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REPORT ON

PLANNING APPLICATION AND ENVIRONMENTAL STATEMENT

VOLUME 6 ECOLOGICAL RISK ASSESSMENT (TIER ZERO & TIER ONE)

PROPOSED WASTE MANAGEMENT FACILITY AT SHANKS WASTE MANAGEMENT LTD PONTYPOOL, S.E. WALES

Submitted to:

Shanks Waste Management Ltd
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New Road, Panteg
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STUDY LIMITATIONS

IMPORTANT: This section should be read before reliance is placed on any of the opinions, advice, recommendations or conclusions herein set out.

a) This report has been prepared for and at the request of Shanks Waste Management Ltd (Shanks) ("the Client") for the purpose of activities pursuant to its appointment of Golder Associates (UK) Limited (Golder) to act as Consultant.

b) Save for Shanks no duty is undertaken or warranty or representation made to any party in respect of the opinions, advice, recommendations, or conclusions herein set out.

c) Regard should be had to the agreement between Golder and Shanks dated 29 January 2005 and subsequent emails in February 2006 and June 2006 instructing Golder to proceed with a Tier Zero and Tier One ERA, when considering this report and reliance to be placed on it.

d) All work carried out in preparing this report has used, and is based upon, Golder's professional knowledge and understanding of the current, November 2006, relevant UK and European Community:

- standards and codes;
- technology; and
- legislation.

Changes in the above may cause the opinion, advice, recommendations or conclusions set out in this report to become inappropriate or incorrect. However, in giving its opinions, advice, recommendations and conclusions, Golder has considered pending changes to environmental legislation and regulations of which it is currently aware. Following delivery of this report, Golder will have no obligation to advise the Client of any such changes, or of their repercussions.

e) Golder acknowledges that it is being retained, in part, because of its knowledge and experience with respect to environmental matters. Golder will consider and analyse all information provided to it in the context of Golder's knowledge and experience and all other relevant information known to Golder. To the extent that the information provided to Golder is not inconsistent or incompatible therewith, Golder shall be entitled to rely upon and assume, without independent verification, the accuracy and completeness of all such information and Golder shall have no obligation to verify the accuracy and completeness of such information.

f) The content of this report represents the professional opinion of experienced environmental consultants. Golder does not provide specialist legal advice and the advice of lawyers may be required.

g) If the scope of the work includes borings, test pits, or engineering interpretation of such information, attention is drawn to the fact that special risks occur whenever engineering and related disciplines are applied to identify subsurface conditions. Even a comprehensive sampling and testing programme implemented in accordance with a professional Standard of Care may fail to detect certain conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between sampling points may differ from those that actually exist. Passage of time, natural occurrences, and activities near the Site may substantially alter

discovered conditions. Similarly, exceptionally high and unrepresentative findings can also occur as a result of random of cross-contamination effects.

h) In the Conclusions and Recommendations, Golder has set out its key findings and provided a summary and overview of its advice, opinions, and recommendations. However, other parts of this report and the covering letter will often indicate the limitations of the information obtained by Golder and therefore any advice, opinions or recommendations set out in the Conclusions and Recommendations ought not to be relied upon until considered in the context of the whole report.

i) The lack of evidence of the presence of hazardous materials at the subject property does not guarantee the absence of such materials, rather it indicates only that none were found as a result of the services provided. The services described in this report were performed in accordance with the general practices and procedures accepted in the consulting field.

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1.0 INTRODUCTION

This Ecological Risk Assessment (ERA) has been undertaken for the purposes of the following project:

Project Title: **Proposed Waste Management Facility at Shanks, Pont-y-felin Industrial Estate, New Inn, Pontypool**

Applicant: **Shanks Waste Management Ltd**

This ERA accompanies, and should be read in conjunction with, the Planning Application and Environmental Statement produced by Golder Associates (UK) Ltd (Golder) for Shanks Waste Management Ltd (Shanks) and submitted to Torfaen County Borough Council (TCBC) in December 2006 in respect of seeking planning permission to provide a new waste management facility comprising a mechanical biological treatment (MBT) plant for the treatment of residual municipal wastes generated in the region.

