated land and involve, for example, surveys which elicit information on the willingness to pay to avoid preventable fatalities.

Some of the methods are subject to significant limitations and criticism, including in particular, the Human Capital and Required Compensation approaches. The Human Capital approach is based on the loss of future earnings in case of disability or premature death with underlying assumption being that labour market is an appropriate measure of a worth of a person. The method "equates" the worth of people to what they produce resulting in different values of lives depending on the projected future earnings. It does not take into account value a person may place on its own life and places no value on people who are outside the workforce. The Required Compensation approach assumes that workers performing jobs associated with high health risks are earning more presumably because they are aware of such risks and require some compensation for undergoing the job. The method, however, does not account for externalities, such as grief and suffering of family and friends and in many instances can not reflect the value of health risks.

Data

Assessment of health related benefits associated with remediation of contaminated land first of all requires information on contaminated site under consideration, including data on key associated contaminants, exposure pathways, toxicity and likely exposure rates. Furthermore, data on observed or estimated changes in the health related effects prior and post remediation are critical to assessing such benefits. Depending on the study design information needs could include damage cost functions associated with different contaminants, input data for environmental and health impacts modelling (e.g. dispersion modelling and source-receptor matrices), as well as local information on hospital admissions and associated costs.

Some exposure-response functions are available, in particular for the most common air pollutants (PM, NOx, SO_2), metals, persistent organic compounds and odour, from studies conducted as part of CAFE, ESPREME, METHODEX programmes.

Furthermore, a range of studies and guidance documents provide estimates of statistical value of life as well as various willingness to pay estimates (e.g. WTP for an increase of one additional year of life expectancy or to reduce the risk of fatality). (see for example Alberini et al, 2007, Department of Health, 1999, IGCB, 2010a, IGCB 2010b).

Valuation Methods

Characterising and quantifying the marginal changes in adverse health effects constitutes the first step in ex-post assessment of remediation of contaminated land. Quantifying the change achieved in terms of health risks reduction

is a challenging exercise and is likely to require some degree of environmental exposure and health impact modelling.

One approach, applied for example where there are air borne contaminants, is to assess the population weighted mean exposure to the contaminant of interest and use of the appropriate exposure-response function to determine health impacts prior and post remediation. Information on the baseline (background exposure and health) will be required in most cases.

The marginal changes in the health related impacts could also be estimated based on the changes in probability of specific health impacts, e.g. cancer, multiplied by the affected population. However, while information on population statistics is available, the changes in probability of different adverse health impacts as a result of remediation will be site specific (depending on the toxicity of contaminants, spatial characteristics, length of exposure etc.). In the context of air borne contaminants, there is considerable uncertainty about the extent to which remediation and hence pollution reduction will increase the months or years of life of people who are already ill. Furthermore, a reduction in air pollution may only marginally improve the quality of life for someone who is already seriously ill with respiratory problems. However, as noted above there seem to be no evidence for widespread impacts of contaminated land on human health (Defra, 2009).

Quantification of these effects, where possible, is often expressed in terms of:

- number of preventable fatalities;
- Quality Adjusted Life Years (QALY). The method utilises information available on the extent of anticipated improvements in health and/or quality of life and on duration of that improvement. A year of life in perfect health is counted as 1.0 whereas years spent in less than perfect health are given values between 0 and of less than 1.0 depending on the state of health. The use of this method allows further monetisation with values being generally derived from stated preference studies. Studies in the health sector have used values of €50.000 to 80.000 for a QALY;
- Disability Adjusted Life Years (DALY). This method is very similar to the previous one effectively being its negative value, i.e. it measures the number of quality adjusted years lost and should lead to the same assessment; and
- Healthy Life Years (HLY). This method measures the number of quality adjusted remaining life years per person. As in the case with DALY, the method is similar to QALY and in essence it is a sum of QALYs, using the remaining life expectancy as the upper bound for summation.

Once quantified, the health impacts can be monetised. The first group of monetising methods are ***preference based*** approaches, which are based on individuals' stated or revealed preferences when exposed to a particular situation that involves a health risk. Preferences are measured by their Willingness To Pay (WTP) for an improvement or Willingness To Accept (WTA) compensation for a worsening. The second group are ***"accounting style"*** approaches and price and cost information from existing labour markets and estimates of medical expenditure.

For assessing preferences, Choice Experiment (CE) approaches have been used to assess the Value of a Preventable Fatality (VPF). For example, in an experiment known as Standard Reference Gamble (SRG), the respondent is asked to compare a known, intermediate state to a gamble, and to choose between the two. The gamble may have

two results: 1) a best health outcome (e.g. "perfect health"), with probability p; or 2) a worst health state outcome (e.g. "dead"), with probability 1-p. In this case, the probability in the gamble is varied until the decision maker is indifferent between the gamble and the intermediate state and this value is the utility of the health state (Sox, Blatt *et al.*, 1988). For example, if the respondent is willing to take a gamble with chance of 20% risk of death and 80% of staying alive rather than accept the intermediate state for certain, then the utility of the intermediate state is 80%.

Using such techniques, a range of studies provide estimates of the Value of Preventable Fatality (VPF), Value of Statistical Life (VOSL) and Value of a Life Year (VOLY) (see Table 5.1).The VOSL is derived by investigating people's WTP for a lower risk of mortality, divided by that risk reduction; it puts a monetary value on the willingness to accept slightly higher or lower levels of risk. The VOLY measures more generally the WTP for an increase of one additional year of life expectancy. While placing a monetary value on the small changes in risk or on the additional year of life expectancy neither VOSL nor VOLY provides a measure of the quality of life. According to the EC Impact Assessment Guideline research undertaken in the past has resulted in values of €1 – 2 million Euros for VOSL and €50,000 – 100,000 for VOLY in Europe.

Table 3.1 Health Related Impacts

Study	Subject of assessment	Results
EC Impact Assessment Guideline (2009)	Value of Statistical Life (VOSL)	1 – 2 million Euros
EC Impact Assessment Guideline (2009)	Value of a Life Year (VOLY)	50,000 – 100,000 Euros
The Department of Health	Costs of hospital admissions (NHS)	£1,400 to £2,500 for a respiratory hospital admission £1,500 to £1,700 for a cardiovascular admission
Stated preference studies	QALY (value of a year in a perfect health)	50.000 – 80.000 Euros
DG-Environment (2001)	Value of preventable fatality (VPF)	1.4 million Euros (2007)
Gayer *et al.* (2002)	Value of a preventable fatality (VPF) for cancer	Between $4.3 million to $8.3 million
Guerriero and Cairns (2009)	Value of preventable fatality (VPF)	2.1 million Euros
Alberini *et al.* (2007)	Value of statistical life (VOSL)	5.6 million Euros (for an immediate risk reduction) 1.26 million Euros (if the risk reduction took place 20 years in the future)
Alberini *et al.* (2010)	Value of a preventable fatality (VPF) for cancer	4.164 million Euros (2008)
Chilton *et al.* (2002)	Value of preventable fatality (VPF)	£1.312 million (2003)
The Department of Health	WTP for a small reduction in risk per death brought forward (due to air pollution) - delay in the probability of death from air pollution	1 year: an upper-bound of £1.4 million and a lower-bound of £32,000 to £110,000 1 month: £2,600 to £9,200

Accounting style approaches include the Cost of Illness, Human Capital and Required Compensation approaches.

The Cost of Illness (COI) approach[19] considers the health impacts, for instance associated with an exposure to contaminated water, and evaluates the cost of treating the resulting illness. If remediation of a site lowers the rate of occurrence of an illness the saved medical expenses can be estimated and constitute a benefit. In broad terms, it captures the medical expenses related to the incidence of an illness and, while it can also capture the income foregone (as a result of sick leave), it does not reflect other indirect costs to society such as loss of hours worked, or how people value their own health. As a result, where COI is used, it is suggested that stated preference based methods (e.g. value of statistical life and value of statistical life year) are also used.

Due to difficulties in COI, it is not widely used to value persistent groundwater contamination events. While it could be applicable to cases when drinking water standards are violated, there are difficulties in measuring cost of treatment and income foregone. Furthermore, consumers (in particular water abstractors) are likely to reduce their risk of exposure through adopting averting behaviour and so the approach is to some extent complementary to the averting behaviour approach.

COI is particularly relevant to situations when adverse health related impacts associated with contaminated land exacerbate existing illnesses (e.g. cardiovascular conditions), for example, due to air pollution. Some data are available on the costs for respiratory and cardiovascular hospital admissions from the NHS.

The Human Capital approach provides a way of measuring the loss of future earnings in case of disability or premature death. It can also be interpreted as a measure of the loss of social welfare caused by death, disability, or lower productivity. In essence, it is a sum of the discounted future earnings of a person with underlying assumption being that labour market is an appropriate measure of a worth of a person.

A potential criticism is that this method leads to different values of lives depending on the projected future earnings, which could be seen as immoral. In particular, one could argue that people are worth more than what they produce. Furthermore, it does not take into account the value a person may place on their own life (e.g. if your wage is low, you still might wish to reduce health risks) and places no value on people who are outside the workforce (such as the elderly).

Average values could be used to lessen these concerns or if the individuals affected by an option cannot be identified precisely enough. The method, however, is not widely used.

The Required Compensation approach also relies on the labour market; it assumes that workers performing jobs associated with high health risks are earning more presumably because they are aware of such risks and require compensation for doing the job. The method is subject to critique for similar reasons to that of Human Capital. In particular, the difference in the wages may not be able to reflect the value of health risks due to lack of information (workers may not be fully aware about the risk), weak bargaining power (workers may not always have alternatives to bid up wage) and higher levels of risk aversion among general population. The method also does not account for externalities, such as grief and suffering of family and friends.

[19] Marbek (2007) discusses valuation approaches to drinking water supply using Damage Function approach for health.

As an illustration, Box 1 shows valuation of health related benefits related to air quality improvements using an accounting style approach.

Box 1 Valuing Health Related Benefits Associated with Air Pollution

Approaches to valuing health impacts include detailed environmental and health impacts modelling (e.g. dispersion modelling and source-receptor matrices) or application of damage cost functions if/when available.

In the context of air pollution in Europe, health impacts have been valued extensively as part of CAFE, NEEDS, ESPREME and METHODEX studies among others. Under the CAFE exposure-response functions for classical air pollutants (PM, NO_x, ozone, SO_2, CO) were collated. NEEDS focussed on exposure-response functions of particular relevance to determining the external impacts of energy generation. ESPREME is focussed on metals and METHODEX has considered a wide range of pollutants including persistent organic compounds, metals and also odour (AEAT, 2006).

Health impact assessment for air quality impacts generally involves assessing the population weighted mean exposure to the pollutant of interest and use of the appropriate exposure-response function to determine impacts. In many cases this may require knowledge of the background rates of the health endpoint of interest in the study population. For instance, the effects of PM (particulate matter) can be largely quantified in terms of years of life lost across an exposed population. These health impacts may then be monetised by applying appropriate valuation figures such as those used within the CAFE. In particular, CAFE provides the median and mean estimates for the value of a life year (VOLY) and statistical life (VOSL). Alternatively, the benefits can be estimated in line with IGCB approaches (IGCB, 2007), although the IGCB and CAFE damage cost functions vary quite significantly for many pollutants.

AEAT (2006): Damage costs for air pollution. Final report to Defra, March 2006. Available from: http://www.defra.gov.uk/environment/airquality/publications/stratreview-analysis/damagecosts.pdf

IGCB (2007): Economic analysis to inform the Air Quality Strategy. Final report, July 2007. Available from: http://www.defra.gov.uk/environment/airquality/publications/stratreview-analysis/index.htm

CAFE: Available from: http://www.cafe-cba.org/assets/marginal_damage_03-05.pdf#

NEEDS: New Energy Externalities Developments for Sustainability

ESPREME: Impacts of heavy metals http://espreme.ier.uni-stuttgart.de

METHODOX: Methods and Data on Environmental and Health Externalities; harmonising and sharing of operational estimates

3.9 (I) Agglomeration Benefits

According to the literature on turban economics the areas of more dense population and activity to which redevelopment of previously contaminated and other brownfield sites may contribute are more productive than are more sparsely settled and used urban areas. Moreover, when comparing developed vs derelict urban areas other benefits include prevention of crime and drug use among others.

Use of Methods

Redevelopment of brownfield sites may contribute to welfare through economies of agglomeration and neighbourhood effects (Jenkins et al., 2006). Although limited empirical work is available on this category of benefit, the methods employed included stated preference methods (e.g. WTP), effect-by-effect modelling and HPM (Alberini et al., 2007).

The underlying conception is that agglomeration benefits arising from greater brownfield development and consequent urban density are expected to be reflected and captured in the capitalised value of the land although the extent to which this is revealed in the market place may depend on the use class designation and any planning conditions attached to the development of the land. Furthermore, it is unlikely that any agglomeration benefits resulting from the reclamation of contaminated land will be reflected in surrounding property values before reuse activity is underway (or at least prior to the designation of the type of use/reuse on the site) (Jenkins *et al.*, 2006)

Valuing spillover benefits (i.e. of people being able to relocate closer to other people) is extremely challenging; even more so if there is a need to link the benefit to the remediation of contaminated land.

Data

The data requirements are the same as for assessing the changes in site and neighbouring property values.

Valuation Methods

The changes in the site and neighbouring properties' values as a result of remediation are expected to reflect agglomeration benefits arising from greater brownfield development and consequent urban density. As a result, agglomeration benefits may already be included in data used in ex-post studies and the potential for double counting should be noted. The extent to which these agglomeration benefits are revealed in the market may depend on the use class designation and any planning conditions attached to the development of the land.

On the other hand, agglomeration benefits associated with remediation of contaminated land prior to remedial actions are unlikely to be reflected in the site and neighbouring property values and so, where possible should be explicitly estimated in ex-ante studies.

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4. Critical Assessment of Methods

The valuation methodologies proposed to be used for assessment of remediation benefits are used more widely in economic assessment and hence, when used, there is a body of additional more general experience to draw on outside the area of contaminated land.

This section discusses these different methods more generally while making reference to their particular use for assessing the benefits of remediation.

4.1 Expert Judgement

Expert judgment can be used to complement other valuation methods and study designs may require different degrees of expert judgement depending, amongst other factors, on the resources and time available. Expert judgement can be used in both ex-post and ex-ante evaluations, including for prioritisation of contaminated sites for remediation and for risk assessment.

Experts can usually provide estimates of the impact of events, based on their previous experience. Dodgeson and Topham (1990) found a close correspondence between professional valuations of properties and estimates from hedonic price models (HPMs). As well as professional estate valuers, the range of relevant experts may include epidemiologists to assess health impacts and medical experts with knowledge of the economic value of preventable fatalities.

However experts often disagree about the impact of an event and their estimates of value can vary and may in practice be less reliable than estimates produced by computer models. There are many reasons for this, including the fact that the human brain cannot recall and combine quantitative information to derive an answer with the same degree of accuracy and reliability as a computer. Computer models which use expert opinion as input provide a form of integrated approach which can, for example, balance the views of a number of experts in a systematised way.

Where experts are able to use aids to assist judgement, e.g. epidemiological models, then estimates of the impact of contaminated land will be relatively reliable. Similarly, where estate valuers have information on house price sales in the neighbourhood of contaminated and remediated sites, estimates of changes in property prices using expert judgement may be reasonably accurate, especially for properties in close proximity to the site. But the effect of distance from a site on property values may be more difficult to estimate without a model such as a HPM.

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4.2 Revealed Preference Methods

4.2.1 Hedonic Price Models (HPM)

Methods using HPMs have the potential to be one the most useful of methods to measure the remediation of contaminated land as, being based on observation of current behaviour, they indicate the overall results of how people actually respond to local circumstances.

HPMs are categorised as 'revealed preference' methods as they are based on the underlying assumption that people's values are revealed by the choices they make in purchasing or consuming marketed goods and services. In the most common applications, the public's willingness to pay for housing is used as a quantitative indicator of the local environmental conditions.

HPMs use observations of changes in levels of rents, house prices or land prices to impute a value to characteristics of the local environment, such as air pollution, water or noise pollution, and to amenities provided by the environment, such as the aesthetic value of the view from a property or its proximity to recreational sites. HPMs can simultaneously combine a number of different attributes to estimate an overall value for the site. In addition, they can be used to estimate values for neighbouring sites and for other effects of the site such as changes in the number of local property transactions, and agglomeration benefits.

HPMs have been used to estimate the environmental externalities from landfill sites, as well as airport and road transport noise and air pollution where degradation in the environment lowers the price of the marketed product (houses). The method has also been used to assess the value of remedial action and clean-up of contaminated sites; for instance for estimating the change in amenity benefits.

The use of HPM depends on observations of behaviour (revealed preferences) and is therefore naturally an ex-post technique. Nevertheless, analysis of prices near an actual contaminated site could be used to forecast the benefits of a hypothetical change if, for example, part of the site was remediated. More generally, where information is available for a site at different stages of remediation, HPMs can be repeated or structured to include a time dimension and so allow a measure of forecasting.

Otherwise, the use of HPM for forward-looking analysis would mainly require applying a pre-existing model based on observations for one site to the new site, making the assumption that the hedonic price functions can be transferred between sites.

Formulating an HPM

The formulation of an HPM requires that each house (or other type of property) is described in terms of a combination of attributes which determine the price which a potential purchaser or tenant is willing to pay. One or more of these attributes can represent environmental factors. Consumer theory allows these attributes to be represented in an equation as follows, where the purchase price which a potential buyer is willing to pay is shown on the left hand side as HP:

$HP = f(S_i, L_i, N_i, E_i, R_i, T_i)$

and where

- S_i = structural characteristics of the property (e.g. plot size; number of reception rooms; number of bedrooms; number of bathrooms; garage space; central heating; structural integrity; etc.);
- L_i = location characteristics (e.g. proximity to various public services, communications, etc.);
- N_i = neighbourhood socio-economic characteristics (e.g. unemployment rate; racial composition; social conditions; etc.); E_i = environmental attributes (e.g. noise, proximity of parks, woodland, open space, air quality, quarries, landfill sites, contaminated land, etc.);
- R_i = property rights attached to the house (e.g. freehold or lease hold, covenant on the land, historical listing of the property prohibiting alternation, etc.); and
- T_i = time trend in house prices.

Issues affecting Use of HPM

HPMs have a number of generic features which can affect their scope of use and accuracy:

- **Omitted variable bias:** the omission of an attribute on the right hand side of the equation may bias the coefficient of one of more of the attributes in the model. For example, the data on house prices and characteristics held by Land Registry is not always sufficiently complete to capture the heterogeneity of different house types;
- **Multicollinearity:** when two or more variables are correlated with each other (e.g. number of bedrooms and number of bathrooms; or traffic noise and air pollution) then an HPM cannot separate the effect of each on the house price; and
- **Functional form:** economic theory provides no guidance on what functional form (the relationship between inputs and outputs) the HPM should adopt, though in practice it is often assumed to be linear. The choice of functional form can have a large and significant impact of the estimated coefficients and hence on implied marginal willingness-to-pay values for changes in the level of any attribute on the model.

When used for the assessment of the benefits of contaminated land, there are specific issues of:

- **Separation of benefits:** Deriving separate values for the different benefits associated with remediation on a site can be a problem with HPM. The change in the price of a property reflects the total change in health risks, amenity benefits, and agglomeration benefits attributable to site clean-up; and it may be difficult to separate all of these if there is, for example, correlation between pollution from a contaminated site and the benefit outcomes. As the house price is assumed to capture all relevant types of benefit, then HPMs are only robust if estimates of total benefits are required;
- **Equivalence of HPM models for ex-ante assessment:** the use of HPM models from one site to predict impacts at another depends on their degree of equivalence for example in terms of site characteristics and the local housing market;

- **Aggregation of results:** An HPM will typically show the impact of remediation on the value of a house of a particular type. The aggregation of benefits is sensitive to the number of properties of this type at different distances from the site and the commonly used measure, census output area (OA) data, may be too crude; and

- **Inability to capture non-use environmental benefits**: HPMs are generally inappropriate for measuring non-use ecosystem and wildlife benefits from remediation and the values captured through property transactions only reflect use benefits that people gain from purchasing a house near a wildlife site.

Using HPM to value Contaminated Land

The HPMs undertaken for assessing the value of remediating contaminated sites can be categorised as risk-price models or as distance-price models. Risk-price models are based on the assumption that house prices reflect risks (or perceived risks) to health while distance-price models assume that prices reflect the simpler statistic of the distance from the site.

Risk-price models may be affected by subjective assessments of risk prior to any scientific assessment of the scale of contaminants on the site. If local residents have concerns about the site prior to a detailed scientific investigation, house prices are likely to fall though may also recover on the publication of better information. Conversely, a scientific investigation of a site may report more severe contamination than was originally thought; in which case house prices may decrease further after the scientific investigation is published. A lack of awareness of the scale, toxicity and proximity of contaminated land (e.g. during searches during purchasing transactions) may also reflect a wider lack of perception which would also lead to under-valuation of remediation work.

Distance-price models investigate how house prices change with distance from a contaminated site. Compared to risk-price models an assumption is made that distance is a determining variable. Implementation requires that this assumption is checked and ensure that there are accurate, reliable and robust coefficients for distance. Technically, there should be small standard errors for the distance coefficient relative to its mean. Larger standard errors indicates uncertainty in the effects of distance and results in a wider range of values for the total benefit of remediation.

Literature Sources

Gayer *et al.*, 2002 investigated how residents responded to US Environmental Protection Agency (EPA) site specific information about risk levels at a National Priorities List (NPL) contaminated site in Grand Rapids, Michigan, using a repeat sales model. They assumed that prior to a detailed Remedial Investigation and Feasibility Study (RI/FS) residents based their estimate of risk on their general knowledge of Superfund sites. Gayer *et al.*, 2002 used two reference points for residents' prior beliefs about risk: the average cancer risk levels at Superfund sites nationwide, and across the Michigan state. They found that prices for housing sales after the release of EPA site specific information were higher than prior to the release of EPA information. After the release of site specific information, house prices increased by an average of $109 to $334 (depending on the reference point) in the housing market surrounding the site, where the average house price was $70,520. These values translated into an implied value of a preventable fatality (VPF) for cancer of between $4.3 million to $8.3 million depending on the

assumption of prior risk (national average risk levels or state-wide risk levels). These estimates are similar to the value of statistical life (VOSL) in many labour market and product market studies. Note, that this study adopted a risk-price model, rather than a distance-price model of the impact of site clean-up.

The fact that the site is designated a contaminated site, and the degree of contamination, should, in theory, cause a greater fall in house prices, compared to non-designation or designation as a less hazardous site. Greenstone and Gallagher, 2005 in the USA investigated sites assigned a Hazardous Ranking System (HRS) score above 28.5[20] and placed on the 1982 National Priority List (NPL) of sites to be remediated. They found that NPL placement had little impact on the growth of property values in the census tract for the periods 1980-1990 or 1980-2000 relative to tracts with sites that narrowly missed placement on NPL. A possible explanation for such a finding is heterogeneity in individuals' valuation of risk associated with contaminated properties: people living near sites may have a lower WTP to avoid risks because of income differences or preference heterogeneity. Another explanation is that people may have imperfect information on the health risks they face and an incomplete understanding of the benefits of cleanup.

The externality effects of hazardous waste sites also affect commercial property markets. Ihlanfeldt and Taylor, 2004 found that small-scale hazardous waste sites in Atlanta, not so severely contaminated as to be on the National Priority List, had a substantial negative effect on the market value of nearby commercial and industrial properties.

4.2.2 Travel Cost Method (TCM)

Travel Cost Method is a survey based approach, which is typically used to value environmental goods and services that have explicit recreational uses such as woodlands, wetlands, rivers and lakes, national parks and coastal areas. Benefits include those from bird and wildlife watching, bathing, angling, water-related sports, forest visits, camping, hiking, and hunting.

The method correlates the cost of accessing an outdoor recreation site (the travel cost) with the decision to visit sites. In particular, it uses travel costs as a proxy for the value of that site. By observing how visitation rates to a site change as the environmental quality of the site changes, the method provides values for environmental quality itself (Environment Agency, 2007).