The development constitutes 'Environmental Impact Assessment (EIA) development' under Paragraph 11 (b) of Schedule 2 of the Town and Country Planning (Environmental Impact Assessment) (England & Wales) Regulations 1999 (as amended) SI 1999 No. 293 (EIA Regulations). This comprises:

"installations for the disposal of waste (unless included in Schedule 1) where:-

i) the disposal is by incineration;
ii) the area of the development exceeds 0.5 ha; or
iii) the installation is to be Sited within 100 m of any controlled waters."

The development satisfies limbs (ii) and (iii) of Paragraph 11b above, covering an area of approximately 3.1 ha and at its closest point, lying approximately 20 m from the Afon Lwyd to the northeast. Thus an EIA was deemed to be required. This was confirmed in a formal 'Screening Opinion' provided by TCBC on 23 November 2005.

1.1 The Context of the Study

Golder requested a Scoping Opinion from TCBC on 11 October 2005 in order to identify the key impacts and issues that consultees believed the EIA should address - i.e. those environmental impacts that are likely to be significant in the views of the consultees. Following consultation with a number of statutory and non-statutory bodies, a Scoping Opinion was provided by TCBC on 17 January 2006. With respect to contaminated land investigation and risk assessment, including ecological risk assessment, TCBC Environmental Health Department confirmed that:

Section from TCBC Environmental Health Department Scoping Opinion

'It will be necessary for the applicant to identify and evaluate all potential sources of contamination and their impacts on land and/or controlled waters, relevant to the Site. A detailed Site investigation shall be carried out to fully and effectively characterise the nature and extent of any land contamination and/or pollution to controlled waters. The study shall specifically include a risk assessment that takes into account the Sites existing status and proposed new use.

The risk assessment must be completed by a competent person for any contaminant encountered. Such a risk assessment should use both the results of the Site investigation and previous investigations in the area. The investigation should specifically include a risk assessment that adopts the source-pathway-receptor principle in accordance with the Contaminated Land Exposure Assessment (CLEA) guidance as advocated by the Department for Environment Food and Rural Affairs (DEFRA, 2002). Should Soil Guidance Values (SGVs) not be available for comparison for soil analysis, the applicant should follow guidelines set out in the CLEA 10 documentation and proceed to carry out Detailed Quantitative Risk Assessment (DQRA) to derive Site specific assessment criteria (SSAC) for the contaminants of concern. This assessment should identify:

- All potential receptors both on and off-Site (**including ecological receptors**)
- The potential risk to each identified end receptor from each contaminant encountered
- Appropriate mitigating measures to protect end receptors

Following the risk assessment process, a remediation options appraisal should be undertaken. The purpose of this stage is to develop a remediation strategy that will reduce or control unacceptable risks identified by the risk assessment. The options should be capable of practical implementation and be robustly and scientifically justified against each identified pollutant linkage'.

A full copy of the Scoping Opinion is contained in Appendix 2 of this report.

Golder has undertaken works throughout 2005 and 2006 in order to assess the status of contamination on-Site in the form of a Phase I desk based assessment, a Phase II targeted ground investigation and subsequent environmental monitoring. As required, a Hydrogeological Risk Assessment (HRA) and Human Health Risk Assessment (HHRA) have been undertaken throughout 2006 and these are presented in the following volumes of the planning submission which is structured as follows:

- **Volume 1** – Planning Application
- **Volume 2** – Environmental Statement
- **Volume 3a and 3b –** Phase I Environmental Assessment and Phase II Environmental Site Assessment and Intrusive Site Investigation Report
- **Volume 4 –** Human Health Risk Assessment
- **Volume 5 –** Hydrogeological Risk Assessment
- **Volume 6** – Ecological Risk Assessment (Tier Zero & Tier One)
- **Volume 7 –** Remedial Options Appraisal and Preliminary Remedial Strategy

Golder Associates (UK) Ltd employed an in-house, experienced ecological risk assessor, Ms Rosana Moraes (Golder Associates sarl, France), to perform the ERA.

1.2 Background to Ecological Risk Assessment

ERA is increasingly becoming used in the UK as a tool to examine the risks to fauna, flora and habitats from current and future stressors including land contamination. This is because contaminants which can be present in soils and waters (groundwater, surface water etc.) can present unique risks to ecological receptors by virtue of their chemical and/or physical properties. The magnitude and severity of the risks can depend on many factors, including the sensitivity of the species concerned, available exposure pathways by which the contaminants may reach the ecological receptors including 'secondary pathways' available through e.g. the food chain and also, factors such as duration and timing of exposure.

In the case of the Pontypool Site, a significant desk based and intrusive Site investigation has been undertaken by Golder in order to identify any areas of contamination in the soil, sediment, groundwater, surface water and ground gas within the area of the Site and immediately adjacent to it, and to determine their likely sources. The data from this investigation has therefore been utilised in this Tier Zero and Tier One ERA in order to specifically examine risks presented by the substances present on-Site and immediately adjacent to the Site, to ecological receptors. The reader should refer to Volume 3 of this Planning Application for further information.

Certain substances detected on-Site (related to previous use of the Site as a high temperature incinerator for their disposal) can present ecological concerns, e.g. Polychlorinated biphenyls (PCBs), dioxins, furans etc. An introduction into the types of risks to ecological receptors presented by such substances (n.b. this is not an exhaustive list, but rather, intended in order to provide some context to the ERA) is provided below.

1.2.1 Polychlorinated biphenyls (PCBs)

Polychlorinated biphenyls (PCBs) are synthetic compounds that contain chlorine and can occur in 209 different configurations, called congeners. In the UK, PCBs were manufactured for use in a wide range of applications between the 1930s and mid-1970s. At that time, they were considered to be safe and were popular because of their extreme thermal, electrical and

chemical stability. We now know that these same properties make PCBs extremely persistent in the environment and that they may bioaccumulate in fatty tissues in humans and animals (DEFRA 2002).

One of the most commercially useful properties of PCBs when they were widely used was that they are chemically stable in relatively adverse conditions, such as temperatures of several hundred degrees in an oxygen-containing atmosphere. Therefore, destruction of PCBs by combustion generally required high temperatures (at least 1,200^{o}C) and an extended contact time (more than 2 seconds) in that temperature with adequate oxygen (US EPA 1999).

Today, the environmental concentrations of PCBs in the UK reflect a combination of on-going releases and redistribution of previous releases although in many places the general background concentrations are dominated by the latter (DEFRA 2002).

Because of their attraction to fats and the slow rates at which they are metabolized by organisms, PCBs can accumulate and even magnify in food webs. Some available mechanisms by which PCBs can affect receptors are presented below:

- plants can take PCBs directly from the soil via their roots or PCBs can enter their leaves directly from the atmosphere;
- invertebrates (e.g. worms and insects) can absorb PCBs from direct contact with or ingestion of soil contaminated by PCBs; and
- birds and mammals can accumulate PCBs by eating food contaminated by PCBs (Environment Canada 2005b).

PCBs have numerous effects on terrestrial forms of life. Some examples of these are presented below:

- soil microbes, which are important for decomposition, recycling and other processes, show lower nutrient recycling rates and lower respiration rates when exposed to PCBs;
- PCB exposure can inhibit plant growth, root growth, water uptake, and leaf development;
- birds can transfer PCBs to their eggs with the consequences of lower rates of hatching, thinner shells, and lower growth rates of offspring; and
- in mammals, PCBs tend to be transported by blood to the liver and other organs. PCBs can have toxic effects on the immune, nervous, and reproductive systems of mammals and can be passed to a foetus through the placenta and to offspring through mother's milk.

1.2.2 Dioxins and furans

The term 'dioxin' is used to refer to the polychlorinated dibenzo-*p*-dioxins (PCDD). The term 'furan' is used to refer to polychlorinated dibenzofurans (PCDF).

Dioxins and furans are chemical compounds that, like PCBs, contain chlorine and can occur in 210 different configurations, (also called congeners). Dioxins have never been produced intentionally, other than in very small quantities for laboratory-scale research, but they may be found as trace by-products from a number of industrial and non-industrial processes, including combustion. There is some evidence of natural formation of dioxins from some biochemical processes such as in compost or in the gut of cows; however the contribution to overall emissions from natural sources is unknown (Defra 2002).

Dioxins and furans can accumulate in the bodies of organisms exposed to these chemicals through diet (i.e. ingestion of contaminated food), or, for example, through direct exposure in water, soil or sediment. Dietary intake is, however, the primary mechanism for exposure of biota to dioxins and dioxin-like chemicals. Ultimately, dietary uptake is dependent upon the concentrations and availability of these chemicals in soil, waters and sediments.