The TCM can be extended to recognize the contribution of particular characteristics of a site to individual welfare. For example, if a number of sites exist in a region and environmental quality varies across sites, the demand for quality should be reflected in the relative intensity of use of the sites. Furthermore, with extensive data on the recreation activities of the population, this demand can be quantified and used to ascertain the marginal and infra-marginal contribution of improvements in environmental quality[21]. Two main approaches are used, a TCM based on geographical zones and TCM based on following an individual's movements (Ribaudo and Hellerstein, 1992).

[20] Score assigned between 0 and 100; sites scoring at least 28.50 are eligible for placement on the National Priorities List (NPL), which designates those sites representing the highest priority for further investigation and possible cleanup

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Formulating a TCM

A linear travel cost model, where an individual (i) has a demand for trips (T_i) is modelled as:

$T_i = \acute{\alpha} + P_i \beta_i$

Where P is the individual's travel cost, β is price coefficient and ά a constant. Travel costs usually included are travel expenditures, entrance fees and the value of time (either a generic value or related to the individual) with the assumption is that higher travel costs lead to a lower number of trips. For work trips the value of time is set at the cost to the employer of the worker involved in the trip; but non-working time is set at the opportunity cost of leisure time foregone, which is some fraction of the wage rate and typically set at 25% of the wage rate.

A demand curve can be generated by regressing the number of visits recorded in the survey to the site on travel cost and other variables characterising the site. Consumer surplus values which can be summed to reflect the overall benefit across all visitors can be generated from this demand curve for "access to the recreation site" by integrating between P and the cutoff point (the price where demand drops to zero). In addition, a change in an environmental attribute will cause a change in the demand curve with the difference reflecting its value.

The method involves the following steps:

1. **Identification of the good/service to be valued** based on the preliminary studies for the project. The TCM is typically applied for the valuation of recreation sites, services/attributes of the site including walking, bird watching, angling etc., or change in the quality or quantity of environmental attribute;

2. **Design and development of a survey**, which usually includes a questionnaire, taking particular care to analyse the main features of the visit (e.g. area of the origin, travel time, length and purpose of the visit). The survey usually includes a breakdown by socio-economic characteristics such as income, age and educational background;

3. **Implementation of the survey** on a random sample carried out face-to-face, by mail, or telephone. A minimum sample size is typically 200 respondents depending on the number of characteristics investigated;

4. **Data validation and analysis**, for example elimination of invalid questionnaires and creation of a database of responses; The analysis of data is mainly aimed at describing the behaviour of specific variables and checking their consistency and suitability; and

5. **Estimation of Willingness to Pay (WTP)** usually expressed in per capita values (WTP/per capita) or in total value (total annual value of the environmental service under consideration)[22].

Issues affecting Use of TCM

The issues in using TCM are related to:

- **Non-use values** - by definition TCM will reflect only use values for visitors, and not non-use values;

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- **Partiality of observation -** TCM cannot account for characteristics that are imperceptible to visitors;
- **Future changes -** TCM cannot be used to estimate the changes that are yet to occur;
- **Sampling and truncation biases -** which may occur due to the fact that only visitors and visits to the site that occur during the sampling period are recorded;
- **The functional form of trip function**, in particular the assumption on how travel costs relate to the number of trips is critical to the estimated values. A linear functional form will produce more conservative estimates of both consumer surplus and visitor numbers to a site; and
- **Multi-purpose trips**, TCM may have difficulty separating out holiday makers and day-trippers and reflecting differences in the calculation of costs and how travel time is accounted for[23][24].

Using TCM to value Contaminated Land

TCMs are typically applied to rural recreation sites and TCMs of urban recreation areas are limited in number. Visitors to many local urban recreation sites live relatively near and walk to the site (see Garrod *et al.*, 1993); although when contaminated land remediation forms part of a major urban regeneration project visitors are often attracted from greater distances and travel by car or public transport. But visitors who walk to recreation sites do not incur travel costs, only time costs of access (and entrance fees if any). It should be noted that non-working time costs can be more difficult to estimate than travel costs.

Using TCM in the context of contaminated land raises two main issues: calculating the consumer surplus for each visit (implicitly the willingness to pay), and calculating the number of visits that might be made to a remediated site compared to a contaminated site. TCM often gives what appear to be quite high values for consumer surplus of recreational sites, much more than the average visitor would probably pay in practice. For example, Carson *et al.*, 1996 showed over a series of studies that the ratio of Contingent Valuation to Revealed Preference estimates (CV/RP) was 0.89; indicating that TCM provides larger values for recreation goods that a comparable CV study. In theory, the application of TC analysis should take into account any displacement effect of visitors from other sites, to obtain a reliable and robust estimate of the value of the new site. It is thus important that the application of the TCM only calculates the net benefit which the new site adds to the benefit provided by the system of recreation sites in the area.

4.3 Stated Preference Methods

Stated preference (SP) methods indicate the nature of the method: responses are sought from individuals as to their actions contingent on a particular hypothetical situation. The practical issues with SP methods relate to design and analysis of the survey and the need to address aspects common to many survey designs, such as minimising bias, avoiding ambiguity, and employing good sampling strategies.

[23] Environment Agency, 2007

[24] Forum for Economics and Environment. MODULE 9

SP methods have been used extensively to value a wide range of environmental externalities including amenity benefits, biodiversity and ecosystem benefits (non-use environmental benefits), and health benefits (such as estimating the value of reductions in risk of premature deaths or non-fatal injuries). In the context of remediation of contaminated land, individuals can be asked for their willingness-to-pay (WTP) for a contaminated site to be remediated; or the amount they would be willing to accept (WTA) as compensation if the contaminated site was not remediated. The methods are very versatile and can be applied to all kinds of benefits.

SP methods can be used when other methods cannot. For example HPMs cannot estimate non-use values of ecosystems and enhanced biodiversity since property prices do not reflect these values. SP can be combined with TCM to estimate use benefits of wildlife where people travel to wildlife sites.

The SP studies most widely relevant for the valuation of remediation provide information on health values by capturing how respondents view better health. For assessing environmental benefits, respondents are asked how they would trade off environmental changes against annual tax payments. In addition to the habitat and wildlife improvements, remediation of contaminated sites could have positive environmental impact in terms of reducing contamination of soil and water (mostly groundwater) and SP methods are also widely used to value these benefits.

Two of the most commonly used forms of SP are Contingent Valuation (CV) and Choice Experiment (CE). CV and CE methods are based on asking people to state their willingness to pay (WTP), contingent on a specific hypothetical scenario and a description of the environmental goods and services. The two are very similar, the differences being that CV focuses on eliciting a value, such as WTP, while CE sets up a set of choices and asks respondents to choose between them. The selection of method is often based on its appropriateness to the policy decision that will finally need to be made, for example determination of an entrance fee might use CV, while determination of a choice of use (skateboard park or nature reserve) might use CE.

As well as providing solutions where other methods cannot, SP also:

- **Addresses situations where levels of awareness are important -** SP overcomes situations where revealed preferences may be subject to error because people are not aware of a hazard (e.g. about the toxicity and health effects from the contaminated site);

- **May better address non-urban sites -** Low housing density leads to limited house price information and may preclude the use of HPMs on these grounds alone.

Issues in the Use of SP to value Environmental Impacts

CV methods often estimate the total value of a habitat, ecosystem, or environmental scheme; rather than the value for a marginal change in a habitat or ecosystem across the UK. This poses a problem in estimating the value of contaminated land remediation for an ecosystem, since the values for remediation at a policy site need to be the value for a marginal change in a habitat or ecosystem. The value of a marginal increase of one or two hectares to the national total of a particular habitat, or to the number of a particular species, through remediation of contaminated land, is likely to be to quite small.

As a result, considerable caution needs to be exercised in using marginal CV values to measure wildlife benefits. Respondents are often insensitive to scope and scale effects in wildlife provision. People often place a high value

on improvements to one or two sites, after which values decrease rapidly for subsequent site improvements (see Bateman *et al*., 2005). This arises because there are often strong substitution effects between essentially equivalent improvements (at different sites) to the same resource, i.e. a particular ecosystem or species. This phenomena of insensitivity to scope can be a major problem with CV methods and marginal values for wildlife and ecosystems are generally recognised not to be readily transferable across regions of the UK (see Hanley *et al.*, 2006). This arises because of different demand and supply conditions for wildlife and ecosystem services between areas, e.g. because of differences in the supply of wildlife, and substitute wildlife for the particular species being considered, and differences in population preferences for wildlife between different areas.

Issues in the Use of SP to value Health Impacts

Stated Preference methods can also be used to elicit the Value of Preventable Fatalities (VPF) which reflects the WTP to avoid the risk of death (and provides an alternative to VOSL approach).

However, stated preference methods can experience difficulties in deriving accurate and reliable estimates for small probability high consequence events, and especially those likely to be manifested at some time in the future. People can experience problems in judging small changes in risk and often heavily discount consequences that occur many years in the future (e.g. cancer and other effects from exposure to chemicals and metals on contaminated land). The value can depend on such variables as respondent characteristics, familiarity with contaminated sites, concern about the health effects of exposure to toxicants, having a family member with cancer, perceived usefulness of remediation programs and others.

A study by Poe and Bishop, 1993 that evaluated health risk perceptions and the distribution of contingent values for groundwater protection associated with different levels of information provision demonstrated that general information about pollutants, specific information about exposure levels, and prior information affect contingent values and that individuals update their perceptions of groundwater safety with new information. Therefore, the ability to assess the exposure risk and the conditional health effects is of fundamental importance in the valuation of groundwater remediation.

The health benefits of improvements result in reductions in direct medical costs but also reductions in deaths and illness which are more difficult to measure because they result in the delay in death of people who already suffer from illnesses and there is considerable uncertainty about the extent to which pollution reduction will increase the months or years of life of people who are already ill. Also the value of a preventable fatality (VPF) for the 'average citizen' is not the same as a death attributable to an older person whose life is cut short by a few months.

Using research on air pollution, the Department of Health, 1999 has estimated a WTP for a small reduction in risk per death brought forward has an upper-bound of £1.4 million and a lower-bound of £32,000 to £110,000 for 1 year, and £2,600 to £9,200 for 1 month delay in the probability of death from air pollution. However, where air pollution exceeds European limit values (i.e. for PM_{10} 24 hour mean, 50 $\mu g.m^{-3}$ not to be exceeded more than 35 times per year; with an PM_{10} annual mean of 40 $\mu g.m^{-3}$) then the cost of marginal abatement should be used to estimate the cost of reducing pollution to these limits; and thereafter a conventional CBA approach used to value reductions below environmental limits (IGCB, 2010a). A recent assessment of the impact of air pollution for a

birth cohort in 2005, estimated a life expectancy reduction of about 6 months, for those exposed to current $PM_{2.5}$ particles compared to exposure to natural background level of these particles (IGCB, 2010b).

A recent contingent valuation study in Italy on WTP for reductions in the risk of dying from cardiovascular and respiratory causes (Alberini et al, 2007), found that older individuals were willing to pay less for a given risk reduction than younger individuals: persons 60-69 and persons aged >70 had WTP amounts 58% and 41% of those aged 30-59. The study also found that persons with cardiovascular problems were willing to pay, all things being equal, about 45% more than persons in better health. The latter finding goes against the use of QALY measures, as used in the Department of Health, 1999 estimates, which discount the value of lives saved and the value of extended lifetimes, of persons in poor health, from improvements in air quality[25].

SP Methods used to estimate Value of Preventable Fatalities (VPF)

The literature on the value of damage to human health is relevant to valuing the potential harm from contaminated land.

Value of Preventable Fatalities (VPF) estimates are available from DG-Environment, 2001 for the EU. In 2007 the VPF was €1.4 million. Guerriero and Cairns, 2009 used this figure to estimate the potential monetary benefits of reclaiming hazardous waste sites in the Campania region of Italy. They applied a 50% premium for a fatal cancer, resulting in a VPF of €2.1 million, a latency period of 20 years, and a discount rate of 4% (the official discount rate of the EC for its policy appraisals). People have different preferences for death by different causes, so premiums and reductions are often added to the VPF in an accidental road traffic accident for other types of death. Latency is also relevant where a pollutant is involved, the exposure to which causes death at some point in the future. And because death is delay and people have a time preference, the discount rate is relevant too.

The VPF was originally established in the UK in the mid 1980's when the human capital approach to the value of a statistical life (VOSL) was replaced by a WTP approach to avoid the risk of death. Research by Jones-Lee *et al*, 1985 employed a contingent valuation (CV) method to assess the general public's WTP for a small reduction in the (already small) probability of a traffic accident and the risk of death in such an accident. A significant number of WTP responses in the survey for the Jones-Lee *et al.*, 1985 study were inconsistent or invariant to the size of the risk change; and the standard deviation of the mean WTP value was extremely large. Since that study, CV methodology has advanced considerably (see Bateman *et al.*, 2002; Haab and McConnell, 2003), and the application of this methodology would increase the accuracy and robustness of any new study. Nevertheless the approach and WTP value to avoid the risk of death was accepted by government and has been used ever since (with updating to reflect increases in gross domestic product (GDP)) to value preventable fatalities not only in transport but also, with suitable adjustment, in other sectors of the economy (H. M. Treasury, 2009).

The road accident VPF figure can be weighted to reflect cognitive psychological aversion to different types of death associated with voluntariness of risk, immediacy, knowledge, control over risk, newness of risk, chronic-catastrophic, common-dread, severity of consequences. However, there is no agreement on how the basic VPF

[25] As a result, the health benefits of tree and shrubs on contaminated land may be greater than that indicated by the Department of Health's approach to estimating the health benefits of air quality improvement.

ought to be adjusted to reflect cognitive psychological aversions to different types of death. The HSE, Department of Environment, Food and Rural Affairs, Department for Transport, Home Office and HM Treasury jointly commissioned research by Chilton *et al.*, 2002 to assess whether the VPF estimate was affected by differing dimensions of risk:

- The number (likely to be killed in a single event);
- Personal control (how much personal control people have over risks);
- Voluntariness (how much choice people have in being exposed to the risks);
- Media-attention (how much media attention the risks receive);
- Expert-knowledge (how much experts know about the risks);
- Uneasiness (how uneasy people feel about the risks);
- Number-per-year (the number of deaths per year resulting from each of the risks);
- Age-groups-affected (the ages of people affected); and
- Household benefit (the benefits of the safety programmes to respondents and their households).

The research revealed that trade-offs between preventing deaths in different hazard contexts were much less pronounced than had been thought (the VFP varied by less than 20% between the different contexts) (see Chilton *et al.*, 2002). The VPF in the UK was £1,312,260 in 2003 prices.

Alberini *et al.*, 2007 used conjoint choice questions to investigate the preferences of people in four cities in Italy for income and future/permanent mortality risk reductions delivered by contaminated site remediation policies. They found a VSL of €5.6 million for an immediate risk reduction. If the risk reduction took place 20 years in the future, the implied VSL was €1.26 million. Respondents' had an implicit discount rate of 7%. The VSL depended on respondent characteristics, familiarity with contaminated sites, concern about the health effects of exposure to toxicants, having a family member with cancer, perceived usefulness of public programs and beliefs about the goals of government remediation programs.

Alberini *et al,* 2010 in CE study preventable fatalities from contaminated site clean up in Italy, assessed the VPF in relation to the size of mortality risk reduction, the cause of death to which the risk reduction applied (cancer, respiratory illness, road traffic accidents), whether the risk reduction would be delivered by a public or private program, the latency (0, 2, 5, and 10 years), at a one time cost to the respondent. They estimated a VPF for cancer (no specific context) of €4.164 million (2008 prices).

Poe and Bishop, 1993 evaluated the distribution of contingent values for groundwater protection. In particular, they evaluated health risk perceptions and the distribution of contingent values for groundwater protection associated with different levels of information provision and concluded that general information about pollutants, specific information about exposure levels, and prior information affect contingent values and that individuals update their

perceptions of groundwater safety with new information. Therefore, the ability to assess the exposure risk and the conditional health effects is of fundamental importance in the valuation of groundwater protection and remediation.

SP Methods used to estimate non-use environmental benefits

Stated Preference methods are widely used to value non-use environmental benefits. Remediation of contaminated sites is likely to have positive environmental impact in terms of reducing contamination of soil and water.

Aulong and Rinaudo, 2008 assessed WTP for groundwater protection, in particular, for eliminating all traces of polluting substances (restoration of natural quality) (77 € per household per year (for ten years) and restoring drinking water quality (42.6 € per household per year) in the Upper Rhine Valley aquifer. They used the Contingent Valuation method (CVM) to assess use and non-use values associated with restoring groundwater quality however it did not allow for assessing separately direct use value, option value and non-use values.

Sun *et al.*, 1992 measured option price for groundwater quality protection, an individual's maximum WTP to secure the option to use a resource or commodity in the future using CVM. Good quality groundwater provides a number of services to groundwater users including health protection (e.g., reduction in the risk of cancer and other illnesses), avoidance of higher water costs (e.g., bottled water purchases, treatment costs), general aesthetic enjoyment derived from a clean environment, and any non-use values associated with protecting groundwater quality (e.g. bequest value, existence value).

Martinez and Prantilla, 2007 also estimated use and non–use values of restoration of the Dumoy Aquifer in the Philippines affected by indiscriminate water abstraction and groundwater pollution using SPM and concluded that there is a need to incorporate the full range of environmental and social costs associated with groundwater use options as non-use values may be as significant as the more conventional benefits.

Randall and deZoysa, 1996 estimated benefits of three environmental services: enhancements to groundwater (stabilization and reduction of nitrate levels in groundwater), surface water (reduction of sediments due to soil erosion, in streams and lake) and wetland habitat (protection and enhancement of wetlands along the shore of the western basin of Lake Erie) using CVM while Barrett *et al.*, 1996 valued alternative groundwater protection programs using and comparing CVM and conjoint methods.

4.4 Direct or Market Based Methods

This group includes the Market Price, Production Function and Avoided Damage/ Substitute Cost Methods[26].

The Market Price Method uses observable prices. The Production Function (PF) Method can be applied when environmental goods and services are an input in the production of a marketed good. The PF method requires data that shows how changes in the quantity or quality of the environmental resource affect: (i) costs of production for the final good, (ii) demand for and supply of the final good, and (iii) demand for and supply of other factors of production.

[26] See Environment Agency (2007), Mishra (2003), Görlach and Interwies (2003) for a detailed discussion on the methods and their selection.

The Avoided Damage Cost and Substitute Cost Methods[27] also comprise direct methods and are applied where investment or costs result from the loss of an environmental resource. In particular, the Avoided Damage Cost (ADC) approaches include the: Averting Behaviour (or Expenditure) Approach and Avoided Treatment Costs Approach.

Görlach and Interwies, 2003 extensively discuss methodological issues and limitations associated with the Averting Behaviour Approach and Avoided Treatment Costs. The approaches are based on analysing the cost incurred in defending against the negative impacts of environmental degradation. For instance, in the context of groundwater contamination due to contaminated site the most common examples are spending on bottled water and water filters.

Mishra, 2003 discusses whether costs of damage avoidance or replacement of an environmental service/good commensurate with the benefits they provide. These approaches involve estimating the cost of provision of an alternative resource that provides the benefit of concern. An example might be the cost of supplying the current quantity and quality of water from an alternative source if a groundwater body is lost due to contamination. According to Mishra, 2003 these methods are based on the assumption that, if people incur costs to avoid damages caused by lost environmental services, or replace them in case they are lost, then those services must be worth at least what people paid to maintain or replace them. The method however, does not take into account the damage to natural resources and ecosystems (Paleologos, 2008).

4.4.1 Averting Behaviour and Production Functions

Ecosystems support habitats and diverse flora and fauna. Remediation of contaminated land may provide additional ecosystem provisioning and regulating services. In some cases, it may reduce such services.

Remediation may support provisioning services in terms of supporting wildlife habitats; whilst some sites or parts of sites may produce goods that are harvested for human consumption. It is also important to note that some non-remediated sites also support some types of flora and fauna, so any estimation of the benefits of remediation should be concerned with the net increase in benefits between the two situations: without and with remediation.

The direct value of marketed goods can be measured and taken as the value that ecosystem services provide, by supporting them. Some natural products grow in the wild and are gathered for personal consumption; whilst some are commercially harvested and sold.

The different valuation methodologies suit different types of benefits. Market value reflects the best proxy for the value of the contribution of ecosystem services to the production of commercial goods. For instance, the Market Price Method uses observable prices from existing markets. The concept is that this price captures the direct value of a particular change, which can be valued “at market prices”.

The Production Function method can also be applied when environmental goods and services are an input in the production of a marketed good. It is based on the changes in the quantity or quality of the environmental resource

[27] In some sources, Averting Cost Method is discussed as part of Revealed preference methods.

affecting costs of production for the final good, demand for and supply of that good and/or demand for and supply of other factors of production.

TCMs can be used to estimate the value of gathering goods for personal consumption.

The benefits gained from regulating services can form an important component of the overall value of ecosystem services. Failure to value such regulating services may result in the omission of a significant element of the aggregate value of the change in contaminated land. The main regulating services provided by ecosystems are:

- Climate regulation (e.g. through carbon regulation);
- Air quality regulation;
- Water purification and waste treatment; and
- Natural hazard regulation and water regulation.

Whether remediation increases or decreases the value of regulating services depends on the nature of the contaminated site before and after remediation.

A contaminated site which has vegetation both before and after remediation may produce soil and vegetation carbon sequestration; whilst shrubs and trees on the site may improve air quality in the surrounding urban area from the capture of PM_{10} and other particulates and gases that cause cancer and respiratory illnesses. Again it is important to evaluate the net difference without and with remediation in respect of carbon sequestration and air quality.

The price of carbon can be estimated as the cost of mitigation to meet carbon reduction targets in the UK. Since carbon accumulation in soil and timber is non-traded, the price for this carbon has been estimated to be £52 /tCO_2e in 2011 (DECC, 2009).

The health benefits of improvements in air pollution comprise reductions in deaths and illness, and reductions in medical costs. Medical costs are the easiest to measure. The benefits of reductions in deaths and illness are more difficult to measure and evaluate (please see the previous sections). The benefits of reduced morbidity comprise reductions in public costs e.g. cost to health provision (NHS):

- Private costs to households e.g. for medicines, etc.;
- Lost output of people prevented from working due to ill-health;
- Welfare costs (reflecting on the pain and discomfort of illness).

Trees on remediated land will take many years to grow and become fully effective in capturing PM_{10}[28], although shrubs will grow more quickly. The time profile of benefits is important in any analysis of costs and benefits. Contaminated and remediated land is often located in urban areas close to sources of pollution. Small areas of trees and shrubs, such as those on contaminated land, have larger edge effects, and will have a proportionately greater air

[28] trees capture PM10 on leaves and bark, and the PM10 is then washed onto the ground with rain or through leaf fall, thus improving air quality

pollution capture effect, per unit area, than that for larger blocks of woodland located at distance from urban areas. In particular, trees located close to the source of pollution capture more pollutants than those located at greater distance; whilst trees at the edge of woods capture more pollutants than those in the middle of forests. Stewart *et al.*, 2002 estimated that doubling the number of trees in the West Midlands could reduce excess deaths due to particulates by up to 140 per year.

4.5 Benefit Transfer (BT)

4.5.1 Issues in using BT

BT is an approach which seeks to use data gathered in one situation and apply it to another with the aim of reducing the time and/or costs of a study and overcome practical constraints on the availability of resources and data. The benefits of remediation can be estimated by one or more of the above methods. Apparently simple, there are a range of issues that arise, which have been addressed using structured approaches discussed here.

Depending on the level of sophistication, reliability and accuracy required, the approach can:

- Use a single value or a range of values (such a demand function);
- Address one attribute or group of attributes at a site;
- Be based on mean unit values or point-estimates; and
- Have adjustments for socio-economic and demographic variables.

Using BT can ultimately be viewed as a trade-off between resources required for conducting a primary valuation study and acceptable error from use of transferred values. However, in practice, the choice may effectively be between use of BT and qualitative judgement and, for many policy problems estimates derived using BT may be close enough to discriminate adequately among different sites. However, the approach should be used only in situations where the sensitivity of the results to levels of accuracy is understood.