There is some evidence that dioxins and furans can bio-magnify in terrestrial food webs. The effects of dioxins and furans on plants, soil microbes, and invertebrates are, however, not well understood. Effects on animals can include decreased food consumption, reduced weight gain, and effects on the reproductive and nervous systems (Australian Government 2004, Environment Canada 2005a).

1.3 UK Framework for Ecological Risk Assessment

In the UK, the general framework for risk assessment is set out in the DETR (2000a) publication '*Guidelines for Environmental Risk Assessment and Management'*. This advocates a staged risk screening and prioritisation approach in order to target investigative effort towards pollutant linkages of greatest concern.

1.3.1 Part IIA of the Environmental Protection Act 1990

In respect of contaminated land, a framework for quantifying the impacts of contaminated land, undertaking appropriate risk assessments, remedial options appraisal and model procedures for management of land contamination are set out in the *Contaminated Land Report (CLR)* suite of reports (DETR 2000b). These address actions which require to be undertaken in accordance with Section 57 of Part II of the Environmental Protection Act (EPA) 1990 which introduced a new regulatory regime for the identification and control of contaminated land in England and Wales. The EPA 1990 defines 'Contaminated Land' 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 significant harm is being caused or there is a significant possibility of such harm being caused; or pollution of controlled waters is being, or is likely to be caused."

The definition of contaminated land is based on risk assessment principals and its approach incorporates the concept of contaminant-pathway-receptor where a receptor is either:

- a living organism, a group of organisms, an ecological system or a piece of property which is in a category listed in Table A of 'Contaminated Land, Environmental Protection Act 1990: Part IIA. DETR Circular 01/2006) (DETR2006) and is being, or could be, harmed by a contaminant; or
- controlled waters which are being, or could be, polluted by a contaminant.

Table A of DETR Circular 01/2006 lists four types of receptors:

- human beings;
- property in the form of crops, including timber; produce grown domestically, or on allotments for consumption, livestock, other owned or domesticated animals, wild animals which are the subject of shooting or fishing rights;
- property in the form of buildings (any structure or erection and any part of a building including any part below ground level, but not including plant and machinery comprised in a building); and
- "any ecological system or living organism forming part of such a system, within a location which is":-

- an area notified as an area of special scientific interest under Section 28 of the Wildlife and Countryside Act 1981;
- any land declared a national nature reserve under Section 35 of that Act;
- any area designated as a marine nature reserve under Section 36 of that Act;
- an area of special protection for birds, established under Section 3 of that Act;
- any European Site within the meaning of regulation 10 of the Conservation (Natural Habitats etc) Regulations 1994 (i.e. Special Areas of Conservation and Special Protection Areas);
- any candidate Special Areas of Conservation or potential Special Protection Areas given equivalent protection;
- any habitat or Site afforded policy protection under Paragraph 6 of Planning Policy Statement (PPS9) on nature conservation (i.e. candidate Special Areas of Conservation, potential Special Protection Areas and listed Ramsar Sites); or
- any nature reserve established under Section 21 of the National Parks and Access to the Countryside Act 1949.

According to the same document, harm to ecological systems outside the descriptions above should be disregarded.

It is of note that PPS9, along with other PPSs is not applicable for Sites in Wales. Rather, Technical Advice Note 5 (TAN 5), Planning and Nature Conservation, 1996 sets out key principles in planning for nature conservation and deals with conserving designated Sites and habitats and protected species. TAN 5 has recently been updated and a consultation draft version published in January 2006 by the Welsh Assembly Government (WAG).

For any of these protected habitats, the types of harm that are to be regarded as significant are:

- harm which results in an irreversible adverse change, or in some other substantial adverse change, in the functioning of the ecological system within any substantial part of that location; or

- harm which affects any species of special interest within that location and which endangers the long-term maintenance of the population of that species at that location.

In addition, in the case of a protected location which is a European Site i.e. a candidate Special Area of Conservation (SAC) or a potential Special Protection Area (SPA), significant harm is defined as harm which is incompatible with the favourable conservation status of natural habitats at that location or species typically found there. Any other description of harm to ecological receptors of the three kinds of significant harm mentioned above should be disregarded.