Benefit Transfer, the term used in this report, is increasingly known as Value Transfer because it can involve costs as well as benefits. Defra provides general guidance on use of the technique beginning with “An introductory guide to valuing ecosystem services” (Defra, 2007) as well as a body of internet resources.

Generic Issues affecting Use of BT

The use of BT depends on:

- **Availability of original studies** which can sufficiently reflect the baseline conditions and the expected change. In practice, the lack of appropriate studies can constitute one of the most significant constraints;

- **The quality of the original studies** as BT results can only be as accurate as the initial estimates. Furthermore any inherent aspects of the methodology need to be acknowledged. For instance, HPM and TCM, which are based on people's observed actual behaviour, cannot address non-use values, so restricting them to valuing recreational and amenity benefits. Of the SP methods, CE approaches which are based on ranking discrete choices may transfer better than CVM which rely on value systems local to the site; and

- **The implementation method**, for example the transfer may be of point estimates or a set of values such as a demand function. The underlying assumption is that the value of the resources is sufficiently similar across the different sites and although transfers which include more information (e.g. entire functions) might be expected to be more reliable, the evidence as to which approach generates the lowest mean transfer error is mixed. Sometimes transfer of unadjusted results can provide valid results.

Using BT to value Contaminated Land

When valuing remediation of contaminated land, as well as following the general guidance available from the Defra resources referred to above, similarity in the following aspects of the policy and study sites is desirable, if not often achievable:

- The contaminants;
- Values expected and achieved from subsequent uses of the sites (including non-use values);
- Timing of the change, especially if time profile of benefits are a concern;
- Location, particularly proximity to populations, proximity to substitutes for remediated land (e.g. parkland), and proximity to complements (e.g. industries needing products made on the site);
- Characteristics of the general population (socio-economic, frequency of use, etc);
- Characteristics of affected populations (users, non-users, specialist groups, general public, etc); and
- Economic conditions and cultural context.

The type of study undertaken is also important; for example, studies might address baseline levels or focus only on changes. Different relative sizes of change can also be important.

Due to these complexities, values for specific benefits may need to be transferred from different study sites, and then aggregated.

4.5.2 Literature Sources

Overview

The process of BT is explicitly addressed in Garrod and Willis, 1999; Hanley *et al.*, 1999; and Boyle and Bergstrom, 1992.

While since its introduction in mid to late 1980 the method seems to elicit different responses, many acknowledge BT as a pragmatic and cost-effective tool (Brouwer, 2000; Wilson and Hoehn, 2006). Time and resources constraints faced by regulatory institutions are suggested as key drivers for the increased application of BT (Brookshire and Neill, 1992). It is argued that the popularity of the BT in the USA is partially caused by the pressure imposed on relevant authorities by judicially and legislatively required deadlines for assessments (Iovanna and Griffiths, 2006). The increasing need for non-market valuation in natural resource damage litigation played a role as well in the increased application of BT (Smith, 1992; McConnell, 1992).

While BT is seen as essential tool in environmental policy appraisal, the process is recognised to be less than ideal (Brookshire and Neill, 1992). Its usefulness for policy makers depends on the levels of accuracy they require. Jiang and Swallow, 2005 and Desvousges *et al*., 1992 stress that if the transfer results are invalid or subject to large error, policy decisions based on the transferred information may be misleading. The use of BT is viewed as a trade-off between resources required for the conducting a primary valuation study and acceptable error in estimation of the values using BT (Barton, 2002; Shrestha and Loomis, 2003; Atkinson *et al*., 1992). Hanley *et al.*, 2001 imply that accuracy of BT demanded by the policy makers may be much lower than that by academics. Atkinson *et al.*, 1992 stress that for many policy problems the benefit estimates may be close enough to discriminate adequately among relevant policy alternatives. Spash and Vatn, 2006 recommend that BT should be used only in the situations where the demand for accuracy is relatively low. However, the authors then claim that given the resource constraints new valuation studies are not on the agenda, and the choice effectively is between use of the BT method and qualitative judgement (Spash and Vatn, 2006). Thus, BT is seen as the best solution in situations where primary studies are not feasible or affordable (Shrestha and Loomis, 2001).

Role of the Original Valuation Studies in Benefit Transfer

BT requires a careful consideration of the similarities between the two sites in terms of contaminants. In particular, application depends on the existence of primary original studies (Spash and Vatn, 2006). BT is simply not possible when there are no original studies (Brookshire and Neill, 1992). Unfortunately, the lack of valuation studies across multiple contexts is indicated by a number of scientists (McComb *et al.,* 2006). According to Troy and Wilson, 2006 lack of economic valuation studies is the most significant constraint to the explicit spatial value transfer at present. Accessibility of valuation studies however, poses another difficulty, as multiple information sources may exist. Rosenberger and Stanley, 2006 suggest that there is significant amount of "grey" literature, which includes research reports of studies, recently completed studies that have yet to be published, and various special publications that are not widely circulated. Moreover, government agencies involved in non-market valuation may compile and maintain lists of valuation studies. Establishment of online databases containing information on thousands of primary environmental valuation studies carried out since 1980s partially answered this challenge. The most popular are EVRI, Envalue, the Ecosystem Services Database and Review of Externality Database[29].

Wilson and Hoehn, 2006 address the quality of the original valuation studies and distinguish a number of issues. First of all, original studies have been designed for different purposes and vary considerably in the content, functionality and application. Thus, BT may use benefit estimates from the original studies in a way that was not intended.

[29] A list of data sources is provided as an Appendix.

Secondly, a number of problems exist with regard to the non-market valuation methods used to obtain the benefit estimates, which are transferred to the sites being valued (referred to as the policy sites). The methods include travel cost method (TCM), hedonic pricing method (HPM), contingent valuation method (CVM) and choice experiment (CE) (Spash and Vatn, 2006). Brookshire and Neill (1992) point out that whatever problems BT creates, they only compound the already identified problems of the generalised benefit estimation process. However, significant work has been done in their development. A number of researchers have addressed measurement errors of the primary studies and proposed solutions to alleviate them. In particular, Rosenberger and Stanley, 2006 call for consistent application of valuation methods that minimize measurement error, or that transparently treat sources of known bias.

Finally, publication error can compromise usefulness of the original valuation studies for BT. Wilson and Hoehn, 2006 point out that it is not uncommon to find that original studies do not contain all the information that would be desirable for application of BT.

Benefit Transfer Methods

There are different methods of BT, which vary in the level of sophistication, reliability and accuracy. The simplest and most often performed way to execute BT is to transfer mean unit values or point-estimates. According to Garrod and Willis, 1999 the underlying assumption is that the value of the resources under consideration is the same (or similar) across the different sites. Transfer of the adjusted unit values or function is another, more theoretically rigorous approach. This approach generally provides more reliable results, as it transfers more information from the study site. So far it uses a set of explanatory variables upon which values are deemed to depend it can be statistically tested and adapted to the policy site (Brouwer, 2000 and Spash and Vatn, 2006).

Possibilities that Geographical Information Systems (GIS) application can offer for BT are also being explored as it is important to take into account spatial distribution of most of the natural resources in valuation studies (Brainard *et al.*, 1999). In particular, the use of GIS can make BT more consistent, precise and spatially sensitive.

While the major focus of discussion lies with the technical validity issues, it has been argued that the problem is much more fundamental, including concerns over whether values are commensurable as discussed in Brouwer, 2000, Spash and Vatn, 2006. Even if a statistically valid transfer can be established, environmental values cannot be reliably predicted across sites and people until differences in underlying reasons and motives are known, stressing importance of attitudes in understanding WTP. Current practices in BT are taking the monetary values as valid and reliable outcomes of people's valuation and do not question them, though Loomis and Rosenberger, 2006 suggest that not all important characteristics of value transfer are associated with objectively measured attributes. Sometimes latent variables, e.g. attitudes, beliefs and perceptions are important to minimize errors. Moreover, Kristofersson and Navrud, 2005 argue that environmental benefits should be assumed to vary from context to context.

In order to address the issue of validity and accuracy of BT, a number of tests have been carried out. The resulting conclusion was that a problem does exist with regard to the validity and accuracy of the most BT methods (Hanley *et al.,* 1999). First of all, validity of the results in relation to the evaluation method used in the original study site is widely debated. Garrod and Willis, 1999 and Brouwer, 2000 conclude that TC and HP models, which are based on

people's actual behaviour, avoid many of the biases related to the expressed or stated preference approaches such as CVM and yield more accurate results. However TC and HP models omit non-use values. The authors also stress that these models rely on assumptions, which might be questioned and the potential use of TC and HP methods seems to be limited to natural resource management involving substantial recreational use (Brouwer, 2000).

Tests of the reliability of BT using CVM method carried out by Downing and Ozuna, 1996 showed that the benefit transfer approach tends to over estimate benefits at the policy site, and that the benefit function transfer approach was not reliable. Hanley *et al.*, 2001 and Johnston, 2007 among others tested suitability of the choice experiment (CE) results for the use in BT and concluded that CE may have better potential than CVM in BT. The ability of CE to value marginal changes in the environmental attributes has been highlighted (Morrison and Bergland, 2006). Jiang and Swallow, 2005 also came to the conclusion that depending on the policy context, use of the choice experiments for BT may be acceptable and empirically valid.

Secondly, discussion on the importance of the choice of the BT method for the reliability of results is ongoing. The use of benefit function transfer (BFT) versus adjusted unit value is then studied. Loomis (1992) argues that transferring the entire demand or benefit function increases the validity and reliability of the transfer, as by transferring the demand function, the practitioner can make needed adjustments to value estimates based upon specific characteristics of the policy site. However, a study carried out by Barton (2002) showed that BFT did not outperform transfer of unadjusted or simple income-adjusted WTP for that particular study. Also Jiang and Swallow (2005) conclude that while the transfer of unadjusted values is not strongly supported, in some contexts a simple model may provide relatively valid transfer results.

In the case of adjusted unit BT, researchers stress the importance of the adjustment for socio-economic and demographic variables in carrying out BT (Spash and Vatn, 2006). However, this basic socio-demographic information may not be measured uniformly or reported in original benefit estimates studies (Ruijgrok, 2001).

Thirdly, a number of scientists worked on conditions to improve validity of BT, minimize errors and developing protocols (Boyle and Bergstrom, 1992; Rosenberger and Stanley, 2006). Wilson and Hoehn (2006) highlights significant progress that was made in identifying the likely sources of error in BT and in developing new methods to control them.

The criteria for the evaluation of the original study site's suitability for the BT have been described. Similarity of environmental good, populations and change in its provision levels is seen as key requirement for valid BT (Brouwer, 2000; Kristofersson and Navrud, 2005). However, most of the studies used for the BT are unable to comply with the criteria as there are difficulties in meeting the protocol. Moreover, even if environmental goods are more or less the same at the sites, their provision and quality levels may differ significantly across them. It is essentially a challenge to locate and use studies that adequately reflect the relevant baseline conditions and the expected change. In fact, as has been stressed this can happen only in exceptional cases. While degree of similarity between a study site and a policy site is an important factor for the validity of BT, close correspondence seems to be necessary but not a sufficient criterion for accurate BT.

Similarity between a study site and a policy site becomes even more an issue in the context of international BT (Loomis and Rosenberger, 2006) as intra-regional BT feature fewer errors than inter-region BT. The issue of

national and international benefits transfer is further investigated by Ready and Navrud, 2006 and Muthke and Holm-Mueller, 2004 who, recognising the challenges, note that problems are not that much different from those encountered in BT between regions within a country. The key difficulties as identified by the authors include currency conversion, differences in measurable attributes of the users, differences in culture, measurements of wealth compared to income and extent of the market. Given the fact that none of these difficulties are wholly unique to international transfers, evidence suggests overall that international benefit transfer is as valid as within a country.

Kaufman and Cloutier, 2006 estimated the impacts on house prices of two contaminated sites in proximity to each other in Wisconsin, USA. Residents voiced concerns about soil and groundwater contamination (volatile organic compounds, diesel range organics, and metals) at the first site, which also contained abandoned buildings and was a magnet for vandalism. The second site had suspected soil contaminants including volatile organic compounds and diesel range organics, but there was no evidence of groundwater contamination. They found that proximity to the first site decreased property value much more than proximity to the second site; but that these negative effects became quite small at 400 feet from each site, and there was virtually no effect on properties at 1000 feet or more from the sites. As with the effects of blight, the contamination at the site and the ancillary social effects may have both contributed to price impacts.

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5. Case Studies

5.1 Case Study One: Mirvale Chemical Works, Mirfield

5.1.1 Overview and Rationale

Mirvale Chemical Works, a former creosote plant in West Yorkshire, has been used for chemicals manufacture for over 100 years. The works are located close to the river Calder and the contamination arising from the activities of the Works has resulted in environmental impacts on surface waters. It is proposed as a case study primarily as an illustration of the application of techniques for measuring environmental benefits.

5.1.2 Background

There is anecdotal evidence that there were works on the Mirvale site as early as 1890 but the first detailed records show the site used for munitions manufacture in the First World War. In the 1950s it became a chemical plant and the scene of a very large fire in the 1970s.

The site is still in use, but the greatest contamination occurred in the period 1920 to 1976 when the site was used to distil coal tar, refine benzole, recover naphthalene and produce organic pesticides including Agent Orange. Its operation resulted in the discharge of quantities of tarry process residues into a shallow alluvial aquiver adjacent to the River Calder. Over the years, this material migrated to the river and was being discharged from the river bank as a highly visible slick.

The site was one of the first Special sites designated under the new contaminated land regime in 2001 and was remediated under the Part 2A of the Environmental Protection Act by the introduction of a metal barrier between the site and the river. Material is collected and removed from the landward side of the barrier and disposed of elsewhere.

Figure 5.1 Mirfield before remediation

Figure 5.2 Mirfield after remediation

5.1.3 Relevant Benefits

This section identifies which decontamination and remediation benefits are relevant to the case of Mirvale Chemical Works and why. Only the benefits considered possible are examined in further detail in subsequent sections. Table 5.1 below, shows the benefit categories we have considered and the rationale supporting this.

Table 5.1 Relevant Benefit Categories - Mirvale

Benefit Category	Relevant	Rationale
(A) Site value	Yes	The site has clear economic value, which may have been affected by the historic contamination and the remediation project.
(B) Neighbouring sites values	Yes	The removal of a disturbing physical eyesore, and subsequent treatment of potential hazards has the potential to boost the value of neighbouring properties.
(C) Property transactions	Yes	Contamination could have affected the perceptions of potential buyers of property in the neighbouring area, and as a result, remediation may have increased the level of transactions.
(D) Productivity	Yes	Site in use, but productivity may have decreased due to ongoing remediation operations.
(E) Environmental	Yes	The site was heavily contaminated, and from survey data was having a detrimental impact on water quality and flora and fauna.
(F) Amenities	Yes	River users are affected.
(G) Greenfield savings	No	No additional development has taken place on site.
(H) Health	No	No direct benefits of remediation.
(I) Agglomeration	No	No changes in agglomeration.

5.1.4 (A) Site Value

The actual site value is its value when sold in the market. The implication of the equation used for the residual valuation method is that the cost of remediation (which constitutes a development cost) is exactly equal to the value added to the site through remediation.

Land value = (value of completed development) – (development costs + developers' profit)

As a result, the key piece of information required to calculate the impact on the site value - the benefit - is the remediation cost. In the present case, the Environment Agency records the remediation cost as £0.774 million.

Compared to the actual site value, the residual valuation is a possible value based on a number of assumptions such as: the costs of remediation would be recovered in a future sale; the value of the completed development can be estimated and that development costs can be predicted.

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In line with these assumptions and assuming that all the expenditure of £0.774 million is considered necessary to relieve the Part 2A designation, it can be used directly as an estimate of the increase in site value, as no market value (for example, an offer to buy the site) is available to test this assumption.

5.1.5 (B) Neighbourhood Values

Approach

Capturing and measuring the presence and extent of the effects of contaminated sites can be done using statistical analysis of property values in the wider area before and after site remediation while accounting for local property market characteristics and exogenous factors (such as macroeconomic shocks).

Two statistical methodologies for assessing impacts of remediation on the local property market have been used in this case study. They differ in how they use data about existing properties:

- The first methodology (B.1) considers *all residential transactions* within a designated radius of the contaminated site; and
- The second methodology (B.2) just considers only residences which were sold both before and after remediation.

In both cases, the price movements for these properties are compared with movements in comparator properties in the wider housing market area. Details in application of the two methodologies (such as whether there are enough paired transactions) affect their individual accuracy and so do not allow an a priori determination of which is the better technique. The hypothesis that remediation is associated with an increase in house prices is nevertheless more certain where both methodologies have statistically significant results and similar conclusions.

Data and Assumptions

Residential Property

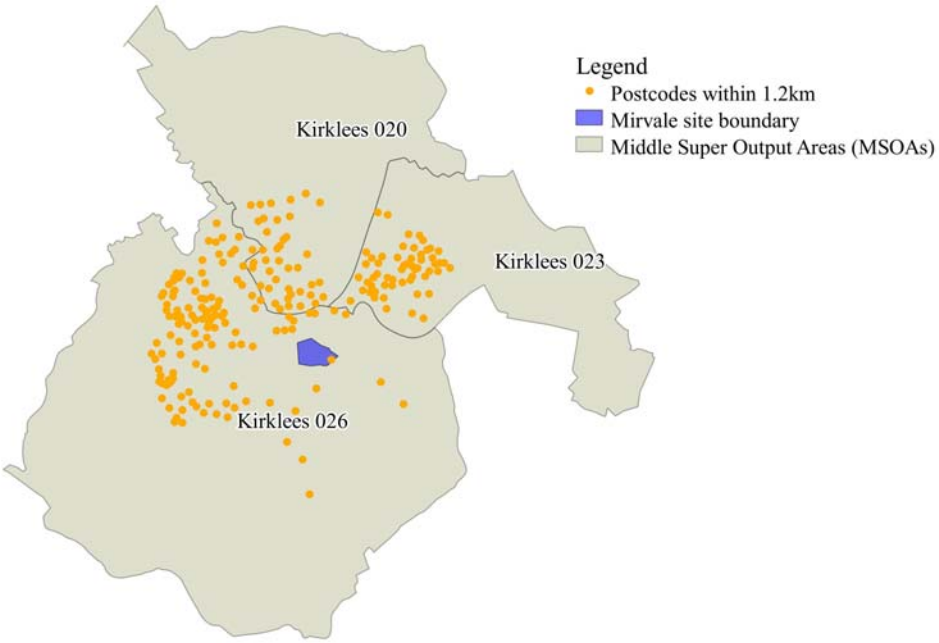
The Mirvale site is bounded to the north and south by sections of the River Calder, but the smell of creosote and the sight of creosote leaking into the river extended the range of affected properties beyond these natural barriers. The Environment Agency remediation note for Mirvale chemical works suggests that the visible creosote spill extended 800 m downstream from the site before become invisible as the river passed through a weir. We have therefore included properties potentially affected by this plume. To the west of the site, a number of other industrial premises can be found, some with their own history of contamination. Since the Mirvale site forms part of a well-known and long-standing cluster of industrial and chemical works, our study area includes the parts of Mirfield closest to the cluster. In this case, we have studied property market impacts within 1.2 km of the contaminated site.

For example, homes in the Mirvale Chemical Works study area can be expected to experience the same effects of the recession as the wider West Yorkshire property market. Therefore, in this Case Study we have adopted the West Yorkshire local authority area as the wider comparator area.

Non-Residential Property

For non-residential property, we use data from two commercial sources, EGi (www.egi.co.uk) and FOCUS (www.focusnet.co.uk) as these constitute the best available resource on commercial and industrial property transactions. For comparator area data on non-residential property, we use data from the Department for Communities and Local Government (DCLG). DCLG produces annual data, drawn from the Valuation Office database, on the average rateable value of commercial and industrial premises down to the Middle layer Super Output Area (MSOA) level for the years 2003 to 2008. Prior to 2003, these data are available only at Local Authority level. MSOAs vary in size and dimension across the country, but in the case of the present study, a 1.2 km radius designation from the contaminated site covers property spread across three different MSOAs. The figure below illustrates how these geographical zones overlap with the study area.

Figure 5.3 Middle Super Output Areas in the Mirvale Study Area



Source: GVA 2011; contains copyrighted data from Ordnance Survey and Office of National Statistics

Residential Impact Assessment Method B.1 (All Transactions)

Method

This method of quantifying the impact of contaminated land remediation on residential property values in neighbouring areas uses the following steps:

1. Data Assembly: Data for all past property transactions in postcodes within a given distance of the site are compiled. In this case, we gathered data on all past property transactions within 1.2 kilometres of the outer boundary of the former Mirvale chemical works site. This totalled 1,698 transactions over the period from January 1999 (the earliest available data) to December 2010; 273 transactions occurred during the pre-remediation period up to December 2000, and 1,212 transactions occurred during the post-remediation period from 9 July 2002. The remaining 213 transactions that took place during the remediation phase were not included in the analysis.

2. Data Matching: Each transaction is matched with the average sale price for properties of the same type (Detached/Semi-detached/Terraced/Flat or Maisonette) in the wider housing market area. In this case study the comparator area used is the West Yorkshire local authority area.

3. Price Indexing: Each observed sale price is expressed as a proportion of the average sale price for that type of property in the wider comparator area in that month. For example, a terraced house sold in Mirfield on 8 January 1999 for £24,000 is expressed as a proportion of the West Yorkshire average for terraced houses sold in January 1999 (£35,005), giving an indexed value of 0.68562. This value represents the relationship between the value of the specific property and the expected value of similar properties in a comparator area. The difference between expected and observed values is caused by features of the specific property such as number of bedrooms and physical condition, and features of the very local housing market such as accessibility and proximity to amenities, where these differ from the same features of the average house in the wider comparator area.

4. Testing for Normality: With complete sets of indexed sale prices for both pre-remediation and post-remediation periods, it is possible to obtain the means for both periods and to compare these with a range of statistical techniques. However, in order to undertake a z-test to compare the distributions of indexed prices pre- and post-remediation we require normally distributed variables, and therefore take the logarithm as follows:

$$\log\left(\frac{P_i}{P^*_{t\alpha}}\right) \text{ where:}$$

- P_i is the observed price paid for transaction i;
- α is the type of house bought in transaction i (detached, semi-detached etc.);

- t is the month and year of transaction i;
- $P^*_{t\alpha}$ is the average price of a home of type α in month t in the wider comparator area; and
- The result of taking the logarithms of the price level ratios is a distribution much closer to the normal distribution. Table 5.2 below reports kurtosis and skewness statistics of the pre-remediation and post-remediation data series are now much closer to zero (the values of a perfectly normal distribution).

Table 5.2 Skewness Statistics for Non-logarithm and Logarithm Distributions - Mirvale

	Distribution of Indexed Prices		Distribution of Logarithms of Indexed Prices	
	Skewness	Kurtosis	Skewness	Kurtosis
Pre-remediation	0.97062	1.35006	-0.30182	0.40619
Post-remediation	1.30114	4.03185	-0.58381	2.52777

Results

Pre-remediation, the mean observed house price in the study area was 111.2% of the expected value of a comparable house in West Yorkshire. Post-remediation, this figure was 113.8%.

A statistical test has been performed to test the significance of the results compared to the null hypothesis that the tested variables (the distributions of the logarithms of the price) are not significantly different to one another. Performing a one-tail z-test at a 5% significance level on the logarithms of these two distributions yields the result that the mean score for pre-remediation values (M=0.01465, SD= 0.16854, N= 273) was not significantly smaller than the scores for post-remediation values (M=0.02551, SD=0.16717, N=1211) using the two-sample one-tail z-test, z=-0.96299, p=0.16778.

The conclusion is that, using method B.1, we cannot reject the null hypothesis at this level of significance (5%) and therefore the rise in house prices relative to the wider housing market area is not statistically significant and should not be used to estimate benefits to neighbouring property.

Residential Impact Assessment Method B.2 (Paired Transactions)

Method

In contrast with the previous method (B.1) which considers all transactions, method B.2 considers only changes in the prices of individual properties sold before and after remediation. As before, this method involves the comparison of two sets of house price data, for the pre- and post-remediation periods. Unlike the previous method, both sets of data used in this analysis refer to exactly the same houses at different points in time. As a result, this methodology offers a way of controlling for more factors than the previous approach.

For pairing, transactions are excluded unless they relate to a property sold once before the remediation process began and once after the remediation process was complete. A pair of transactions is accepted where the address, tenure and type of dwelling are the same; otherwise the pair is also excluded from the analysis. For example, the sale of a freehold on a property in 1999 cannot be matched with the sale of a leasehold on the same property in 2005. In many parts of the country there is limited difference between long leasehold and freehold sale values, but in order to avoid the possibility of comparing unlike transactions, such mismatched pairs are excluded. More generally, for some sites and/or time periods, the number of acceptable pairs of transactions may be very low, and the smaller number of data points may constrain the possible degree of analysis.

The methodology involves the following steps:

1. Data Assembly: Data for all past property transactions in postcodes within a given distance of the outer site boundary are compiled, as above. In this case, there are 125 properties within 1.2 km of the site that where ownership changed during both periods and the pairs of transactions are acceptable.

2. Data Matching: For each pair of transactions a pair of reference values is taken from the Land Registry data for the wider comparator area. Again, in this instance we take West Yorkshire as the wider comparator area, and select average house prices relevant to the type of house and the date of the transactions in each pair.

3. Price Indexing: The observed sale prices of both transactions in each pair are expressed as proportions of the average sale price for that type of property in the wider comparator area in the transaction months. For example, a terraced house sold in Mirfield on 31 August 2000 for £39,950 is expressed as a proportion of the West Yorkshire average for terraced houses sold in August 2000 (£37,373), giving an indexed value of 1.06895. The same house sold again on 17 December 2003 for £58,000, which is expressed as 0.93453 when compared to the relevant West Yorkshire average of £62,063. These indexed values represent the relationship between the value of the specific property and the expected value of similar properties in a comparator area. In contrast to the previous approach, this methodology explicitly controls for any changes in the type of property being studied – the houses in each pair of transactions are considered to be exactly the same. Once again, in order to approximate a normal distribution and allow certain statistical tests to be performed, we take the logarithm of the indexed prices. The skewness and kurtosis of a normal distribution are both approximately zero. Taking the logarithms instead of the indexed prices reduces the skewness and kurtosis of the two distributions significantly, as shown in Table 5.3.

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Table 5.3 Skewness Statistics for Non-logarithm and Logarithm Distributions - Mirvale

	Distribution of Indexed Prices		Distribution of Logarithms of Indexed Prices	
	Skewness	Kurtosis	Skewness	Kurtosis
Pre-remediation	1.30098	2.07488	0.00839	0.15709
Post-remediation	1.37073	2.70525	0.02838	0.52128

Table 5.4 below shows a sample pair of transactions, illustrating the complete information required for each pair for each property.

Table 5.4 Sample Data for a Pair of Transactions - Mirvale

Pre-remediation Sale							
Address	Type	Tenure	Date	Price	W. Yorks. Mean	Indexed Price	Log (Indexed Price)
Address 1	Terraced	Freehold	31/08/2000	£39,950	£37,373	1.68954	0.028959
Post-remediation Sale							
Address	Type	Tenure	Date	Price	W. Yorks. Mean	Indexed Price	Log (Indexed Price)
Address 1	Terraced	Freehold	17/12/2003	£58,000	£62,063	0.934534	-0.0294

Results

We use a one-tail paired sample t-test (alpha = 0.05) to test statistically whether the increase in means is significant compared to the null hypothesis which is that there is no difference between the means of the two logarithm distributions.

The mean of the pre-remediation logarithm distribution was -0.00581, and the mean of the post remediation logarithms was 0.03771. The difference between them is 0.04352 (M=0.04352, SD=0.11900, N=125) was significantly greater than zero t(246)=2.0587, one-tail p=0.02029 indicating that the remediation has resulted in an increase in relative house prices. Taking the anti-logarithm of this change, the analysis indicates an increase in the ratio between study area and West Yorkshire price levels of 10.54% from pre-remediation values, with a 95% C.I. of (5.3057%, 16.0345%). This central estimated mean increase represents 10.4% of the West Yorkshire price level at a given point during the post-remediation period, and the confidence interval translates to (5.24%, 15.82%) as proportions of West Yorkshire price levels.

Method B.2 suggests that the increase in relative house prices is statistically significant and, together with (1) an estimate of the local housing mix and (2) an estimate of the number of houses affected, can be used to estimate (3) aggregate benefits from remediation.

Use of Results

(1) Estimate of the Local Housing Mix

In order to apply the average change in property value established above to the complete population of houses in the study area, we also require a breakdown of houses by type of house (detached, semi-detached, etc) since average prices for each type of property vary considerably. This estimate is constructed by taking the 2001 Census results relating to the breakdown of dwelling types in an area as contiguous to the study area as possible, and applying this mix of dwelling types to the number of residential properties provided in the Post Office Codepoint file for postcodes within the study area. Within 1.2 km of the boundary of the Mirvale chemical works site, the Codepoint file counts 3,337 residential delivery points (equivalent to letterboxes). In the 11 Lower-level Super Output Areas matching the study area as closely as possible, the Census reports a breakdown of dwelling types. Combining data from these sources results in the housing mix profile shown in Table 5.5.

Table 5.5 Study Area Housing Mix - Mirvale

	Proportion of Housing Stock	Number of Houses in Study Area
Detached	22.93%	765
Semi-detached	32.84%	1096
Terraced	34.03%	1136
Flat/Maisonette	10.20%	340
Total	***100%***	***3,337***

(2) Estimate of Number of Houses and (3) Aggregate Benefits

Taking the latest available data from January 2011 and the same bounding perimeter as above, it is possible to construct an estimate of the total impact of remediation priced into local house values as shown in Table 5.6.

Table 5.6 Houses in study area - Mirvale

	Houses in Study Area	W. Yorkshire Average Price (01/2011)	Remediation Uplift per House (10.4% of W.Yorkshire Average)	Total Remediation Uplift
Detached	765	£217,000	£22,568	£17,264,520
Semi-detached	1096	£115,962	£12,060	£13,217,760
Terraced	1136	£77,413	£8,051	£9,145,936
Flat/Maisonette	340	£120,683	£12,551	£4,267,340
Total	***3,337***			***£43,895,556***

On this basis, the total contribution of the remediation process to the value of homes in the study area is £43.9m in January 2011 and it can be said with 95% confidence that the value is in a range from £22.1m to £66.8m.

As house prices fluctuate this effect will change, and as a result it is impossible to give a stable numerical value to the impact of remediation. However, the process of remediating the Mirvale chemical works has, as demonstrated through this methodology, been associated with a closure of the gap between surrounding housing values and price levels in the wider housing market area.

Development of the Methodology

The approach demonstrated is based on the fact that the available housing data contains little information about the property other than price and property type.

If additional data was available, the analysis could be refined to take account of the following factors:

- **Distance of the property from the site -** If the sample of houses within the chosen radius of the site is a not a true random distribution of all houses within that distance, then the estimate of the impact will be biased;
- **The time of comparison -** 'Before' and 'after' may not sufficiently capture temporal variation, especially if this occurs for reasons other than remediation (e.g. other regeneration initiatives in the area);
- **The type and condition of property -** 'Before and after' relies on the samples at different times being nevertheless broadly equivalent; and
- **The representativeness of the housing market comparator area -** These were decided by judgement, but might in principle be tested, for example through comparison between sub-sections of the proposed comparator area.

The geographical area over which the effects of remediation are observed in house prices is also important to the calculation of an aggregate value. Generally, an accurate estimate of an environmental impact can only be made by aggregating price effects in distance bands around a site. Such an approach recognises the larger price effects and

the smaller number of properties near a site and the smaller price effects further from the site and the (generally) more numerous number of properties. Aggregating values over the area as a whole as is done in the case studies, rather than by distance bands, can lead to an over-estimation of the total value of an environmental improvement.

The value of the remediation work is the difference in house prices before the remediation work is announced and after the remediation work is completed. An issue with the analysis is the disparity in sample sizes before and after the remediation (e.g. a sample of 273 house price sales pre-remediation in Mirfield, and 1212 sales post-remediation). Such disparities in sample sizes may be the reason for being unable to reject the null hypothesis of no change in house prices in this case.

5.1.6 (C) Property Transactions

As well as affecting sale values of properties, remediation may have an effect on the number of transactions taking place. The number of transactions is commonly taken as an indicator of liquidity, or how easy it is to find a counterparty and make a purchase or sale.

Method

The methodology for quantifying the impact of contaminated land remediation on the level of residential property transactions in the neighbouring area involves the following steps:

1. Data Assembly: Data for all past property transactions in postcodes within a given distance of the outer site boundary are compiled. Transactions are aggregated for the month in which they occurred. For example, in this case, there were 16 residential property transactions in March 2000 within 1.2 km of the Mirvale chemical works.

2. Data Matching: Monthly transaction totals for the study area are matched to the total monthly transactions occurring within the wider comparator area (in this case West Yorkshire) using data from the Land Registry. For example, there were 3,662 residential property transactions in March 2000 in West Yorkshire. The total number of transactions in the study area is then expressed as a proportion of all sales in the wider comparator area. For example, transactions within 1.2 km of the Mirvale chemical works comprised 0.44% of all transactions in West Yorkshire in March 2000.

3. Testing for Normality: In order to perform statistical tests on the pre-remediation and post-remediation distributions of proportional transaction levels, it is necessary for both distributions to be normally distributed and to achieve this we take the logarithms of transaction levels, since the distribution of these logarithms is much closer to a normal distribution. The skewness and kurtosis statistics for logarithm and non-logarithm distributions are provided in Table 5.7 (a perfectly normal distribution would have skewness and kurtosis of zero).

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Table 5.7 Skewness Statistics for Non-logarithm and Logarithm Distributions - Mirvale

	Distribution of Transaction Proportions		Distribution of Logarithms of Transaction Proportions	
	Skewness	Kurtosis	Skewness	Kurtosis
Pre-remediation	-0.16374	-0.92790	-0.71772	-0.20444
Post-remediation	1.11489	1.52496	-0.11910	0.09906

Results

Transaction levels before and after remediation are compared to detect any statistically significant change in the level of transactions in relation to the wider comparator area. The pre-remediation average for logarithms of transaction levels in the study area was -2.512, or 0.31% of total West Yorkshire transactions, while the post-remediation average was -2.485, or 0.33%. A two sample unpaired one-tail t-test is applied to the two distributions. The null hypothesis is that the change in transaction levels is not statistically significant.

The t-test indicates that the mean of pre-remediation transaction levels (M=-2.51200, SD=0.1472, N=24) was not significantly smaller than the mean of post-remediation transaction levels (M=-2.48452, SD=0.17964, N=102) using the two-sample unpaired one-tail t-test, $t(41) = -0.78693$, $p>0.2$.

The conclusion is ***we cannot reject the null hypothesis at this level of significance (5%). The evidence does not support the suggestion that post-remediation transaction levels in the study area now make up a statistically significantly greater proportion of total transactions in the wider comparator area.***

5.1.7 (D) Productivity

Productivity benefits are estimated to be zero or less as the site is in use and activities on it are largely unchanged as a result of remediation. There may be productivity dis-benefits as the remediation programme requires the overhead of removing tarry residues using removal infrastructure and transport offsite. Dis-benefits include these direct costs as well as indirect costs such as significant reductions in the usable area of the site and any significant business interruptions due to resulting transport logistics operations.

5.1.8 (E) Environmental

While health and amenity benefits are expected to be reflected in house prices as residents enjoy them directly there are challenges in determining benefits individually. In general, good quality water status, for example, can only be established with technical monitoring programmes though remediated sites often have monitoring programmes which generate data which can be used for assessing environmental benefits.

The assessment of environmental benefits builds on understanding and knowledge of the damage caused by contamination to the environment including the wildlife, plants, and fish. The toxicity of substances and their

prevalence and extent within the site will determine the potential damage, while the exposure of habitat and species would determine actual damage, as some are more susceptible than others.

Assessment of environmental damage depends on establishing the type and extent of contamination and the observed ecological damage. In the first instance, this will require expert knowledge such as an ecologist to link the chemical concentrations observed with the damage caused to particular species. More generally, any monetary valuation (primary or BT) will require a qualitative representation of the changes due to contamination and remediation followed by a characterisation in quantitative terms (e.g. area affected, number of species).

The environment the Mirvale site most affects is the river Calder and estimates of the environmental benefits that are most appropriate relate to rivers. In the UK, CV and CE[30] approaches were used to assess the environmental (non-use) benefits associated with reaching good ecological and chemical status in a range of water bodies. The values in Table 5.8 result from this study and are a first estimate which could be used at Mirvale.

Table 5.8 River basin benefits per year for improvement Poor to Good Status

River basin	Average benefit – per km river (£k per year) for a range of Status Changes		
	Poor to Good	Poor to Moderate	Moderate to Good
Anglian	24.9	11.3	13.5
Dee	42.6	19.4	23.0
Humber	19.7	9.0	10.6
North West	18.7	8.5	10.1
Northumbria	20.5	9.3	11.1
Severn	24.2	11.0	13.1
Solway Tweed	16.5	7.5	8.9
South East	26.8	12.2	14.5
South West	13.3	6.1	7.2
Thames	38.4	17.5	20.7
Western Wales	26.4	12.0	14.3

The Benefits of Water Framework Directive Programmes of Measures in England and Wales, NERA, (2007). A Final Report to DEFRA re CRP Project 4b/c disaggregated and quoted in the Application of Disproportionate Cost Assessment to WFD Driver Specific Schemes in the Water Quality PR09 National Environment Programme, Environment Agency, 2009.

The table provides benefits expressed in £ per km of river. The methodology adopted is implicitly one of benefits transfer, in that benefits estimated in another context are being used to value those at this site.

To use the values in the table, they need to be combined with specific features of the site which in this case are:

- The contribution to the change in river status that could be attributable to remediation actions; and

[30] Contingent Valuation and Choice Experiment (see Section 3)

- The river length to be used for benefit assessment.

These are ultimately technical judgements which depend on the science of the individual site. Note that the number of visitors is not relevant as it is the improvement of the river per se that is being assessed not the enjoyment of an improved river by residents (which would be captured as an amenity benefit).

One approach to the estimation of river status would be to involve a water expert who would in this case undertake the following steps:

1. Identify the River Basin District (RBD) where Mirvale is situated;
2. Establish pre-remediation water body quality status;
3. Establish current status; and
4. Make a judgement as to what extent remediation was responsible for the improvement and assign a value to the length of the river affected.

An alternative approach would be to make such a judgement based only on previous studies. A refinement would enlist a water expert to ensure that any existing information can be matched with the generic table of benefits. One known report is "The Biological Survey of the River Calder to assess the impact of the contaminated land site at Mitchell Cotts, Environment Agency 1998". It identifies that the river overall is of very poor biological quality due to upstream sources (particularly Huddersfield Waste Water Treatment Works) as well as the site at Mirvale, but nevertheless identifies that fauna indicate "more toxic conditions in this locality [i.e. near to Mirvale]". The report notes that the effluent from the Water Treatment Works is being improved.

Furthermore, the generic values in the table could also be refined or replaced. For example, a CV/CE survey could be undertaken in the local area to establish the environmental value local residents put on this specific water body. Although relevant for some study designs, this might nevertheless be inappropriate for others. Local residents may not be the only groups interested in the environmental improvement of the river Calder, and may therefore be an unrepresentative sample. A study which was seeking to compare this site with others, might not need an additional survey as it would introduce elements of specificity which might not be present at other sites. A better overall use of resources might be to conduct surveys across all sites, or in a way that resulted in updated results representative for the whole UK. The Environment Agency has updated its recent guidance on assessing water quality which could also be used[31].

Uncertainty in both scientific information and any generic information as well as any unavailability are an unavoidable feature of these assessments and sensitivity analysis is generally recommended in the study design.

Data sources that can be consulted are:

- ESIS (European chemical Substance Information System) provides information on the existing and new substances

[31] Benefits Assessment Guidance (BAG). http://www.environment-agency.gov.uk/business/sectors/37305.aspx

- Existing Chemicals (ESIS: EINECS, HPV-LPV, IUCLID DS, ORATS)
- New Chemicals (ESIS: ELINCS, NLP)
- Classification & Labelling / CLP-GHS information (ESIS: CLP/GHS)

- ECHA (European Chemical Agency) provides information on:
  - Classification & Labelling / Legislation (ECHA: Classification Legislation)
  - Legislation (ECHA: Legislation)
  - REACH information (ECHA: About REACH)
- IHCP (Institute for Health and Consumer Protection (IHCP))
  - Biocides information (IHCP: Risk Assessment of Biocides)
  - EUSES information (IHCP: EUSES)
- IUCLID (International Uniformed Chemical Information Database)
  - IUCLID information can be found at http://iuclid.eu/.

5.1.9 (F) Amenities

Amenity benefits result from improvements due to remediation which allow the site to be enjoyed more fully by the residents and other visitors often for the purposes of recreation. The level of amenity is likely to influence neighbouring property values and may be assumed included (as in this case) in local house prices. There are additional amenity benefits where a site attracts people from a wider area. In this case there is no evidence that the site is enjoyed by a wider group of people.

For other study designs where amenity benefits are estimated independently, the following approach and variations could be used.

Generic estimates exist for the benefits from recreational water use (see Table 5.9). These willingness to pay (WTP) estimates vary depending on the elicitation method used in the underlying contingent valuation study. For example, WTP is the additional day ticket price to ensure fishing at a good trout fishery in Entec, 1993, and the *total* willingness to pay including travel costs for premium game fishing in a flowing river in Green and Willis, 1996.

Table 5.9 Benefits from Informal Recreation

Original Study	Value for benefit transfer, £
Green and Tunstall (1991) Improving river from good enough for water birds to good enough to support fish. (The value of improving the river from not capable of supporting water birds to good enough for water birds would be £1.09 per visit. The value of improving the river from good coarse fishery to able to support trout would be £0.15 per visit.	0.22
Hanley (1989) Recreational value of forest visits (landscape, bird watching)	1.84
Filion et al. (1994) Nature trips or outings (with the purpose of encountering wildlife to watch etc.) and/or hunting for mammals, waterfowls and other birds per participant per day. (£3.16 depending on the province)	4.06
Green and Willis (1996) Improving the site to ensure good trout fishery (per person per trip)	26.15
Ecotec (1993) Ensuring trout fishery (anglers WTP was about 50% higher than the average cost of day ticket)	5.63
Ecotec (1993) Ensuring salmonid fishery (anglers WTP was about 50% higher than the average cost of day ticket)	12.00
Green and Willis (1996) Improving the site to ensure good salmonid fishery (per person per trip)	41.17

Note: Another study by Shafer et al. (1993) on recreational trout fishing, wildlife viewing of hawks, eagles and waterfowl in Pennsylvania state wilderness areas estimated the WTP for wildlife viewing (waterfowl) at £3.72 per visitor day.

Methods which seek to use the values in Table 5.9 are implicitly using a benefits transfer approach. In order to implement this approach, estimates are required for the increased recreational use following remediation. Recreational use is characterised in terms of the nature of the activity and the number of people enjoying it. Measures are required of the level of improvement due to remediation, the size of affected population, and the value placed on the improvement. These can be derived independently.

At Mirvale, press information prior to the remediation quotes benefits to anglers from new coarse fishing and leisure activities, as well as cleaner birds[32]. An assumption that angling was the only benefit would provide a lower estimate if in fact there are other recreational water users. Estimates of increased use of the river for angling would preferably be based on surveys before and after remediation. An alternative, which might be over optimistic, might assume no angling before and average UK levels after, though it is important to recognise that proxies should only be used to estimate actual changes where such data is missing. Proxies do not, for example, represent a better or alternative choice per se. Evidence on angling in the UK is available from a range of publications such as “Public Attitudes to Angling, Environment Agency, 2010”.

[32] Huddersfield Daily Examiner, October 2, 2001

The basis of quantitative monetised estimates is the multiplication of unit values (e.g. £/trip) by the size of population enjoying the benefit.

5.1.10 (G) Greenfield Savings

Greenfield Savings are estimated to be zero as the site is in use despite being contaminated. It has not been returned to use, which would otherwise have potentially saved development of a greenfield site.

5.1.11 (H) Health

Health benefits are included within the site and neighbouring value assessment and as a result, in this study, no additional benefits would be calculated.

If Health benefits were to be calculated independently they would probably be estimated to be zero as the risks to health have been assessed and can be controlled. The "Mirfield Chemicals - Interpretative Report, Carl Bro Aquaterra, 1999" identified "the primary risk driver with regard to on-site human receptors" as potential ingestion and dermal contact with contaminants present within the shallow sub-surface.

A capping layer of clay, soil or hardstanding (according to the use of the different parts of the site) was adopted to break the pathway between source and receptor, and its removal was also considered but rejected as being overly costly.

The site's use has not changed as a result of the remediation. Furthermore, although the site is now better understood, it is unlikely that people at the site were undertaking activities which put them at serious risk of harm prior to the remediation as it was well known that the site had been used for industry, including chemical manufacture. Remediation has not changed the risk to humans or required a change in their behaviour and hence there are no health benefits.

5.1.12 (I) Agglomeration

Agglomeration Benefits are estimated to be zero as the site is in use despite being contaminated. There are therefore no changes in industrial or residential density which would lead to potential agglomeration benefits.

5.2 Case Study Two: Ince Central Estate, Wigan

5.2.1 Overview and Rationale

Ince Central Estate in Wigan comprises housing built in an area previously used for industry. It has a resident population and exhibited contamination which could have resulted in significant risks to their health. The site was remediated in 2010.

This site was chosen as a case study as there is information on the potential health impacts which were a primary justification for remediation work. The predominantly urban character of the location contrasts with that of the other two case studies.

It should be noted that this case study is purely illustrative and is based only on the relevant available secondary data. No site visits have been undertaken and no primary (qualitative or quantitative) data has been collected.

5.2.2 Background

The Ince Central Estate consists of approximately 300 properties of which 100 are privately owned. The land has a legacy of over a century of past industrial land use. Records for the site for the period from 1849 show chemical production plant was on site followed from 1930 to 1956 by textile manufacturing. The estate has a history of subsidence problems but an investigation into a hole that appeared in the garden of a house in the summer of 2003 revealed a significant range of contaminants in the ground.

A report was commissioned in 2003 from Wardell Armstrong to investigate the problem and outline measures to determine the extent of the soil contamination. The results detailed 18 different types of contaminated waste that had been found in what was described as a "patchwork quilt" of contamination on the estate. The main contaminants were metals such as Arsenic, Cadmium, Chromium, Lead, and Nickel, and some polyaromatic hydrocarbons such as BAP (Benzo(a)pyrene) and Naphthalene. By the end of June 2005, the site investigation had revealed that only 30 houses had contaminants below the safety levels.

Remediation methods included containment, where contamination was covered with a flagged or concrete barrier, and excavation, amounting to replacement of the contaminated soil with clean soil.

Works started on site on 30th May 2006 after further detailed survey s of gardens, soil contents & house structures of every residents. The work was planned in Phases. Phases 1 to 2 and 7 to 9 addressing the most contaminated sites and Phases 4 to 6 the less contaminated. 26 plots in Phases 4, 5 and 6 are classed as having contaminants below the set safety levels and these properties were not remediated, but received some environmental works including fencing and patios.

Early Phases of remediation tried to provide 'like for like' replacement for garden areas including garden features, plants, structures etc. This was as a result of strong lobbying of residents who wished to retain aspects of their property they had developed and worked on for years. Unfortunately in later phases this had to be abandoned due to the excess cost and view that it was not consistent with the regulatory requirements of simply breaking the pollutant linkage.

The site was determined and remediated as Contaminated Land under Part 2A of the EPA 1990 on the basis of Significant Possibility of Significant Harm to Human Health. The remediation project cost approximately £9 million and was completed in 2010.

It could be argued that whilst remediation of the estate protected residents from long term exposure to soil contaminants, the general improvement of the environment in which they live produced other less quantifiable

improvements. The remediation may also have brought negative impacts such as stress for those whose gardens were not remediated 'like for like'.