The process that can be used to predict or estimate significant harm to any defined ecological receptor from land that is, or may be, contaminated is defined as "Ecological Risk Assessment" (ERA). Further information on this is provided in Section 2.

1.4 Scope and Objective of the Study

The initial stages of works undertaken and presented here are the Tier Zero and Tier One Ecological Risk Assessments. These have been completed in a phased manner, based upon current knowledge of the Site. This has included review of available chemical analytical data (Site specific data from Golder 2005 and 2006; on and off-Site soil and foliage data provided by Shanks from 1998 to 2005) and ecological surveys (Gemmell 1991). The latter incorporates a desk based review in order to identify existing protected habitats within the study area. Additional surveys for protected and important species by Golder have also been used as reference for the study. Reference should be made to the Ecological Impact Assessment, Chapter 7 of the Environmental Statement presented in Volume 2 of this submission for further information.

1.4.1 Objectives of Tier Zero ERA

The objectives of the Tier Zero ERA (completed in May 2006) were as follows:

- to identify theoretical linkages between contaminants originating from the Site - pathways of exposure - ecological receptors of relevance under Part IIA of the Environmental Protection Act 1990 (DETR 2006);

- to develop a preliminary conceptual Site model (CSM) based on the current knowledge of the Site; and

- to evaluate if further ecological risk assessments beyond Tier Zero (i.e. Tier One) were warranted.

1.4.2 Objectives of Tier One ERA

The Tier Zero ERA (presented in full in this report), identified that a Tier One ERA was warranted. The objectives of the Tier One ERA were therefore as follows:

- to evaluate which chemicals at the Site are present in concentrations potentially high enough to cause effects on ecological receptors;

- to refine the preliminary CSM;

- to evaluate if further ERA beyond Tier One (i.e. Tier Two) would be warranted; and

- to make recommendations for future work.

1.5 Report Format

Section 2 provides an introduction to the ERA framework adopted throughout this study.

Section 3 presents the findings of the Tier Zero ERA, including a summary of existing information of relevance, the identification of contaminants – pathways – receptors, the preliminary CSM, uncertainties, conclusions and recommendations.

Section 4 presents the findings of the Tier One ERA, including the methodology used, the evaluation of whether the chemical concentrations at the Site (and in close proximity to the Site, including those predicted, for example, in the Hydrogeological Risk Assessment (HRA) Volume 5) are sufficiently elevated to cause potential effects on ecological receptors. Uncertainties remaining at the close of the Tier One ERA, a revised CSM and conclusions and recommendations for further work are also outlined.

Section 5 presents references. A full glossary is also provided at the end of the report.

2.0 OVERVIEW OF THE ECOLOGICAL RISK ASSESSMENT FRAMEWORK

Although there is much in common between the assessment of risks to human health and to ecological receptors, there are some important differences. One of them is the fact that HHRA focuses on effects on individuals; whilst ERA focuses on effects on populations, communities and ecosystems.

The reference documents described in Section 1.3, which form the UK risk assessment framework for contaminated land, do not explicitly provide a methodology for undertaking ERA**.** Thus, in 2002, the Environment Agency published a proposed framework to deal with risks to ecological receptors ("*Assessing risks to ecosystems from land contamination*"). Subsequently, a scientifically based framework for undertaking ERA, consistent with the UK Government guidelines cited above, has been prepared. *'Ecological Risk Assessment, a public consultation on a framework and methods for assessing harm to ecosystems from contaminants in soil'* was published in December 2003 by the Environment Agency. The framework and the proposed methods for assessing harm to ecosystems from contaminants in soil were subject to public consultation until February 2004. The Environment Agency is now currently working with partners in industry to test the framework on real situations and when this work is complete, it is understood that the results of the consultation and the testing exercise will be reported together (Environment Agency website, December 2006).

The ERA process set out in *'Ecological Risk Assessment, a public consultation on a framework and methods for assessing harm to ecosystems from contaminants in soil'*, December 2003 consists of a four-tiered approach to the evaluation of risks; successive tiers requiring greater refinement in the quality and quantity of information gathered and progressive reduction in uncertainties. Early tiers can be used to screen out sites that pose little or no risk to receptors. The tiered approach ensures that resources are allocated to sites with greater risk.