Figure 5.4 Ince Estate before remediation

Figure 5.5 Ince Estate after remediation

Photographs courtesy of Mouchel

5.2.3 Relevant Benefits

This section identifies which decontamination and remediation benefits are relevant at the Ince Central Estate and why. Only the benefits considered possible are examined in further detail in subsequent sections. Table 5.10 shows the benefit categories considered and the supporting rationale.

Table 5.10 Relevant Benefit Categories - Ince

Benefit Category	Relevant	Rationale
(A) Site value	Yes	The site has clear economic value, which may have been affected by the historic contamination and the remediation project.
(B) Neighbouring sites values	Yes	The presence of a 'patchwork quilt' of contamination on a nearby housing estate could be expected to affect the value of property. Correspondingly, these properties could see some gain in value due to the decontamination process.
(C) Property transactions	Yes	Contamination could have affected the perceptions of potential buyers of property in the neighbouring area, and as a result, remediation may have increased the level of transactions.
(D) Productivity	No	Land was residential.
(E) Environmental	Yes	The site was heavily contaminated, and it is possible that this was having a detrimental impact on wildlife and biodiversity e.g. through contamination via the drainage system.
(F) Amenities	Yes	People were prevented from using gardens which contained soil, preventing their use for horticulture. Children were at risk from ingesting soil and plants. Although remediation has not increased the amount of amenity space, it has increased the range and levels of use from the available amenity space (especially back gardens). For example, the development of established

Benefit Category	Relevant	Rationale
		gardens.
(G) Greenfield savings	Yes	Keeping the homes on the Ince Central Estate safe for human habitation could in theory have resulted in greenfield savings.
(H) Health benefits (soil/water)	Yes	Removing significant and harmful levels of contamination is expected to result in health benefits.
(I) Agglomeration benefits	No	No additional on-site development has taken place.

5.2.4 (A) Site Value

In the case of the Ince Central Estate, the contaminated site was already developed, and therefore use of the residual valuation method (as used in the case of Mirvale) is less readily applicable. However, as regulatory intervention was proposed, the initial site value is relevant to assessing the impact and in particular, establishing a baseline for later comparison. When contamination was discovered, residents were allowed to remain in their homes and were given advice on how to change their behaviour to avoid the possibility of harmful exposure by, for example, preventing children ingesting contaminants while playing in private gardens. However, the 297 homes were found to be situated on land containing levels of contaminants beyond those designated as safe by current regulations. As a result, *without decontamination*, these homes would have been defined as unsafe for human habitation, and their value would have been severely affected.

The legally acceptable levels of contaminant therefore determined the amount of remediation necessary, and thereby influenced the change in site value. Below the legally acceptable threshold, a house has a normal market value, but above the legally acceptable threshold, it has the market value minus the cost of legally necessitated remediation activity. In the case of Ince Central Estate, the estimated total remediation cost was £7.5 million[33], which would be the value added to the site according to the standard residual formula[34]. It should be noted that adding this amount to the site value does not mean that the site is worth £7.5 million or more. Prior to remediation, the actual value of contaminated plots (there value when sold in the market) may have been negative due to the high remediation costs necessary and probably low final development values.

When using the development costs as the estimate of gain in site value, there is also the possibility that remediation works have gone above and beyond the minimum required to make the site appropriately safe for its designated end use. We are unable to determine whether this is the case for the Ince site, but in applying this method on other sites, it would be appropriate to understand how the cost of actual remediation compares to the hypothetical cost of a 'minimum' level of remediation (that satisfies end land use and regulatory requirements). This minimum cost is a possible alternative estimate of the change in site value.

[33] Report of Director of Environmental Services to Wigan Council, 5 September 2007, p.3.

[34] See Site Value calculation in Mirvale case study

5.2.5 (B) Neighbourhood Values

Approach

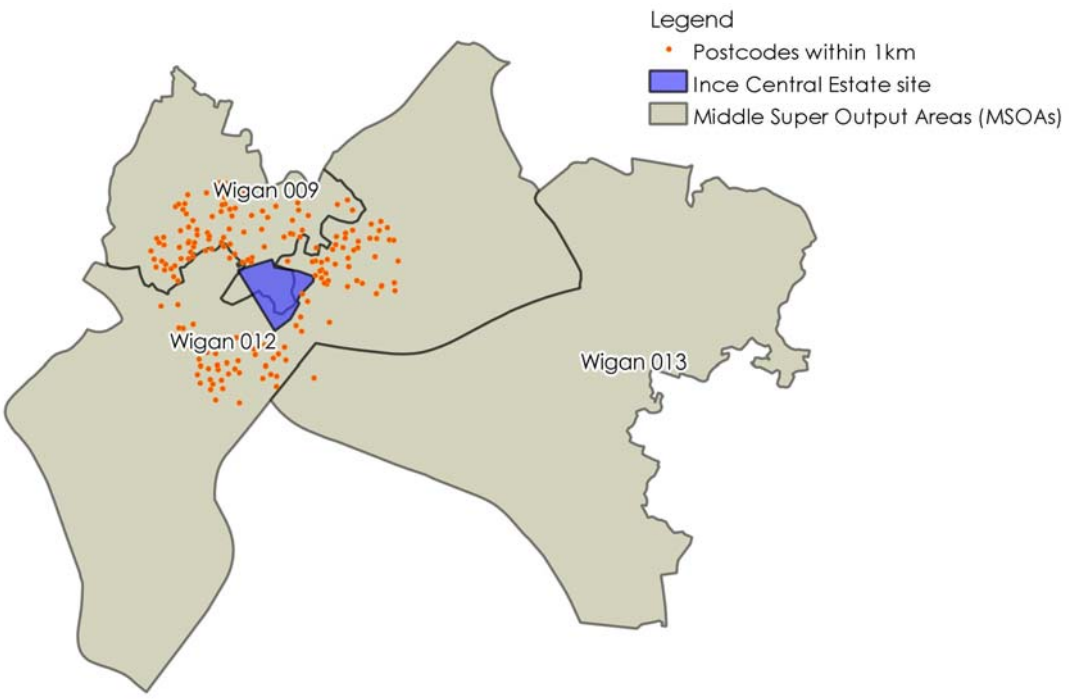
The approach follows the template of the Mirvale Case study which can be used as a reference. A summary of the steps and the aspects specific to Ince are provided here.

Both methodology B.1, relating to all transactions and methodology B.2, relating to paired transactions, are used.

Data and Assumptions

A canal to the west of the site limits access to the Ince Central Estate from central Wigan, while the nature of the estate, which has no through roads, significant employment sites or amenity spaces, means that it is not a common destination for non-residents. This contributed to the decision to define a perimeter for the local property market at a 1 km radius around the contaminated site. This covers property spread across different MSOAs. The figure below illustrates how these geographical zones overlap with the study area.

Figure 5.6 Middle Super Output Areas in the Ince Study Area



Source: GVA 2011; contains copyrighted data from Ordnance Survey and Office of National Statistics

Residential Impact Assessment Method B.1 (All Transactions)

Method

This approach to quantifying the impact of contaminated land remediation on residential property in neighbouring areas involves the following steps:

1. Data Assembly: Data for all past property transactions in postcodes within given radii of the site are compiled. In this case, we gathered data on all past property transactions within 1 kilometre of the outer boundary of the Ince Central Estate. This totalled 454 transactions during the period from the discovery of contamination was discovered up to the start of remediation work (June 2003 to May 2006), and 54 transactions since the start of the post-remediation period in March 2010.

2. Data Matching: Each transaction is matched with the average sale price for properties of the same type in the wider housing market area. In this case study we have used Wigan as the wider comparator area, since the study area is wholly encompassed by the Wigan local authority area.

3. Price Indexing: Each observed sale price is expressed as a proportion of the average sale price for that type of property in the wider comparator area in that month. For example, a terraced house sold in Ince on 13 June 2003 for £40,500 is expressed as a proportion of the Wigan average for terraced houses sold in June 2003 (£43,942), giving an indexed value of 0.9217. This value represents the relationship between the value of the specific property and the expected value of similar properties in a comparator area. The difference between expected and observed values is caused by features of the specific property such as number of bedrooms and physical condition, and features of the very local housing market such as accessibility and proximity to amenities, where these differ from the same features of the average house in the wider comparator area.

4. Testing for Normality: With complete sets of indexed sale prices for both pre-remediation and post-remediation periods, it is possible to obtain the means for both periods and to compare these with a range of statistical techniques. In this case we do not take logarithms of the price ratios since the logarithm distribution displays more skewness and kurtosis than the ratio distribution. Table 5.11 below, shows the kurtosis and skewness values for pre-remediation price ratios and their logarithms.

Table 5.11 Skewness and Kurtosis Statistics for Non-logarithm and Logarithm Distributions - Ince

	Distribution of Indexed Prices		Distribution of Logarithms of Indexed Priced	
	Skewness	Kurtosis	Skewness	Kurtosis
Pre-remediation	0.479052255	1.842361518	-1.109464308	2.885136666
Post-remediation	0.008379418	-0.838566082	-0.562889536	-0.423926466

Results

Pre-remediation, the mean observed house price in the study area was 98.3% of the expected value of a comparable house in Wigan. Post-remediation, this figure was 100.6%.

The mean scores from the same statistical test [two-sample one-tail z-test, z=-0.51808, p=0.30220] are: pre-remediation (M=0.98290, SD=0.29335, N=454); post-remediation (M=1.00586, SD=0.30951, N=54) and were not significantly different.

The conclusion is that, using method B.1, (and as with Mirvale) we cannot reject the null hypothesis at this level of significance (5%). The rise in house prices relative to the wider housing market area is not statistically significant and should not be used to estimate benefits to neighbouring property.

Residential Impact Assessment Method B2 (Paired Transactions)

Method

The methodology involves the steps (using the template for Mirvale):

1. Data Assembly: Data for all past property transactions in postcodes within a given distance of the outer site boundary are compiled, as above. In this case, there are 11 properties within 1km of the site where ownership changed during both periods.

2. Data Matching: For each pair of transactions a pair of reference values are taken from the Land Registry data for the wider comparator area. Again, in this instance we take Wigan as the wider comparator area, and select average house prices relevant to the type of house and the date of the transactions in each pair.

3. Price Indexing: The observed sale prices of both transactions in each pair are expressed as proportions of the average sale price for that type of property in the wider comparator area in the transaction months. For example, a terraced house sold in Ince on 4 July 2003 for £41,567 is expressed as a proportion of the Wigan average for terraced houses sold in July 2003 (£44,743), giving an indexed value of 0.9290. The same house sold again on 19 November 2010 for £76,000, which is expressed as 1.2535 when compared to the relevant Wigan average of £60,631. These indexed values represent the relationship between the value of the specific property and the expected value of similar properties in a comparator area. In contrast to the previous approach, this methodology explicitly controls for any changes in the type of property being studied - the houses in each pair of transactions are considered to be exactly the same. Since, as above, taking the logarithms of the price indices produces a distribution with greater kurtosis and skewness than the original series, we do not use the logarithm values for this analysis. Table 5.12 shows a sample pair of transactions, illustrating the complete information required for each pair for each property.

Table 5.12 Sample Data for a Pair of Transactions - Ince

Pre-remediation Sale						
Address	**Type**	**Tenure**	**Date**	**Price**	**Wigan Average**	**Indexed Price**
Address 1	Terraced	Leasehold	04/07/2003	£41,567	£ 44,743	0.929017
Post-remediation Sale						
Address	**Type**	**Tenure**	**Date**	**Price**	**Wigan Average**	**Indexed Price**
Address 1	Terraced	Leasehold	19/11/2010	£76,000	£ 60,631	1.253484

Results

The pre-remediation average price level (as a ratio of Wigan averages) for the 11 properties in the study area was 0.91905, and the mean of the post remediation values was 1.15024.

A one-tailed paired sample t-test (alpha = 0.05) is used to test whether the increase is statistically significant. The null hypothesis is that there is no difference between the means of the two distributions.

The increase in the mean relative price (M=0.23120, SD=0.26395, N=11) was significantly greater than zero, t(10)=2.90505, one-tail p=0.00785, providing evidence that the remediation has resulted in an increase in relative house prices. A 95% C.I. about the increase in the mean relative house price is (0.05387, 0.40852).

Method B.2 suggests that the increase in relative house prices is statistically significant (as with Mirvale) and together with (1) an estimate of the local housing mix and (2) an estimate of the number of houses affected can be used to estimate aggregate benefits from remediation.

Use of Results

Estimate of the Local Housing Mix

Using the same procedure as in the Mirvale template, within 1km of the boundary of Ince Central Estate, the Codepoint file counts 2,834 residential delivery points (equivalent to letterboxes). In the 9 Lower Super Output Areas matching the study area as closely as possible, the Census reports a breakdown of dwelling types and housing mix profile shown in Table 5.13 below.

Table 5.13 Study Area Housing Mix - Ince

	Proportion of Housing Stock	Number of Houses in Study Area
Detached	5.39%	153
Semi-detached	31.82%	902
Terraced	41.20%	1168
Flat/Maisonette	21.59%	612
Total	***100%***	***2,834***

Estimate of Aggregate Benefits

Using the latest available data from January 2011 and an area bounded by the choice of perimeter as above, it is possible to construct an estimate of the total impact of remediation priced into local house values.

The analysis indicates an increase in the ratio between study area and Wigan price levels of 23.12 percentage points, with a 95% Confidence Interval of it being between 5.38% and 40.85%.

Table 5.14 Aggregate benefits of remediation - Ince

	Houses in Study Area	Wigan Average Price (01/2011)	Remediation Uplift per House (23.12% of Wigan average)	Total Remediation Uplift
Detached	153	£185,712	£42,936.17	£6,569,234
Semi-detached	902	£101,334	£23,428.18	£21,132,218
Terraced	1168	£59,603	£13,780.07	£16,095,122
Flat/Maisonette	612	£75,033	£17,347.45	£10,616,639
Total	***2,834***			***£54,413,214***

On this basis, the total contribution of the remediation process to the value of homes in the study area is £54.4m in January 2011 and it can be said with 95% confidence that the value is in a range from £12.7 to £96.1.

Commercial and Industrial Property Market Impacts

Similar approaches can be taken to address the commercial and property market impacts of a remediation project, but as noted above, historic transaction data suffers from major data quality issues, and commercial or industrial property is characteristically less easily comparable than residential property. To illustrate the limitations of the data, we gathered all the transaction information for office, retail, industrial and warehouse properties within the Ince Central Estate study area from both EGi and FOCUS. Table 5.15 compares the number of data points

provided by the two sources, grouped by type of property and period. The number of data points is insufficient in every case to allow for any robust comparison of price levels before and after the remediation project.

Table 5.15 Data availability - Commercial and Industrial properties

Valid Transaction Records		Office		Retail		Industrial/Warehouse	
		FOCUS	EGi	FOCUS	EGi	FOCUS	EGi
Lettings	Pre-remediation	0	1	0	0	0	0
	Post-remediation	0	1	1	3	0	0
Sales	Pre-remediation	2	0	3	0	0	0
	Post-remediation	0	0	0	0	1	1

Data sufficiency for this analysis would require either paired transactions of commercial or industrial premises (as above with residential transaction pairs), or a sufficiently comparable floorspace area being exchanged in both periods.

5.2.6 (C) Property Transactions

The approach follows the template of the Mirvale case study which can be used as a reference. A summary of the steps and the aspects specific to Ince are the focus here.

Method

The methodology for quantifying the impact of contaminated land remediation on the level of residential property transactions in the neighbouring area involves the following steps:

1. Data Assembly: Data for all past property transactions in postcodes within a given distance of the outer site boundary are compiled aggregated to the month in which they occurred. For example, in this case, there were 12 residential property transactions in April 2003 within 1km of the contaminated area of Ince Central Estate.

2. Data Matching: Monthly transaction totals for the study area are matched to the total monthly transactions occurring within the wider comparator area (in this case Wigan), using data from the Land Registry. For example, there were 524 residential property transactions in April 2003 in Wigan. The total transactions in the study area are then expressed as a proportion of all sales in the wider comparator area. For example, transactions within 1 km of the Ince Central Estate site comprised 2.29% of all transactions in Wigan in April 2003.

3. Testing for Normality: In order to perform statistical tests on the pre-remediation and post-remediation distributions of proportional transaction levels, it is necessary for both distributions to be approximately

normally distributed. In this case we have not taken logarithms, since transaction levels, unlike prices, do not experience the same long tail at the upper end of the distribution. Table 5.16 shows the skewness and kurtosis statistics for the non-logarithm and logarithm distributions.

Table 5.16 Skewness and Kurtosis of Non-logarithm and Logarithm Transaction Distributions - Ince

	Transactions (as % of total Wigan transactions)		Transactions (as % of total Wigan transactions) (logarithms)	
	Skewness	Kurtosis	Skewness	Kurtosis
Pre-remediation	-0.3292106	-0.2913514	-1.9914044	6.512897186
Post-remediation	-0.44252611	-0.29778662	-1.68468105	2.850958288

Results

The pre-remediation average transaction level in the study area was 2.57% of total Wigan transactions, while the post-remediation average was 2.05%.

The mean of pre-remediation transaction levels (M=0.025693, SD=0.008353, N=35) was not significantly larger than the mean of post-remediation transaction levels (M=0.020488, SD=0.009481, N=10) using the two-sample unpaired one-tail t-test, t(13)=1.57072, p=0.070130.

We cannot reject the null hypothesis at this level of significance (5%). The evidence does not support the suggestion that post-remediation transaction levels in the study area now make up a statistically significantly greater proportion of total transactions in the wider comparator area.

5.2.7 (D) Productivity

No productivity benefits were identified.

5.2.8 (E) Environmental

The approach to environmental benefits follows the same conceptual structure as illustrated in the Mirvale case study. In principle, an estimate can be developed using a form of benefit transfer with:

- A specification of the environmental and ecosystem damage and the impacts of remediation for the site; and
- Generic estimates of the value people place on changes in the environment and ecosystems.

However, compared to Mirvale, where a river was in close proximity, Ince does not benefit from particular natural features or ecosystems. After remediation, the environment would resemble the surrounding environment and might be assumed to be equally valued. To test this, stated and revealed preference methods could be used.

Existing studies and methods are often focused on estimates of the total value of a habitat, ecosystem, or environmental scheme rather than the value of a marginal change in a habitat or ecosystem. For example, there are numerous studies that assess non-use environmental benefits associated with water, soil and air quality.

Also, there is a lack of estimates of ecological benefits associated explicitly with land cleanup overall. It should be noted that the value of a marginal increase of one or two hectares to the national total of a particular habitat, or to the number of a particular species, through remediation of contaminated land, is likely to be to quite small.

Ince was subject to extensive investigation and the specific contaminants and their locations were identified in 2004 and the environmental impacts can be assessed using the data collected at this time. However there has not been the same level of change as experienced for example at Mirvale and, without other evidence, the environmental benefits of remediation would be conservatively assessed as zero.

5.2.9 (F) Amenities

Remediation of the site resulted in amenity benefits e.g. an improved visual appearance of the area and improved local recreational opportunities such as use of gardens.

Due to the characteristics and location of the site, it is not a common destination for non-residents. Therefore the extent of the amenity benefits is limited to the local population only and changes to the site and neighbouring property values already capture these values.

Illustration of an alternative method for independently calculating amenity benefits is included in the Mirvale case study.

5.2.10 (G) Greenfield Saving

One model for calculating the greenfield saving in this case follows from the possible baseline assumption that the contamination, once discovered, rendered the residences on the Ince Central Estate unsafe for human habitation. In this case, the loss of 297 homes from the housing market in the Wigan area would immediately add pressure on housing supply. The largest possible extent of greenfield saving from remediating Ince Central Estate is therefore the scenario in which 297 new homes are built on greenfield sites nearby. Using an average housing density of 31 dwellings per hectare (England provisional 2009 estimate[35]), this upper limit translates to 9.58 hectares of greenfield land. To obtain an economic value for the benefits that would be lost through development of this amount of un-developed land, we use figures from the 2004 ODPM report *Valuing the external benefits of undeveloped land*[36], adjusted for inflation, and apply values based on the land profile of typical greenfield sites

[35] Land Use Change Statistics: Table P231 Land Use Change: Density of new dwellings built, England, 1989 to 2009.

[36] Valuing the External Benefits of Undeveloped Land, ODPM August 2004.

around Wigan. We characterise the land profile as closest to the land type unforested Urban Fringe, which was defined by ODPM as follows:

> ***Urban Fringe:*** *The urban fringe is a zone of transition where urban areas meet the countryside. These areas are often characterised by a wide variety of suburban related uses, which are, in many instances, space-demanding, such as water treatment works and golf courses. Typically urban fringe will comprise large residential areas and associated suburban development, which often form the distinct urban edge with the countryside. The urban fringe zone also includes those areas of countryside which are within the 'urban shadow' and are often experiencing the greatest pressure for development, particularly in locations where undeveloped land abuts major arterial roads, railways and airports. The urban fringe areas contain a large range of types of undeveloped land likely to be considered suitable for development and comprise areas of land use change. Broadly, the urban fringe constitutes 10% of the land area of lowland Britain.*

In the OPDM 2004 estimates unforested Urban Fringe greenfield land provided £889 of external benefit per hectare per year, which (with a 3% appreciation rate under a 3.5% discount rate) equated to a present value of £177,800 per hectare.

Adjusting this 2004 figure for inflation by the CPI to give 2010 prices, this amounts to a present value of £207,736 per hectare.

Multiplying this by the 9.58 hectares required for 297 dwellings given an all-England average density of 31 dwellings per hectare (dph), the resulting greenfield saving is worth £1,990,242 for this site.

This value represents an estimated upper limit for this category of benefit. The presence of spare capacity within the housing market to absorb extra households without new development is likely to bring this total down. Gauging the spare capacity within the housing market, or comparing the likely absorptive capacity of two or more areas, requires deeper insight into the local property markets and is best sought from local agents. If the development required to relocate the 297 households could take place on available brownfield sites, the amount of greenfield saving will reduce correspondingly.

Without the baseline assumption that the houses are rendered unfit for human habitation, the greenfield saving is equal to zero in this case, since there is no net additional development taking place.

5.2.11 (H) Health

Health benefits are included within the site and neighbouring value assessment and as a result, in the methodology used in this study, no additional benefits would be calculated.

If health benefits were to be calculated independently then the following assessment steps could be used:

1. Identification of the types of contamination.

2. Specification of the associated risks.
3. Specification of hazards and exposure scenarios.
4. Valuation and monetisation of impacts.

In general, risk to human health arises from dermal exposure to soil, ingestion of soil and water contaminants, and inhalation of soil contaminants. Impacts on health will depend on the type of contaminants and exposure levels but may include mortality, long term life expectancy, emergency hospital admissions due to illness, chronic and carcinogenic effects.

The hazard assessment typically uses the source-pathway-receptor model to identify how hazards might arise while exposure assessment is predominantly related to understanding how people might encounter hazards.

Benefits may be achievable at low cost. For example, should contamination be discovered in a public place, fencing off the area may be sufficient to break the source-pathway-receptor chain and achieve many of the health benefits. There is still the risk of a broken fence and so potential exposure despite being greatly reduced may still not be zero.

The value placed on better health by individuals and society has been subject of much research which can be used to assess the value of different scenarios of exposure to contaminated land. Methods include cost of illness, human capital, required compensation, and preference based approaches[37]. Examples of important values from the research are the value of a statistical life and value of a statistical life year. The table below summarises estimates of values placed on health from the research.

Table 5.17 Health Related Impacts

Study	Subject of assessment	Results
EC Impact Assessment Guideline (2009)	Value of Statistical Life (VOSL)	1 – 2 million Euros
EC Impact Assessment Guideline (2009)	Value of a Life Year (VOLY)	50,000 – 100,000 Euros
The Department of Health	Costs of hospital admissions (NHS)	£1,400 to £2,500 for a respiratory hospital admission £1,500 to £1,700 for a cardiovascular admission
Stated preference studies	QALY (value of a year in a perfect health)	50.000 – 80.000 Euros
DG-Environment (2001)	Value of preventable fatality (VPF)	1.4 million Euros (2007)
Gayer et al (2002)	Value of a preventable fatality (VPF) for cancer	Between $4.3 million to $8.3 million
Guerriero and Cairns (2009)	Value of preventable fatality (VPF)	2.1 million Euros

[37] Cost of illness, human capital and required compensation approaches build on the information on labour markets and medical expenditure, while preference based methods analyse individuals' stated or revealed preferences with respect to being exposed to a particular situation that involves a health risk.

Study	Subject of assessment	Results
Alberini et al (2007)	Value of statistical life (VOSL)	5.6 million Euros (for an immediate risk reduction) 1.26 million Euros (if the risk reduction took place 20 years in the future)
Alberini et al (2010)	Value of a preventable fatality (VPF) for cancer	4.164 million Euros (2008)
Chilton et al (2002)	Value of preventable fatality (VPF)	£1.312 million (2003)
The Department of Health	WTP for a small reduction in risk per death brought forward (due to air pollution) - delay in the probability of death from air pollution	1 year: an upper-bound of £1.4 million and a lower-bound of £32,000 to £110,000 1 month: £2,600 to £9,200

As well as estimates based on theoretical models defining possible exposures using specifications of source-pathway-receptors, estimates could in principle also be based on changes observed in health indicators in the resident population, such as number of illnesses and hospital admissions. In fact, separating out the impact of contaminated land from other health effects is difficult and may not be possible.

On the Ince Estate the detailed investigation of contaminants contained the following conclusions[38]:

> The contamination is classed as being of "moderate to low risk to human health."
>
> The risk to human health from eating vegetables and herbs grown on the estate is moderate to low.
>
> Analysis of dust samples that were taken indoors and outdoors on the estate do not reveal any risk to human health.
>
> The quality of the water under the ground is generally good and there has been no contamination of the drinking water.
>
> There is no problem with landfill gas in the area to the rear of The Grove where the former branch canal was filled in.
>
> Sulphates are one of the substances that have been found in the soil samples taken from across the estate. Sulphates are not considered to present any risk to human health but are linked with chemical attack on concrete that can result in damage to the foundations of the properties."

An independent assessment of health benefits which used the source- pathway-receptor model would need to consider the contaminants one by one and develop exposure scenarios. These would then be expressed in terms of health impacts (e.g. additional mortality) and then these health effects would be monetised using values from Table 5.17. The result would be an estimate of the loss in health from living at the site, though this might also need to include the mitigating effects of strategies such as 'averting behaviour' where residents might, for example,

[38] Ince Central Estate Newsletter Number 6, Thursday 18th March 2004

deliberately avoid growing their own vegetables, and families with small children choosing not to take up residence.

The valuation of the site and neighbouring properties includes people's overall estimates of health effects and is simpler to calculate although it would not provide a separate estimate of health benefits alone.

5.2.12 (I) Agglomeration

There is no development or employment creation associated with this remediated site and agglomeration benefits are estimated at zero.

5.3 Case Study Three: Phoenix Park, Thurnscoe

5.3.1 Overview and Rationale

Phoenix Park is the result of the decontamination and restoration of the 67 hectare former Hickleton Colliery site near Thurnscoe, South Yorkshire. Since 2004 the site has been owned and managed by the Land Trust, a Charity that delivers high quality stewardship, manages ongoing environmental risks and provides open access to local communities.

This site has been chosen as a case study for the following reasons. Whilst there is no development on site, it is possible that Phoenix Park has generated significant social and economic benefits within surrounding areas. Its position between population centres results in impacts on the neighbouring area and its new use as parkland illustrates increased amenity value from the remediation. The nature of the improvement is seen in Figures 5.3 and 5.4. The development of parkland may require expenditure additional to that required for decontamination and these costs should be accounted for in an overall cost-benefit assessment which includes the value of the benefits.

5.3.2 Background

The Phoenix Park site occupies 67 hectares of restored land located between the villages of Thurnscoe, Goldthorpe and Hickleton in South Yorkshire. The site is positioned equidistant between Doncaster and Barnsley, just north of the A395, which links the A1(M) and M1.

The site has played a key role in the social and economic fabric of the local area. From the late nineteenth century until it closed in 1988, it was home to Hickleton Colliery, the single largest employer in the community. The site was heavily contaminated and the resulting detrimental impacts were typical of previous use for heavy industry.

Following the closure, the site remained a blot on the landscape as well as a reminder of the collapse of local industry for over a decade. In 1997 it became part of the National Coalfield Programme (NCP), and following consultation with the local community, a decision was made to invest in transforming the site including addressing contamination of the soil.

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A programme of decontamination and land remediation was carried out between late 1999 and early 2001. The main remediation works at Hickleton Colliery were delivered by Yorkshire Forward using £4.2m of NCP funding. Associated works were delivered in the same time period on a site neighbouring the Colliery by a partnership between Yorkshire Forward and Groundwork Dearne Valley at an additional cost in excess of £1.2m[39]. In 2004 the site ownership was transferred from English Partnerships to the Land Restoration Trust (now The Land Trust), along with an endowment. The Land Trust will own and manage the site in perpetuity.

Today the site is primarily used as public open space including footpaths, community woodland and natural wildlife habitats (see Figure 5.8). The park also has a large number of innovative amenity structures, including 'green gyms', mother and baby fitness walks and a sculpture park.

The Land Trust has invested in a number of other activities to enhance the value of the site, including health activities and guided walks; educational activities themed around the environment and wildlife; and social cohesion activities involving children with learning difficulties.

Figure 5.7 Hickleton Colliery (c1988)

Figure 5.8 Phoenix Park (c2010)

In addition to the direct impacts on site, a small number of commercial developments have been created on its periphery - specifically adjacent to Barrowfield Road to the South West of the site.

5.3.3 Relevant Benefits

This section identifies which decontamination and remediation benefits are relevant at Phoenix Park and why. Only the benefits considered possible are examined in further detail in subsequent sections. Table 5.18 shows the benefit categories we have considered and the rationale supporting this.

[39] Funding sources were £915,000 from ERDF and £316,000 from English Partnerships Voluntary Sector Land Reclamation Programme.

Table 5.18 Relevant Benefit Categories - Thurnscoe

Benefit Category	Relevant	Rationale
(A) Site value	No	The site generates no income. It sits as a liability on the balance sheet of its owner. It might achieve value at sale (i.e. has potential option value).
(B) Neighbouring sites values	Yes	The removal of a physical eyesore, treatment of any potential hazard, and creation of attractive shared space, has the potential to boost the value of neighbouring sites - in this case particularly residential properties.
(C) Property transactions	Yes	A more vibrant property market is to be expected given a more attractive environment. It could be more competitive in the sub-regional economy.
(D) Productivity	Yes	A potential productivity benefit is that (as with forested areas elsewhere) the trees could provide a source of timber.
(E) Environmental	Yes	The site was heavily contaminated leading to a potential for improvement.
(F) Amenities	Yes	The end use for the majority of the site is public open space, and a long term management organisation has been installed with the remit to engage the community.
(G) Greenfield savings	No	No development has taken place on site.
(H) Health (soil/water)	Yes	The creation of accessible public open space and delivery of community projects together with the removal of contamination suggests that there could be significant health related benefits for the local population.
(I) Agglomeration	No	The lack of direct development of site suggests that there are no possible agglomeration benefits.

5.3.4 (A) Site Value

The site currently generates no income and, from this perspective, it has no economic value. It nevertheless retains an option value which is the price it would achieve if sold in the market. Its main value currently lies in its social and community uses.

5.3.5 (B) Neighbourhood Values

Approach

The approach follows the template of the Mirvale case study which can be used as a reference. A summary of the steps and the aspects specific to Thurnscoe are described here.

Both methodology B.1 relating to all transactions and methodology B.2, relating to paired transactions, are used.

In this case timing issues may be relevant. Remediation work started Thurnscoe in 1999, the date from which house price sales were collected. There may have been some increase in price immediately prior to remediation in the expectation of the effect of the remedial work. If this is the case then the full value of the remediation work will not be captured in the analysis. House sales during the remediation work are explicitly excluded from the analysis.

It is also important to note that estimates are made with respect to the final land use (a park) rather than for decontamination of the land per se. The increased value is the result of the site being transformed into a park, with open access for recreation and pleasant views from neighbouring houses over the site, as well as the effect of the removal of the contaminated land hazard. If the land at Thurnscoe had been developed into an industrial estate, then the neighbouring house price increase may differ from that estimated with respect to the final land use adopted (a park) and, similarly, the site itself would have a different value.

Data and Assumptions

As regards data availability, in this case study there are many more data points available post-remediation (2,996 transactions) than pre-remediation (107 transactions) within 2 km of the contaminated site. This choice of the perimeter is driven primarily by the need to capture a sufficient number of data points to enable robust analysis, whilst at the same time making a professional judgement as to the locus of the community impacted by or able to access the site on a regular basis.

The selection of the wider comparator area reflected a need to include the effects of the 2008-2009 recession in Thurnscoe as in the wider South Yorkshire property market.

Residential Impact Assessment Method B.1 (All Transactions)

This approach to quantifying the impact of contaminated land remediation on residential property values in neighbouring areas uses the following steps:

1. Data Assembly: Data for all past property transactions were gathered within 2 kilometres of the outer boundary of the site. This totalled 3,443 transactions over the period from January 1999 to December 2010; 107 transactions occurred during the pre-remediation period up to November 1999, and 2,996 transactions occurred during the post-remediation period from July 2001. The remaining 340 transactions that took place during the remediation phase were not included in the analysis.

2. Data Matching: Each transaction is matched with the average sale price for properties of the same type in the wider housing market area. In this case study we have used South Yorkshire as the wider comparator area, since the study area lies very close to the boundaries of Doncaster, Rotherham and Barnsley.

3. Price Indexing: Each observed sale price is expressed as a proportion of the average sale price for that type of property in the wider comparator area in that month. For example, a terraced house sold in Goldthorpe on 4 January 1999 for £24,000 is expressed as a proportion of the South Yorkshire average for terraced houses sold in January 1999 (£29,617), giving an indexed value of 0.8103. This value represents the relationship between the value of the specific property and the expected value of similar properties in a comparator area. The difference between expected and observed values is caused by features of the specific property such as number of bedrooms and physical condition, and features of the very local housing market such as accessibility and proximity to amenities, where these differ from the same features of the average house in the wider comparator area.

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4. Testing for Normality: In order to undertake a z-test to compare the distributions, logarithms were used. Comparisons of kurtosis and skewness statistics of the pre-remediation and post-remediation data are shown in Table 5.19.

Table 5.19 Skewness and Kurtosis of Non-logarithm and Logarithm Transaction Distributions - Thurnscoe

	Distribution of Indexed Prices		Distribution of Logarithms of Indexed Prices	
	Skewness	Kurtosis	Skewness	Kurtosis
Pre-remediation	1.11565	3.92183	-0.40565	-0.12157
Post-remediation	2.23139	9.70317	0.03222	0.95640

Results

Pre-remediation, the mean observed house price in the study area was 84.5% of the expected value of a comparable house in South Yorkshire. Post-remediation, this figure was 88.1%.

The mean score for pre-remediation values (M=-0.16902, SD=0.18833, N=107) was significantly smaller than the scores for post-remediation values (M=-0.12706, SD=0.17766, N=2996.) using the two-sample one-tail z-test, z=-2.26891, p=0.012 at a 5% significance level. The resulting difference between means was 0.04196, and a 95% confidence interval about the difference between means was (0.00762, 0.07630).

Taking the anti-logarithm of this change, the analysis indicates an increase in the ratio between study area and South Yorkshire price levels of 10.14% from the pre-remediation ratio, with a 95% C.I. of (1.77%, 19.21%). This increase represents 7.57% of the South Yorkshire price level at a given point during the post-remediation period, and the confidence interval translates to (1.32%, 14.34%) as proportions of South Yorkshire price levels.

Method B.1 suggests that the increase in relative house prices is statistically significant and together with (1) an estimate of the local housing mix and (2) an estimate of the number of houses affected can be used to estimate (3) aggregate benefits from remediation.

Use of Results

(1) Estimate of the Local Housing Mix

Using the same procedure as in the template, within 2 km of the boundary of Phoenix Park, the Codepoint file counts 6,519 residential delivery points (equivalent to letterboxes). In the Middle Super Output Areas which matches the study area more closely (E02001522/Barnsley 014 and E02001530/Barnsley 022), the Census reports a breakdown of dwelling types as shown in the table below. Combining data from these sources results in the housing mix profile also contained in Table 5.20 below.

Table 5.20 Study Area Housing Mix - Thurnscoe

	Proportion of Housing Stock	Number of Houses in Study Area
Detached	11.28%	735
Semi-detached	46.44%	3027
Terraced	36.73%	2394
Flat/Maisonette	5.56%	362
Total	***100%***	***6,519***

(2) Estimate of Number of Houses and (3) Aggregate Benefits

Taking January 2011 as the latest available data and still bounded by the choice of perimeter as above, it is possible to construct an estimate of the total impact of remediation priced into local house values.

Table 5.21 Aggregate benefits of remediation

	Houses in Study Area	S.Yorkshire Average Price (01/2011)	Remediation Uplift per House (7.57% of S.Yorkshire average)	Total Remediation Uplift
Detached	735	£186,407	£14,112.67	£10,372,812
Semi-detached	3027	£98,205	£7,434.99	£22,505,715
Terraced	2394	£67,953	£5,144.65	£12,316,292
Flat/Maisonette	362	£97,809	£7,405.01	£2,680,614
Total	***6518***			***£47,875,433***

On this basis, a central estimate of the total contribution of the remediation process to the value of homes in the study area is £47.9m in January 2011. Furthermore it is 95% likely that the value is between £11.2m and £121.5m.

On this basis, the total contribution of the remediation process to the value of homes in the study area is £47.9m in January 2011 and the 95% confidence interval of our estimated mean increase produces a range from £11.2m to £121.5m.

Residential Impact Assessment Method B2 (Paired Transactions)

Method

The methodology involves the steps (taken from the Mirvale template):

1. Data Assembly: Data for all past property transactions in postcodes within a given distance of the outer site boundary are compiled, as above. In this case, there are 74 properties within 2 km of the site that where ownership changed during both periods and the pairs of transactions are acceptable.

2. Data Matching: For each pair of transactions a pair of reference values is taken from the Land Registry data for the wider comparator area. Again, in this instance we take South Yorkshire as the wider comparator area, and select average house prices relevant to the type of house and the date of the transactions in each pair.

3. Price Indexing: The observed sale prices of both transactions in each pair are expressed as proportions of the average sale price for that type of property in the wider comparator area in the transaction months. For example, a semi-detached house sold in Thurnscoe on 16 June 1999 for £12,000 is expressed as a proportion of the South Yorkshire average for semi-detached houses sold in June 1999 (£43,094), giving an indexed value of 0.2785. The same house sold again on 17 December 2001 for £16,000, which is expressed as 0.3194 when compared to the relevant South Yorkshire average of £50,099. These indexed values represent the relationship between the value of the specific property and the expected value of similar properties in a comparator area. In contrast to the previous approach, this methodology explicitly controls for any changes in the type of property being studied - the houses in each pair of transactions are considered to be exactly the same. Once again, in order to approximate a normal distribution and allow certain statistical tests to be performed, we take the logarithm of the indexed prices. The skewness and kurtosis of a normal distribution are both approximately zero. Taking the logarithms instead of the indexed prices reduces the skewness and kurtosis of the two distributions significantly, as shown in Table 5.22.

Table 5.22 Skewness Statistics for Non-logarithm and Logarithm Distributions - Thurnscoe

	Distribution of Indexed Prices		Distribution of Logarithms of Indexed Prices	
	Skewness	Kurtosis	Skewness	Kurtosis
Pre-remediation	1.624530	4.006347	0.097815	-0.517464
Post-remediation	2.804293	10.862845	0.765201	1.880103

Table 5.23 below shows a sample pair of transactions, illustrating the complete information required for each pair for each property.

Table 5.23 Comparison of Pre and Post remediation Sale prices - Thurnscoe

Pre-remediation Sale							
Address	**Type**	**Tenure**	**Date**	**Price**	**S. Yorks. Mean**	**Indexed Price**	**Log (Indexed Price)**
Address 1	Semi-detached	Freehold	16/06/1999	£12,000	£43,094	0.278461039	-0.55523556
Post-remediation Sale							
Address	**Type**	**Tenure**	**Date**	**Price**	**S. Yorks. Mean**	**Indexed Price**	**Log(Indexed Price)**
Address 1	Semi-detached	Freehold	17/12/2001	£16,000	£50,099	0.319367652	-0.49570908

Results

The mean of the pre-remediation logarithm distribution was -0.21045, and the mean of the post remediation logarithms was -0.15541. We use a one-tail paired sample t-test (alpha = 0.05) to test whether the increase in means is statistically significant. The null hypothesis is that there is no difference between the means of the two logarithm distributions.

The increase in the mean logarithm of relative prices (M=0.0550, SD=0.1388, N=74) was significantly greater than zero, t(73)= 3.411, one-tail p = 0.0005, providing evidence that the remediation has resulted in an increase in relative house prices. A 95% C.I. about the increase in mean logarithms of relative house price levels is (0.02288, 0.08719). Taking the anti-logarithm of this change, the analysis indicates an increase in the ratio between study area and South Yorkshire price levels of 13.51% from pre-remediation values, with a 95% C.I. of (5.41%, 22.23%).

This central estimated mean increase represents 8.32% of the South Yorkshire price level at a given point during the post-remediation period, and the confidence interval translates to (3.33%, 13.70%) as proportions of South Yorkshire price levels.

Method B.2 suggests that the increase in relative house prices is statistically significant (as with Mirvale) and together with (1) an estimate of the local housing mix and (2) an estimate of the number of houses affected can be used to estimate aggregate benefits from remediation.

Use of Results

(1) Estimate of the Local Housing Mix

Using the same procedure as in the template, within 2 km of the boundary of Phoenix Park, the Codepoint file counts 6,519 residential delivery points (equivalent to letterboxes). In the Middle Super Output Areas matching the study area as closely as possible (E02001522/Barnsley 014 and E02001530/Barnsley 022), the Census reports a breakdown of dwelling types and housing mix profile shown in Table 5.24 below.

Table 5.24 Study Area Housing Mix - Thurnscoe

	Proportion of Housing Stock	Number of Houses in Study Area
Detached	11.28%	735
Semi-detached	46.44%	3027
Terraced	36.73%	2394
Flat/Maisonette	5.56%	362
Total	***100%***	***6,519***

(2) Estimate of Number of Houses and (3) Aggregate Benefits

Taking January 2011 as the latest available data and an area bounded by the choice of perimeter as above, it is possible to construct an estimate of the total impact of remediation priced into local house values.

Table 5.25 Aggregate benefits of remediation - Thurnscoe

	Houses in Study Area	S.Yorkshire Average Price (01/2011)	Remediation Uplift per House (8.32% of S.Yorkshire average)	Total Remediation Uplift
Detached	735	£186,407	£15,513.44	£11,406,104.79
Semi-detached	3027	£98,205	£8,172.96	£24,742,369.69
Terraced	2394	£67,953	£5,655.28	£13,539,847.02
Flat/Maisonette	362	£97,809	£8,140.00	£2,948,482.18
Total	***6518***			***£52,636,804***

On this basis, the total contribution of the remediation process to the value of homes in the study area is £52.6m in January 2011 and the 95% confidence interval of our estimated mean increase produces a range from £21.1m to £86.6m.

It is notable that the estimate of £52.6m using this method (B.2) is close to the £47.9m using the previous method (B.1).

5.3.6 (C) Property Transactions

The approach follows the template of the Mirvale case study which can be used as a reference. A summary of the steps and the aspects specific to Ince are the focus here.

Method

The methodology for quantifying the impact of contaminated land remediation on the level of residential property transactions in the neighbouring area involves the following steps:

As well as affecting sale values of properties, remediation may have an effect on the number of transactions taking place. The number of transactions is commonly taken as an indicator of liquidity, or how easy it is to find a buyer or seller and make a transaction. The methodology for quantifying the impact of contaminated land remediation on the level of residential property transactions in the neighbouring area involves the following steps:

1. Data Assembly: Data for all past property transactions in postcodes within a given distance of the outer site boundary are compiled. Transactions are aggregated for the month in which they occurred. For example, in this case, there were 20 residential property transactions in March 2000 within 2 km of the site.

2. Data Matching: Monthly transaction totals for the study area are matched to the total monthly transactions occurring within the wider comparator area (in this case South Yorkshire) using data from the Land Registry. For example, there were 1,912 residential property transactions in March 2000 in South Yorkshire. The total transactions in the study area are then expressed as a proportion of all sales in the wider comparator area. For example, transactions within 2 km of the former Hickleton Colliery comprised 1.046% of all transactions in South Yorkshire in March 2000.

3. Testing for Normality: The skewness statistics are -0.03339 and -0.04496 for pre- and post-remediation series respectively which are close enough to zero not to require the taking of logarithms to perform the statistical tests.

Results

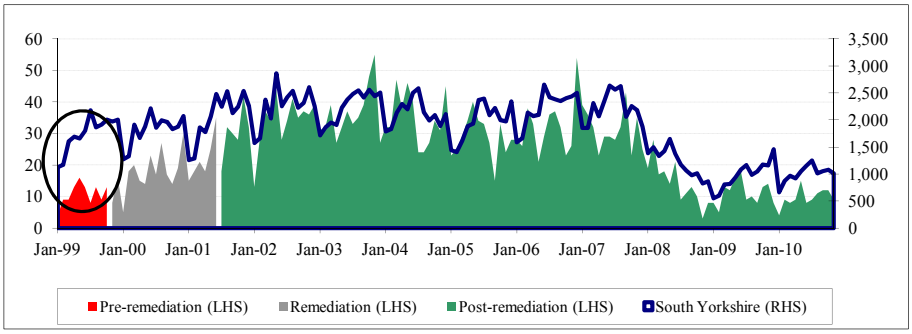
The pre-remediation average transaction level in the study area was 0.63% of total South Yorkshire transactions, while the post-remediation average was 1.38%. A two sample unpaired one-tail t-test is applied to the two distributions. The null hypothesis is that the change in transaction levels is not statistically significant.

The t-test indicates that the mean of pre-remediation transaction levels (M=0.00632, SD=0.00194, N=10) was significantly smaller than mean of post-remediation transaction levels (M0.01378, SD=0.00401, N=113) using the two-sample unpaired one-tail t-test, $t(17)=-10.34521$, $p<0.000001$ at a 5% significance level. The resulting difference between means was 0.00745, and a 95% confidence interval about the difference between means was (0.00491, 0.01000).

In summary, the rise in house prices relative to the wider housing market area is statistically significant at this level of significance (5%).

The effect of the remediation can be seen in the chart below which displays trends in transactions for the area around Thurnscoe and for South Yorkshire, with the suppressed pre-remediation housing market highlighted.

Figure 5.9 Number of Transactions by month - Phoenix Park



5.3.7 (D) Productivity

The remediation has introduced a range of woodland species to the forested parts of Phoenix park. Some of these may have a commercial value and contribute to the productivity of the site without changing its current end use. The value of the trees, if managed as a commercial timber stock could alternatively be considered a component of the site value. The value can be set based on the prices for similar woodland of a similar size by consulting with experts from the timber industry.

Aside from this, there is no commercial development on site and most of the businesses located nearby were already in place pre-remediation.

5.3.8 (E) Environmental

Environmental benefits will depend on the diversity within the Thurnscoe site compared to the surrounding area.

The methodology for assessing these benefits follows the same approach as in the other case studies. Survey data is required to confirm whether there are significant aspects to the ecosystems at the site. Once the survey is completed, then other studies can be researched for equivalent values to support a methodology of benefit transfer.

In general terms, Phoenix Park is likely to differ from surrounding areas which are mainly farmed and this may attract species which otherwise would not be seen in the area. Should it develop a very unique habitat with very rare species on which the public place a high value, then the environmental benefits might come to dominate an assessment. Such high levels may occur as a result of the declared and actual end use (a park), but are only a potential benefit. The assessment should compare the existing habitat with similar habitats in order to assess the current value of benefits.