Figure 1 presented below illustrates the various tiers of the UK ERA framework. Decision points in each tier determine whether:

- to stop the work (risk acceptably low); or
- to continue the assessment by gathering further information.

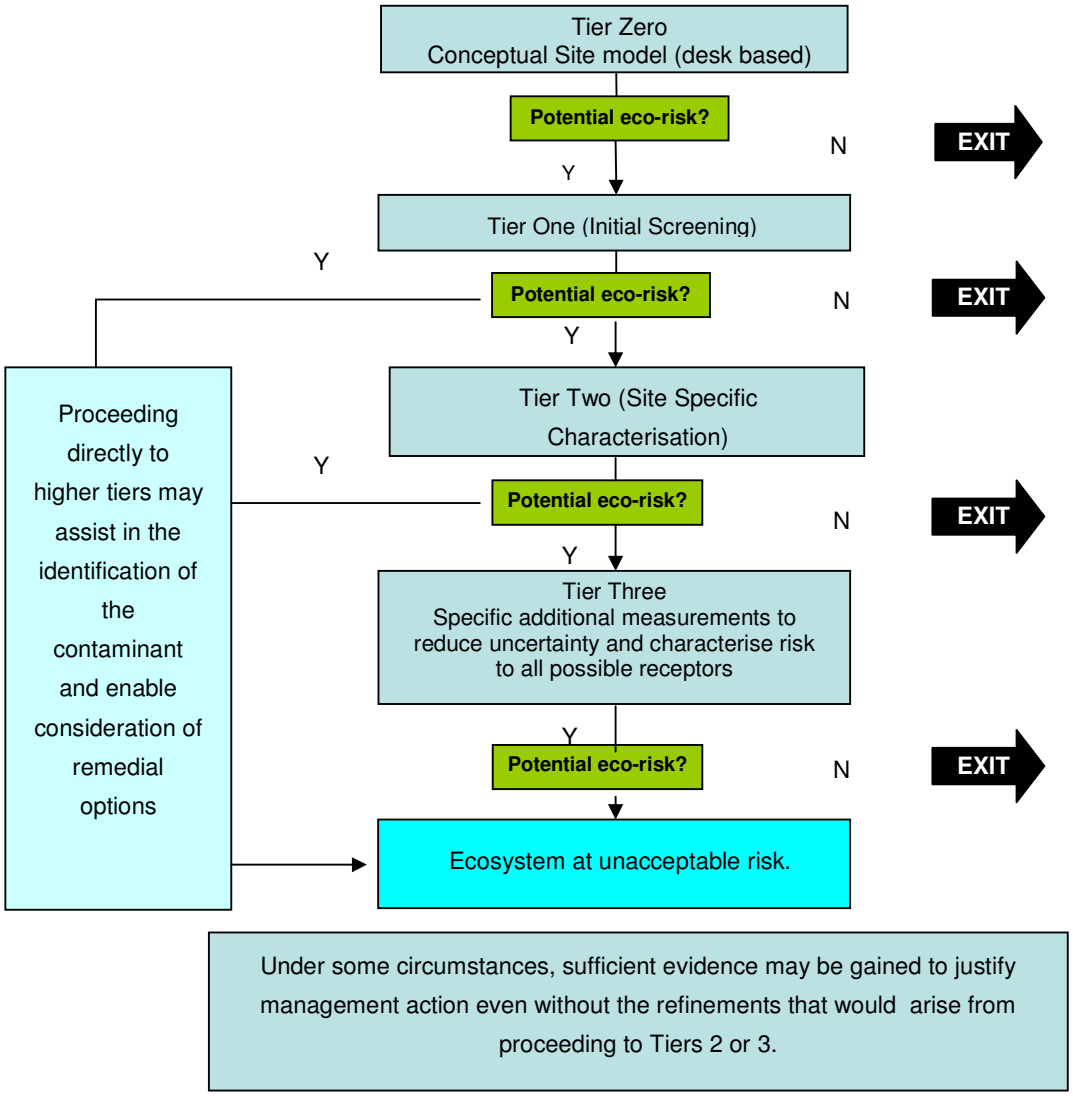


Figure 1: Overview of the Tiered Ecological Risk assessment (EA, 2004a)

The ERA presented here uses the Environment Agency framework in respect of methodology, taking account of the wider framework of documents cited above.