The change in the site over time as species become established may affect other types of benefit. For example rare species may attract visitors from outside the area together with the benefit of their expenditure in the local economy.

5.3.9 (F) Amenities

Amenity benefits are included within the site and neighbouring value assessment. However, there may be additional benefits if people from outside the area travel explicitly to enjoy the park. To include these benefits assessment methods would need to be extended. In using these additional methods, residents from the local area where benefits are already capitalised into house prices need to be excluded to avoid double counting.

Amenity benefits can be assessed using a benefit transfer approach drawing on a wide range of existing studies that assess landscape/ visual, disamenity and recreational activities. In particular, studies are available that assess recreational values of forest visits, bird and wildlife watching, bathing, angling, water-related sports, camping, hiking, hunting using a range of different methods which can be seen in practice in examples from the EVRI database (see Appendix B).

Surveys of visitors from outside the area are almost essential in order to go beyond the implicit amenity value captured in local house prices. TCM is a clear candidate methodology, as it would indicate both the value and numbers of visitors. As the park is already established, CE and CV methods with their emphasis on hypothetical situations do not need to be used, though, if visitor numbers are low, might help analyse indicate the reasons.

5.3.10 (G) Greenfield Saving

The redevelopment of Phoenix Park is not intended to provide a location for business and industrial development that would have occurred elsewhere and hence does not contribute to Greenfield savings.

5.3.11 (H) Health

Health benefits are included within the site and neighbouring value assessment and are not separately assessed here. Examples of methodologies for independent health assessments are included in the other case studies.

5.3.12 (I) Agglomeration

A park may separate businesses which could otherwise be closer but may also attract businesses which then obtain agglomeration benefits. On balance there is expected to be no benefit from agglomeration.

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Appendix A
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Appendix B
Data Sources

Assessing the benefits of remediation of contaminated land would require a wide range of information. Table B1 summarises information on a wide range of sources of information.

The inventory contains information on the holder and accessibility of the information as well as on the frequency of updating, coverage and scale of the data presented.

The inventory includes a brief description of each source of information and provides comments on its relevance and usefulness to assessing the benefits of remediation of contaminated land. For each data/information source the most relevant categories of benefits are set out.

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Table B.1 Inventory of the Data Available for Valuing the Benefits of Remediation of Contaminated Land

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
Background	Taking Part Survey	DCMS	Open	Public	http://www.culture.gov.uk/what_we_do/research_and_statistics/4828.aspx	Annual	2009/10	The Taking Part Survey collects data on many aspects of leisure, culture and sport in England, as well as an in-depth range of socio-demographic information on respondents. Arts Council England, English Heritage, the Museums, Libraries and Archives Council and Sport England commissioned the Taking Part survey to improve the consistency and quality of data on engagement with culture and sport. In the context of removing contamination, it could provide valuable data on the change in participation in activities, satisfaction with facilities, social capital, volunteering and barriers to participation. The survey provides annual data for children, and both annual and quarterly data for adults.	England	GOR level	Health risks Amenity benefits

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
Background	Environmental Protection Expenditure by Industry	DEFRA	Open	Public	http://www.defra.gov.uk/evidence/statistics/environment/envsurvey/index.htm	Annual	2008	This aims to establish how much industry spends annually on protecting the environment - e.g. investing in equipment to clean up waste water produced during processing, or investing in "clean" technology which makes production cleaner by reducing pollutant emissions. This also includes operating costs (e.g. the cost of running environmental protection facilities, paying contractors to get rid of waste, payments to water service companies for sewage treatment). It also helps to demonstrate any associated benefits from environmental protection spending, for example cost savings from using alternative materials, and what the costs are of Environmental Management Systems. It is an annual survey owned and undertaken by DEFRA. In the context of this study this source would be valuable to: estimate the level of resources committed by industry on decontamination and restoration; understand how industry pollution has changed over time, and identify key polluting industries.	7 key polluting industries	Industry level	Ecosystem impacts Greenfield dev savings

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
Background	DoE Industry Profiles	EA	Open	Public	http://www.environment-agency.gov.uk/research/planning/33708.aspx	1995 only	1995	These provide information on the processes, materials and waste associated with individual industries with regard to land contamination. They provide developers, local authorities and other organisations interested in land contamination, with information on the processes, materials and wastes associated with individuals industries. They are not definitive studies but they introduce some of the technical considerations that need to be borne in mind at the start of an investigation for possible contamination. For this study these provide interesting contextual references and support the development of impact measurement methods. They support the risk management process when assessing the benefits of investing in decontamination. Finally, they will provide an indication of the pollutants and kinds of contamination associated with particular industries and previous site uses.	47 industries	Industry level	Ecosystem impacts Greenfield dev savings Agglomeration benefits

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
Background	Annual Population Survey	ONS	Open	Public	https://www.nomisweb.co.uk/articles/511.aspx?Session_GUID={4E343F89-977C-417D-B6EA-1D42F1930BB0}	Quarterly	Mar-10	The Annual Population Survey is a major source of social and socioeconomic statistics at a local level. The survey asks 65,000 households a year about their own circumstances and experiences regarding a range of subjects including housing, employment and education. Together with other data sources, the survey provides an annual update on much of the information collected as part of the decadal Census. The Health and Safety Executive sponsors a boost module covering workplace health, and provides a separate analysis. In the context of this study, the APS provides a range of data on skills, employment, the link between health and economic activity and economic participation. It could be an important source when investigating the impact of decontamination on the local population, including how better health, for example, can lead to economic outcomes.	England and Wales	Local Authority level	Health risks Productivity benefits
Background	2001 Census	ONS	Open	Public	http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=9343	Decadal	2001	The last census for England and Wales was on 29 April 2001. The next will take place on 27 March 2011 and will involve around 25 million households. Data covers all aspect of life from demography, religion and employment through to skills and health. Once the 2011 data is available, the ten year comparison offers the opportunity to investigate whether decontamination and land restoration could have a material difference on the lives of people that	England and Wales	CAS ward level	Health risks Productivity benefits

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
								live in nearby communities. The 2001 data remains the highest resolution of information available concerning the socioeconomic context for site decontamination at very small area level.			
Background	Small Area Population Estimates	ONS	Open	Public	http://www.statistics.gov.uk/about/methodology_by_theme/sape/default.asp	Annual	2008	An ONS led scheme to investigate the production of postcensal population estimates for geographical areas smaller than local authorities in England and Wales. This was set up in response to the increasing demand for small area statistics identified by initiatives such as New Deal for Communities, Best Value, and the National Strategy for Neighbourhood Renewal (encompassing Neighbourhood Statistics). This data set contains primarily population data and could be used as context in any impact assessment.	England and Wales	LSOA	Health risks Productivity benefits
Background	Annual Survey of Hours and Earnings	ONS	Open	Public	http://www.statistics.gov.uk/statbase/product.asp?vlnk=13101	Annual	2010	The Annual Survey of Hours and Earnings (ASHE) provides information about the levels, distribution and make-up of earnings and hours paid for employees within industries, occupations and regions. It was developed to replace the New Earnings Survey (NES) in 2004. When assessing the direct and indirect economic and social benefits of investment in land decontamination, this provides useful context and also a source for change analysis.	UK	GOR for detailed analysis; Local Authority high level only	Health risks Productivity benefits Agglomeration benefits

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
Background	Business Demography	ONS / BIS	Open	Public	http://www.statistics.gov.uk/statbase/product.asp?vlnk=15186	Annual	2009	ONS's main resource for measuring the births, growth rates and deaths of enterprises. This could provide some business context, help support the economic argument and measure pre and post decontamination enterprise levels.	UK	Local Authority level	Health risks Productivity benefits Agglomeration benefits
Background	Business Register and Employment Survey / ABI	ONS / BIS	Proprietary	Public	http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=15390	Annual	2009	The Business Register and Employment Survey (BRES) has replaced and integrated two existing the Annual Business Inquiry (ABI) and Business Register Survey (BRS) and is a sample survey of approximately 80,000 businesses. It collects information from businesses representing the majority of the Great Britain economy. This could provide important information on the change in local business outlook and views.	UK at high level; GB in detail	ABI ward / LSOA	Health risks Productivity benefits Agglomeration benefits
Background	Active People Survey	Sport England	Open	Public	http://www.sportengland.org/research/active_people_survey.aspx	Annual	2008/09	The survey provides the largest sample size ever established for a sport and recreation survey and allows levels of detailed analysis previously unavailable. It identifies how participation varies from place to place and between different groups in the population. The survey measures; the proportion of the adult population that volunteer in sport on a weekly basis, club membership, involvement in organised sport/competition, receipt of tuition or coaching, and overall satisfaction with levels of sporting provision in the local community. This provides an interesting source of data in understanding the social, community and (possibly) health benefits of creating accessible open spaces in communities.	England	Local Authority level	Health risks Amenity benefits

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
Benefits Transfer	ValueBase Swe	Beijer International Institute of Ecological Economics / Swedish Environmental Protection Agency	Open	Public	http://www.beijer.kva.se/valuebase.htm	2003 only	2003	The Valuation Study Database for Environmental Change in Sweden (ValueBaseSWE) was developed at the Beijer Institute of Ecological Economics within a project funded by the Swedish Environmental Protection Agency. The database is the result of a survey of empirical economic valuation studies on environmental change in Sweden. This document provides the starting point to a whole series of studies into the value of environmental change, including a number relating to land restoration and decontamination.	170 case studies from Sweden	Case study level	All benefit categories
Benefits Transfer	Benefits Table database (BeTa)	European Commission	Open	Public	http://ec.europa.eu/environment/enveco/air/pdf/betaec02a.pdf	1998 only	1998	BeTa (the Benefits Table database) has been developed by netcen, part of AEA Technology, to provide a simple ready reckoner for estimation of the external costs of air pollution. Health effects are divided into two types of category. The first deals with the duration of exposure leading to an effect. Effects caused by short-term exposure (in the order of days or hours) are described as 'acute effects'. Those caused by long-term exposure (in the order of months or years) are identified as 'chronic effects'. The second category deals with the general type of effect, described as 'mortality' or 'morbidity'. Impacts on mortality relate to people dying earlier than they would in the absence of air pollution. Morbidity relates instead to illness, ranging from minor effects such as coughing to life threatening conditions that require hospitalisation.	Europe-wide effects of airborne pollutants on health, building fabric and agricultural yield	Impact level	All benefit categories

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Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
								This source clearly provides a strong source of evidence in relation to costs, and therefore, potential benefits through reduction, of air pollution.			
Benefits Transfer	Greek Environmental Valuation Database (GEVaD)	National Technical University of Athens	Open	Public	http://www.gevad.minetech.metal.ntua.gr/home.php	User-updated	Current	This database provides necessary data to value environmental impacts of industrial activities in Greece and other European countries by means of the Benefit Transfer method in compliance with the institutional and research context of the international scientific community. So far, more than 300 studies have been registered in GEVAD. These studies are classified according to the environmental asset, good or service, which is valued (e.g. amenities, water and air quality, land contamination, etc.), the valuation method used, the main author and the country of the study site. The database is searchable through a user-friendly environment and includes also a tool for adjusting the transferred values in order to offset influences concerning differences of price level and time between the study and the policy site.	317 case studies from49 countries	Case study level	All benefit categories
Benefits Transfer	NZ non-market data bases	Lincoln University, Christchurch NZ	Open	Public	http://www2.lincoln.ac.nz/nonmarketvaluation/	Periodically updated	Ongoing	This database enables easy identification of non-market valuation studies that have been undertaken in New Zealand. It also includes contact details for New Zealand non-market valuation practitioners and analysts. This provides some interesting perspectives on non-market valuation, with some detailed case studies, and could act as a template for a UK-centric database.	New Zealand	Case study level	All benefit categories

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
Benefits Transfer	EVRI (Environmental Valuation Reference Inventory)	Environment Canada	Open	Public	https://www.evri.ca/Global/Splash.aspx	Periodically updated	Ongoing	This is a subscriber based searchable storehouse of empirical studies on the economic value of environmental benefits and human health effects. It has been developed as a tool to help policy analysts use the benefits transfer approach. Using the EVRI to do a benefits transfer is an alternative to doing new valuation research. In the context of this study EVRI can provide evidence around the benefits transfer approach and provides a source for benefits transfer literature. A Benefits Transfer Bibliography is updated regularly to help users locate these studies.	International	Case study level	Health risks Ecosystem impacts Productivity benefits
Benefits Transfer	ENVALUE	New South Wales Department of Environment and Climate Change	Open	Public	http://www.environment.nsw.gov.au/envalueapp/	1995 - 2004	Jun-05	ENVALUE is a searchable archive of previous environmental valuation projects and case studies from around the world. It contains methodologies and values (in AU$2002) suitable for Benefit Transfer procedures to support the integration of environmental valuation in government decision-making. In the context of this study ENVALUE will be a key source of case studies and comparative methodologies.	International	1700 Case studies	All benefit categories

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
Other	Greenbelt Statistics	DCLG	Aggregated	Public	http://www.communities.gov.uk/publications/corporate/statistics/lagreenbelt2009	Annual	Mar-10	Estimates of Green Belt land in individual local authorities in England are collected annually on AGB1 (Annual Green Belt) return via Interform, a housing and planning electronic data collection system. Quarterly data releases present National Statistics on the estimates of the area of designated Green Belt land in England by region and by local authority. If the release of brownfield sites to protect greenbelt land is a potential benefit, this could provide a data resource.	England and Wales	Local Planning Authority level	Greenfield dev savings
Other	Indicators for Land Contamination	EA	Open	Public	http://publications.environment-agency.gov.uk/pdf/SCHO0805BJMD-e-e.pdf	2004 only	2004	The result of a project to establish indicators for England and Wales for measuring progress with identifying land contamination (including land affected by radioactivity) and securing its remediation where necessary to protect human health and the environment. The final results estimate the scale of contaminated land across England and Wales, and detail the methodology and sources whereby these figures were obtained. In the context of this study, these results will be important in understanding the scale of contaminated land across the country, and the benefits from decontamination that may result. In addition, the methodological discussions in the report are of substantive interest.	England and Wales	GOR level	Health risks

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
Pathway/ Migration	Borehole data	British Geological Society	Mixed	Private	http://www.bgs.ac.uk/data/bmd.html	Continually updated	Current	The BGS British onshore borehole collections contain data from approximately 15,000 boreholes - categorised into ten different types. This would be valuable data in establishing a profile for a site and understanding potential benefits.	UK	Site level	Health risks Ecosystem impacts
Pathway/ Migration	The natural (baseline) quality of groundwater in England and Wales	British Geological Society /EA	Open	Public	http://www.bgs.ac.uk/research/groundwater/UKbaseline/baseline_study_results.html	Continually updated	Current	British Geological Survey (BGS) and the Environment Agency (EA) undertook a collaborative project called The Natural (Baseline) Quality of Groundwaters in England and Wales. This investigated the baseline quality of groundwater in aquifers or aquifer blocks in 23 study areas producing a report on each area as well as a report that synthesised all the results. This, and a number of regional analytical reports, provide a sound baseline around groundwater quality.	England and Wales	Geological region	Health risks Ecosystem impacts
Receptor/ Exposure	Inter-Departmental Business Register	BIS	Proprietary	Public	http://www.statistics.gov.uk/idbr/idbr.asp	Continually updated	Sep-10	The Inter-Departmental Business Register is the most comprehensive register of businesses held by the government. It compiles businesses registered for VAT purposes with those registered under PAYE rules, and therefore contains a large number of firms below the VAT threshold. Since it contains confidential data, access to the dataset is permitted with restrictions, and details may not be used for any other than statistical purposes. In the context of this study, the IDBR will be extremely useful in understanding the business dynamics surrounding contaminated sites. Since the database includes turnover information, an indication	Great Britain	Address level	Productivity benefits Agglomeration benefits

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
								may be given of how, for instance, retail turnover changes when derelict land is remediated. Furthermore, with the possibility of quarterly extracts for all years since 1995, the IDBR and/or its partner Business Structure Database will enable a historical analysis of business demography, productivity and sales data.			
Receptor/ Exposure	Focus	Costar Group	Proprietary	Private	http://www.focusnet.co.uk/	Continually updated	Current	Focus is an online service providing subscribers with detailed databases of office & industrial availability. Extensive deals information, building reports and town reports are also available. There is the functionality to search office & industrial buildings available to let or for sale, find information on individual buildings, including ownership, occupiers, lease details and rents, photographs, maps and historical data for the past 20 years. Comparing towns according to specific criteria is also possible, as is the analysis of market conditions from an historical, socio-economic or demographic perspective. This would be a major source of information to understand the change in land prices following decontamination, and also the impact this has on neighbouring housing and business premises.	UK	Address level	Site value Neighbouring property Agglomeration benefits
Receptor/ Exposure	Groundwater Source Protection Zones	EA	Proprietary	Public	http://www.environment-agency.gov.uk/research/policy/123355.aspx	Continually updated	Current	This is one of a number of baseline information and datasets for Strategic Environmental Assessment and Sustainability Appraisal held by the EA. Together with other data this can help map groundwater issues and benefits.	England and Wales	Site level	Health risks Ecosystem impacts

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
Receptor/ Exposure	EGi	Estates Gazette	Proprietary	Private	http://www.egi.co.uk	Continually updated	Current	EGI is very similar to Focus, albeit owned and operated by a different provider. There is little to choose between them in terms of data quality or relevance.	UK	Address level	Site value Neighbouring property Agglomeration benefits
Receptor/ Exposure	Price Paid Dataset	Land Registry	Proprietary	Public	http://www1.landregistry.gov.uk/property_info/ppd_add/	Continually updated	Current	The Price Paid dataset includes: address, price paid for the property, the date of transfer, the property type, tenure. This information is available for all residential property sales in England & Wales and lodged with Land Registry for registration. . Currently this dataset contains in excess of 15 million house transfers. In the context of this commission, this dataset provides sound evidence as to a possible change in residential house prices adjacent to a decontaminated site.	England and Wales	Address Level	Site value Neighbouring property Agglomeration benefits
Receptor/ Exposure	Changes of Ownership by Dwelling Price, 2008 (House price and market data by MSOA)	ONS (Neighbourhood Statistics)	Open	Public	http://neighbourhood.statistics.gov.uk/dissemination/datasetList.do?JSAllowed=true&Function=&$ph=60&CurrentPageId=60&step=1&CurrentTreeIndex=-1&searchString=&datasetFamilyId=776&Next.x=11&Next.y=2	Annual	2009	Official ONS statistics relating to house prices. This will be important when assessing the property market impact of an intervention.	England and Wales	MSOA	Site value Neighbouring property Agglomeration benefits
Receptor/ Exposure	Property ratings (also contains description of	VOA	Open	Public	http://ratinglists.voa.gov.uk/irl2k5/index.jsp	At tax revaluation	2010	The Valuations Office undertakes national revaluations of both commercial and residential property across England and Wales on behalf of HMRC. The most recent revaluation took place in 2010.	England and Wales	Address Level	Site value Neighbouring property Agglomeration benefits

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
	property by type and use)							Searchable by address and Local Authority, the Ratings database constitutes one of the most comprehensive sources of data on current site use, with address information, SIC codes and tenure histories. In the context of this study, VOA data will be important not only in understanding and modelling property market impacts of decontamination, but also in establishing the population and businesses located in the proximity of, or downstream of, contaminated sites.			
Source/ Contaminant	Land-Use Change Statistics	DCLG	Open	Public	http://www.communities.gov.uk/planningandbuilding/planningbuilding/planningstatistics/landusechange/	Annual	2009	Land use change data have been obtained from Ordnance Survey (OS) since 1985; DCLG receives a depth of intelligence which is not publicly released, including grid reference of each site, previous and new uses, and approximate area. Live tables are produced summarising headline figures. In the context of this study, historical land use change data would be of particular interest in identifying sites of potential contamination and assessing the agglomeration benefits of decontaminating land.	England	Local Authority level (4-yearly data only); GOR level (Annual)	Greenfield dev savings Agglomeration benefits

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Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
Source/ Contaminant	CL1/CL2 forms	DEFRA	Proprietary	Public	http://www.environment-agency.gov.uk/research/planning/121220.aspx	Continually updated	Current	These forms are submitted by Local Authorities to the Environment Agency in order to apply for a grant to subsidise contaminate land remediation or site studies. As a result they provide details of sites under investigation, prior to entry on the public register of contaminated land. Alongside other EA sources, this dataset will support identification of potentially contaminated sites, either for case studies or in order to understand the scale of contamination nationally and the potential benefits of remediation.	England	Site level	All benefit categories
Source/ Contaminant	United Kingdom Pollutant Release and Transfer Register	DEFRA	Open	Public	http://prtr.defra.gov.uk/index.php	Annual	2008	Industrial operators handling pollutants above a certain threshold quantity have an obligation to collect information on releases and off-site transfers of pollutants and wastes from their facilities, and report these annually to different parts of government. DEFRA collates these reports into the UK PRTR, which records the emission of specific chemicals to land, water and air. Small area data on releases of pollutants will contribute to a fuller picture of current industrial activity and its resultant contamination risks.	UK	Site level	Health risks Ecosystem benefits

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
Source/ Contaminant	Waste management licence register	EA	Open	Public	http://wastedirectory.netregs.gov.uk/	Quarterly	2010	One of the Environment Agency's public registers, the register of active waste management sites contains the former REGIS database. Landfill sites have been one of the key historic sources of land contamination, and they now come under closer scrutiny. This register will be important, in conjunction with other EA sources, in identifying potential sources of land contamination and the distribution of contamination risks across the country.	England and Wales	Address level	All benefit categories
Source/ Contaminant	Register of sites under Part IIA of EPA 1990	EA/Local Authorities	Proprietary	Public	http://www2.environment-agency.gov.uk/epr/info.asp	Continually updated	Current	A centralised database of special sites of contaminated land maintained by the EA. Local Authorities separately maintain local registers of sites under Part IIA of EPA 1990. Documentation on the register will include details of contaminants, prior use and remediation activities carried out. This dataset will be a useful source of potential case studies to test valuation methods, and provides site level information on past decontamination efforts.	England and Wales	Site level	All benefit categories
Source/ Contaminant	UK Soil and Herbage Pollutant Survey	EA	Open	Public	http://www.ni-environment.gov.uk/uk_soil_herbage_pollutant_survey_report1.pdf	2007 only	2007	The UK SHPS was a major survey of contaminant levels in soil and herbage in all four nations of the UK. It provides information about a range of pollutants including PCBs, dioxins, polycyclic aromatic hydrocarbons and trace metals in soils and herbage. For many contaminants, the survey provides the first and only coherent picture of their concentrations across the UK. The results provide a reliable	UK	86,000 data points	Health risks Ecosystem benefits

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
								baseline against which intensive local surveys and future national surveys can be assessed, and will help the Environment Agency and others to monitor and remedy pollution events more efficiently. In the context of this survey, the SHPS will provide baseline intelligence on expected ambient levels of pollutants, to compare against site level data.			
Source/ Contaminant	National Incident Recording System (NIRS)	EA	Proprietary	Public	http://www.findmaps.co.uk/assets/pdf/Environmental_Pollution_Incidents_user_guide_v2.0.0.pdf	Continually updated	Current	The NIRS has two parts, covering 1999-2001 and 2001-present; both parts are databases of pollution incidents (i.e. non-licensed pollution instances), ranked by level of severity. Data is georeferenced and the pollutant category is included. Along with several other EA datasets, the NIRS will be crucial in identifying potential sources of contamination across the country. It will also be useful in profiling the risks of accident associated with particular industrial sectors and processes.	UK	Site level	Health risks Ecosystem benefits

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
Source/ Contaminant	Pollution Inventory	EA	Open	Public	http://www.environment-agency.gov.uk/business/topics/pollution/32314.aspx	Annual	2009	The Pollution Inventory (PI) is an annual record of pollution in England and Wales from selected activities regulated by the Environment Agency. The PI includes seven years of data from major industrial sites, and is used to identify where industrial processes need to be improved to minimise environmental damage and negative health impacts. Along with several other Environment Agency registers and databases, the Pollution Inventory will be a key source of intelligence on potential sources of land, air and water contamination; it will also provide an overview of the risk profile of particular industrial activities.	England and Wales	Site level	All benefit categories
Source/ Contaminant	Known Historic Landfill Sites	EA	Proprietary	Public	http://www.environment-agency.gov.uk/research/policy/123355.aspx	Archive	Current	The Environment Agency holds a shapefile map of all known historic landfill sites in the UK. This register, not currently available to the public, will be important in identifying potential sources of contamination.	UK	Site level	All benefit categories

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
Source/ Contaminant	Control of Major Accidents and Hazards Register	EA	Open	Public	http://www2.environment-agency.gov.uk/epr/info.asp	Continually updated	Current	One of the Environment Agency's public registers, the COMAH register is maintained under Regulation 21 (4) of the Control of Major Accident Hazards Regulations 1999. COMAH applies mainly to the chemical industry, but also to some storage activities, explosives and nuclear sites, and other industries where threshold quantities of dangerous substances identified in the Regulations are kept or used. These companies must notify the Competent Authority (the Health and Safety Executive in England) of their activities with hazardous chemicals and substances, and are required to have mitigation and contingency plans should accidents occur. The register is one of several EA databases which identify potentially contaminative sites; put together these will provide the best current intelligence on sources of pollution and contamination risks.	UK	Site level	Health risks Ecosystem benefits
Source/ Contaminant	National Land Use Database – Previously Developed Land	HCA	Open	Public	http://www.homesandcommunities.co.uk/nlud-pdl-results-and-analysis.htm	Annual	2008	Maintained by the Homes and Communities Agency, the National Land Use Database contains information on previously developed land and buildings in England that may be available for development and is updated annually. The NLUD-PDL classifies brownfield land into five main types: 1. Previously developed land now vacant 2. Vacant buildings 3. Derelict land and buildings 4. Previously developed land or buildings currently in use and	national coverage	Site level	All benefit categories

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
								allocated in local plan or with planning permission 5. Previously developed land or buildings currently in use with redevelopment potential but no planning allocation or permission The aim of the NLUD-PDL database is to provide a consistent, comprehensive, and up to date record of all previously developed land and buildings in England that may be available for development, whether vacant, derelict, or still in productive use. Although it does not specify potentially contaminated sites, the NLUD-PDL may be useful in the context of this study in order to identify the scale and socioeconomic impacts of derelict and vacant land across the country; it also constitutes the most detailed public source of site level data across the UK.			

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
Source/ Contaminant	Historic Land Use Database	Landmark Information Group	Proprietary	Private	http://www.landmarkinfo.co.uk/corp/graphics/corp2/data_index_%20land%20use.pdf	Archive	1840s - 1996	Assembled from three key historical land use map archives, the HLUD is a proprietary database used most frequently when attempting to identify site histories. It allows overlays of prior use, and is commonly used to assess the potential for historic contamination. It includes data covering over 390,000 Historical Tanks and Energy facilities in Great Britain, which have been identified from text on historical OS maps. HLUD has over 700,000 instances of potential contaminative features equating to over 420,000 individual features within the database, in addition to 145,000 areas of infilled land. In the context of this study, HLUD presents the most comprehensive detail on past site uses. Typically called upon to check individual sites, the dataset as a whole may offer the best coverage of such crucial intelligence in the absence of a public source.	Great Britain	Site level	All benefit categories
Source/ Contaminant	Envirocheck	Landmark Information Group	Proprietary	Private	http://www.envirocheck.co.uk/	Continually updated	Current	Envirocheck is a proprietary site checking platform which aggregates references from over 50 separate data sources including Environment Agency, British Geological Society, Historic Land Use, Health Protection Agency and Coal Authority datasets. It is designed to inform site investigations and contaminated land assessments, and is the industry standard desk-based analysis tool for outline environmental assessments.	UK	Site level	All benefit categories

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
								In the context of this study, the Envirocheck service could be used in place of assembling the various individual sources.			
Source/ Contaminant	Public Registers of Contaminated Land	Local Authorities	Open	Public	via LA websites	Continually updated	Current	Every Local Authority is required under Part IIA of EPA 1990 to maintain a public register of contaminated sites. A register entry is created when one of the following happens: 1. the land is designated a special site 2. a remediation declaration is published 3. a remediation statement is published, or 4. a remediation notice is served. Councils do not have to put land on the register until one of these actions has been undertaken. This means that sites under investigation due to their previous use or suspected pollutant releases are not listed on these public registers.	England and Wales	Site level	All benefit categories
Source/ Contaminant	Scottish Vacant & Derelict Land Survey	Registers of Scotland	Open	Public	http://www.scotland.gov.uk/Topics/Statistics/Browse/Planning/SVDLSSiteRegister	Annual	2009	The SVDLS has been running since 1990, and assesses the amount of derelict land in Scottish Local Authorities; with a particular focus on sites near centres of population with 2000+ residents. Derelict land is not necessarily contaminated, rather it is land which has been so damaged by development, that it is incapable of development for beneficial use without rehabilitation. Land also qualifies as derelict if it has an unremediated previous use which could constrain future development.	Scotland	Site level	All benefit categories

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
								In the context of this study, the Survey could provide numerous examples of derelict sites being brought back into use after remediation, and, in conjunction with other data sources, these examples could be valued for their economic impact.			
Source/ Contaminant	National Survey of Contaminated Land in Wales	United Kingdom National Digital Archive of Datasets	Open	Public	http://www.nationalarchives.gov.uk/catalogue/displaycataloguedetails.asp?CATLN=3&CATID=59168&SearchInit=4&SearchType=6&CATREF=BD+83&j=1	1983/4 and 1987/8 only	1988	The aim of the original survey and the 1987/88 update was to identify contaminated sites before they were redeveloped, thereby avoiding the financial costs and risks to which developers and eventual occupiers of the site might be exposed. This entailed consultation with each district council, followed by visits to each district to check on sites for which information seemed questionable. No detailed site investigations were carried out specifically for the survey. Site identification was divided into three categories as follows: 1. Those sites originating in the expansion of heavy industry between 1850 and 1950, since abandoned. 2. Refuse and industrial waste disposal sites. 3. Industrial sites which had been abandoned after 1950. Although the register is clearly out of date, it could be relevant in the context of this study in order to provide known case studies for economic valuation. In addition, it provides a detailed register of information regarding previous uses and locations.	Wales	Site level	Productivity benefits Agglomeration benefits

Category	Source	Owner	Permission	Sector	Link	Frequency	Latest data	Description	Coverage	Level	Most relevant data categories
Receptor/ Exposure	Association of Public Health Observatories	Various Data sets	Open	Public	http://www.apho.org.uk/resource/view.aspx?RID=71961	Long term data available	Current	The definitive guide to the health of the UK, this source includes children's health, adult health, diseases, life expectancy, local and regional health profiles. This is the primary source of data for all health indicators and will be important on evidencing the health benefits of decontaminating land.	UK	Various	Health benefits

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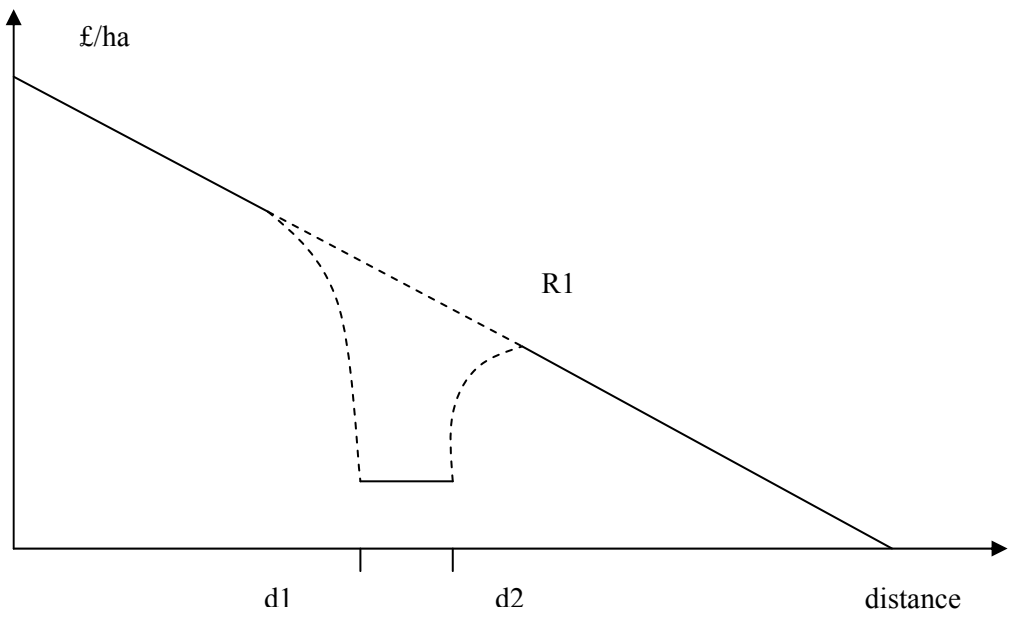
Appendix C
Micro-economic Representation of the Spatial Impact of Contaminated Land

The economic cost of contaminated land can be illustrated in terms of bid rent curve or land value curve which shows how land prices decline with distance from the city or urban centre[40] (see Figure C.1). This concept is used in a number of benefit methodologies, for example, hedonic pricing.

Figure C.1 Land Value Curve



The contaminated land between d1 and d2 has a lower value than the surrounding land[41]. The curved lines show the impact on values of neighbouring property. This externality effect is assumed to decline with distance from the contaminated site.

This analysis is based on a partial equilibrium perspective: it assumes that the contaminated land site(s) is/are small enough, such that when they are remediated they do not affect the bid rent curve. This would be a poor assumption if there was a large amount of contaminated land.

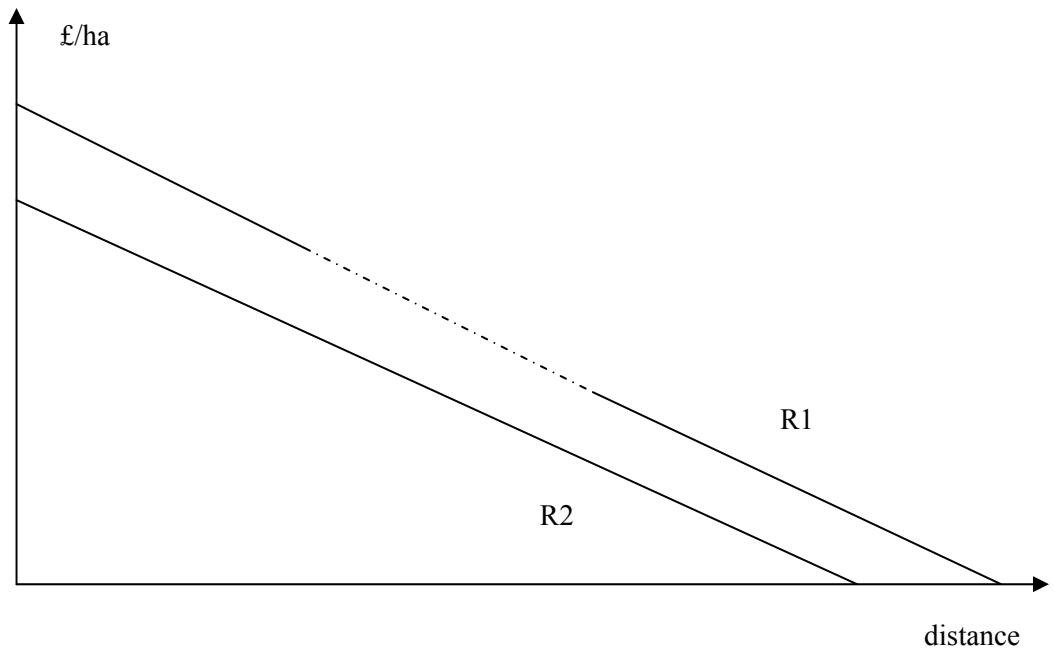
[40] most contaminated land sites are in proximity to some urban area. Thus a bid rent curve framework is a valid way of conceptualising the economic problem and the analysis.

[41] this is intuitively obvious. CL has to have a lower economic value. If CL did not have a lower value then there would not be an economic problem

If the quantity of contaminated land is large, relative to other land in the city/urban area, then remediation will result in a shift in downward land supply curve. This will reduce the marginal price of land, and since the bid rent curve is the marginal valuation curve, it will result in a shift in the bid rent curve downwards. If such a shift occurred, the value of the remediated land would be less than the current price of non-contaminated land. The estimation of this new bid rent curve, or price of contaminated land following remediation would require a general equilibrium model to estimate the extent of the shift in the bid rent curve.

This general equilibrium position is illustrated in Figure C.2. If the supply of contaminated land is large, then the predominant effect of land reclamation would be to make urban land more plentiful in general, and willingness to pay in general would decline, resulting in the bid rent curve moving from R_1 to R_2. Potential purchasers would be willing to pay less for any particular parcel because there are more parcels available from which to choose. This reduces the pressure for expansion of the urban area into green field land, and although the current boundary of the urban area would remain the same, the pressure to expand the city would be reduced.

Figure C.2 General Equilibrium



The bid rent curve might also be affected by an adaptive reaction to the risk of the contamination. The bid rent curve in Figure 1 might change very little if there is an adaptive reaction to the increased risk. Thus people may lower their Willingness To Pay to avoid risks because of income differences or preference heterogeneity, or people may have imperfect information on the health risks they face and an incomplete understanding of the benefits of remediation.

Appendix D
Glossary

Benefit transfer (BT): a technique that makes use of previous estimates of the value of a good derived from a study site to calculate estimates for a good in a different context, known as the policy site. What is transferred may be a mean WTP value, or a benefit function with some adjustment for changed conditions (e.g., different income levels of the populations) between the two sites.

Choice experiment (CE): A stated preference technique in which respondents are presented with a series of alternatives and asked to choose their most preferred. It is possible to infer willingness to pay or accept indirectly from responses stated by respondents (as opposed to directly asking as in a contingent valuation survey).

Contingent valuation: (CV): A stated preference approach to valuing non-market goods and services where individuals are asked what they are willing to pay (or accept) for a change in provision of a non-market good or service.

Economic value: The monetary measure of the wellbeing associated with the change in the provision of some good. For market goods this is ordinarily measured by market price; for non-market goods this ordinarily measured by willingness to pay (WTP) or willingness to accept (WTA)

Ecosystems services: A term that is used to describe a framework for analysing how human populations are dependent upon the condition of the natural environment. The approach explicitly recognizes that ecosystems and the biological diversity contained within them contribute to individual and social wellbeing.

EVRI: The Environmental Valuation Reference Inventory. A database of existing economic valuation evidence (i.e. secondary evidence) for the purpose of facilitating value transfer (further information in the Appendix).

Experts (as used in this report): a term applied to people who have qualified in a profession (e.g. medical doctors, charter estate agents, etc,) who use their professional knowledge, experience, and expertise to provide a diagnosis, or value judgement on an issue e.g. the price a property would sell for on the open market.

Functional form: the mathematical relationship between two variables y and x. This relationship might be linear, logarithmic, exponential, quadratic, etc.

Hedonic pricing method (HPM): A revealed preference valuation method that estimates the use value of a non-market good or service by examining the relationship between the non-market good and the demand for some market-priced complementary good (e.g. property or land prices)

Non-market goods and services: Goods and services that are not traded in markets and are consequently 'un-priced' (e.g. environmental goods and services).

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Non-use value: Economic value not associated with any use of a resource and including altruistic, bequest and existence values.

Ordinary least squares (OLS): a method for estimating unknown parameters in a linear regression model. OLS minimises the sum of the squared difference between an observed and a predicted value. OLS provides a minimum variance mean unbiased estimator when errors have finite variance.

Policy good: A value transfer term. The good or service for which monetary valuation evidence is required. It could be a physical commodity and market good (e.g. property), it could be a non-market amenity (e.g. recreation) or service (e.g. water quality), or environmental impact (e.g. improved water quality, a decrease in air pollution). Typically contrasted with "study good".

Regulating services: A category of ecosystem services which refers to the regulation of ecosystem processes such as climate regulation, air quality regulation, water regulation (e.g. flood control), water quality regulation (purification/detoxification) and erosion control.

Revealed preference: a method that derives WTP estimates from observations of people's behaviour and actual decisions, rather than from their response to hypothetical questions

Study good: A value transfer term. The good or service for which economic valuation evidence is available. Typically contrasted with "policy good".

Total economic value (TEV): The economic value of a resource comprised of its use and non-use values.

Travel cost method (TCM): A revealed preference and survey based valuation method that uses the cost incurred by individuals travelling and gaining access to a recreation site as a proxy for the recreational use value of that site.

Use value: The economic value that is derived from using or having potential to use a resource. It is the net sum of direct use values, indirect use values and option values.

Value transfer: Process by which readily available economic valuation evidence is applied in a new context for which valuation is required

Willingness-to-accept (WTA) compensation: The monetary measure of the value of forgoing a gain in the provision of a good or service or allowing a loss.

Willingness-to-pay (WTP): The monetary measure of the value of obtaining a gain in the provision of good or service or avoiding a loss.

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Appendix E
Comparison of Total Economic Value (TEV) and Ecosystem Services Approaches

Figure E.1 shows the conceptual framework used by the UK National Ecosystem Assessment (UKNEA). The UK NEA uses the term good(s) to include all use and non-use, material and non-material benefits from ecosystems that have value for people.

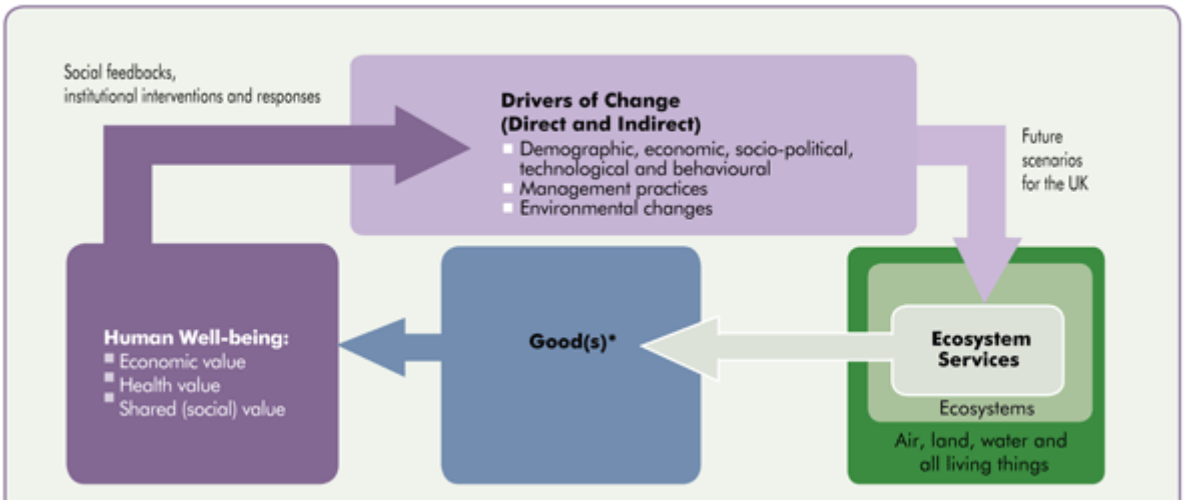

Figure E.1 Conceptual Framework for ecosystem services as illustrated in the UK National Ecosystem Assessment.

In general, ecosystem services do not provide a complete framework for specifying the value of the impacts of a remediation programme at a contaminated land site, for example components of value related to the site but unrelated to the environment there would be excluded. A particular difficulty with use of ecosystem services is that the specification of causal links between changes in their level and their impacts on markets is not simple. Other difficulties include conflicts between ecosystem services valuation languages (Martinez-Alier, J., 2002).

In contrast, TEV includes all sources of value by definition, though the components of TEV and their valuation have developed over time and may not appear as holistic an overall approach as ecosystem services which begins with a single starting conception - the environment (labelled as “air,land,water and all living things” in Figure 2.1).

TEV works on the premise that if something had value (for whatever reason) then estimating impacts of its change will allow assessment of benefits. It does not decide how things come to have value. The ecosystems services approach instead needs techniques to translate an underlying physical description of changes and use of a particular resource - the environment, into a measure of value. Despite having different starting points, TEV and ecosystem

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services may use some of the same techniques. For example, they both recognise recreational benefits and can use the Travel Cost Method to value them[42].

A more minor difference is that TEV tends to focus on changes in value whereas an ecosystem services approach is more likely to work in terms of absolute values as this allows the representation of physical aspects such as thresholds.

Assessment of property market impacts can be used to illustrate the difference between TEV and ecosystem services approaches. Property prices reflect a range of factors some of which are related to the environmental situation and the local ecosystems, but also others which are unrelated, such as unfounded fears of the damage being caused by a contaminated site. Separating out the movements in price due to changes in ecosystem services from other changes is very difficult, particularly as factors resulting from ecosystem services (e.g. a nice park) may not be interpreted in terms of the underlying individual ecosystems services and attributing value to each of these is a difficult and potentially arbitrary process.

In contrast, changes in house prices, from whatever cause, have the benefit of being commonly used as measures of changes in value. Also, the house market is active, responds to causes that buyers and sellers understand, and has prices which are frequently updated and subject to professional opinion. In practice, they are often easier to use as well as being a benchmark that is both seen as objective and relevant to any party directly affected by property values. In practice, use of headline house price movements as a measure of changes in value may be required as part of engagement with the local population and as a result there may be no need or reason to relate these to specific ecosystem services.

It is possible for a study to use an ecosystem services framework as a primary framework for valuation, but it might need to be restricted to objectives where links between the services and the values of their outputs was less uncertain and where, for example, other factors such as house prices were not a factor in the analysis. This would be appropriate if, for example, the aim of a study was to assess a set of sites in terms of their relative contribution to a national inventory of ecosystem services. In this case, each site would be assessed based only on the changes in value arising directly from ecosystem services, and these values would be based on a linkage to the change in the level of ecosystem service (for example, the introduction of a pond attracting a wider variety of birds).

The benefits arising from changes in ecosystem services are discussed below under the headings usually used to group them and in terms of how they would be represented in a TEV framework. This enables a characterisation of an environment using ecosystem services to be 'mapped' to TEV benefit categories. For clarity, TEV: and ES: are used to prefix benefit categories.

ES:provisioning services largely fall within the TEV:site value category, though also may affect TEV:productivity benefits and TEV:environmental benefits. The TEV:site value includes the value of resources (provisions) it can produce. For example, a site with a forested or coppiced area may produce timber for construction. Remediation of the site, for example through soil replacement, might also improve the TEV:productivity of the land such that more timber (ES:provisions) would be produced. Changes in the level of ES:provisioning services such as an increase in

[42] Using the Travel Cost Method, the value depends on observations of the cost and time people are prepared to pay to enjoy a particular amenity.

the supply of rare plants could be accounted for in the TEV:site value but might also form part of TEV:Environmental benefits if such plants also contributed, for example, to an improvement in habitat. For clarity, increases in levels of provisions would not be seen as a TEV:benefit of reduced health risks.

Benefits of **ES:regulating services** on the site itself can be captured in the TEV:site value. To the extent that services on the site help neighbouring areas, benefits of ES:regulating services affect may also increase the TEV:value of neighbouring property such as where a marshland helps protect neighbouring properties downstream from flooding or a screen of trees provides a shield mitigating noise pollution. ES:regulating services may also result in TEV:environmental benefits if they improve the quality of habitat. Changes in the levels of ES:regulating services may result in benefits captured under TEV:reduced health risks if the regulating service leads to a healthier environment at or in the neighbourhood of the site. One example is the impact of vegetation on air pollution

The influence of **ES:supporting services** is by definition on other ecosystem services and so supporting services could be assumed not to have direct impacts on any of the TEV categories of benefit. However, this is primarily a question of attribution. If remediation of soil results in better nutrient cycling and so better plant growth then a benefit could be seen in TEV:productivity. This highlights the need to avoid potential issues of double counting.

Benefits of **ES:cultural services** correspond well to the benefits arising under the TEV:amenity category. From a utilitarian perspective, cultural services are all amenity benefits.

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