2.1 Tier Zero

The Tier Zero stage aims to determine whether the Site falls under EPA Part IIA considerations and involves the development of a conceptual Site model (CSM) based on existing data on geology, chemical analytical data, ecological surveys and a Site visit. Using the current knowledge of the Site, the CSM identifies potential contaminants, pathways and receptors. If as a consequence of undertaking a Tier Zero assessment, a site is considered to potentially fall under Part IIA conditions and there are at least theoretical contaminant-pathway-receptor linkages, progression to the next stage (Tier One) is warranted.

At Pontypool, this initial stage of works was undertaken and presented in a report issued to Shanks in May 2006. This report has been incorporated into the combined Tier Zero and Tier One ERA presented here (see Section 3.0).

2.2 Tier One

The Tier One stage focuses on a chemical-specific risk assessment, where concentrations of known or potential contaminants present in the environment are compared against thresholds for individual chemicals e.g. soil quality guideline values (SQGVs). In addition, some toxicity screening (e.g. Microtox™ tests) may be incorporated as a means of reducing the chances of missing contaminants that are not covered by traditional environmental quality guideline values (EQGVs). The findings of the Tier One ERA are presented in Section 4.0 of this report.

2.3 Tier Two

Beyond Tier One, the Tier Two stage primarily concerns the assessment of ecological (or biological) significance of the contaminants present at the Site. Appropriate biological information may be obtained through toxicity testing (e.g. acute lethal earthworm test using soil samples from the Site), ecological assessments (e.g. community surveys) or a combination of both. Further chemical analysis may or may not be required. Issues related to contaminant bioavailability or elevated natural levels of contaminants may for instance warrant further chemical analysis. Tier Two may be the most detailed level of assessment applied at most contaminated sites. The need for a Tier Two assessment has not yet been established. Rather, the Tier One ERA recommends further monitoring, verification and risk assessment work to corroborate (or otherwise) current findings. Shanks is committed to this work being undertaken over forthcoming months following submission of the planning application as referenced in Section 4.5.4.

2.4 Tier Three

Tier Three aims to determine the magnitude of the risk to ecological receptors over and above there being a significant risk of significant harm. This is likely to require the application of ecological theory and modelling to define estimates of exposure or to assess impacts at different levels of biological organization.

3.0 TIER ZER0 ASSESSMENT FOR THE SITE

3.1 Definition of the Study Area

It was deemed appropriate to define a reasonably conservative geographical study area for the initial Tier Zero assessment in order to capture the entire footprint of the Site (approximately 3.1 ha) as well as areas which might reasonably be anticipated to be potentially impacted by Site activities. Thus, an initial 10 km radial area from the Site was defined. This captures land within the jurisdiction of the administrative areas of Blaneau Gwent County Borough Council, Caerphilly County Borough Council, Monmouthshire County Council, Newport City Council and Torfaen County Borough Council within which the Site is located. The study area shown on Figure ERA 1 (Appendix 1) therefore comprises:

- areas downstream of the Site which may have received an input of contaminants released from the Site to surface water and sediments;
- soils downwind of the Site (near-field and far-field) which may have received airborne particulate deposition when the incineration process when the plant was active (1974 – 2002); and
- any other areas or ecological receptor communities that may be affected indirectly from on-Site sources of contamination.

3.2 Part IIA Ecological Receptors within the Study Area

The first step in the Tier Zero assessment is to identify where within the 10 km study area, sites which are classified as ecological receptors under the EPA Part IIA 1990 are present. In order to assist in this, the Golder desk based assessment (see Chapter 7 of the Environmental Statement, Volume 2) was used and further consultations were undertaken with TCBC in order to confirm the status of certain sites, which were understood to be in the process of designation as Sites of Importance for Nature Conservation (SINCs). Results are summarised in the Table 1 below and presented on Figure ERA 1 (Appendix 1).

Table 1 - Part II A Ecological Receptors within the Study Area

Categories of Part IIA Ecological Receptors	Part IIA Ecological Receptors within the 10 km Study Area	Approximate Distance and Direction from Site (at closest point)	General Direction in Relation to Afon Lwyd Flow	General Direction in Relation to Prevailing Wind *
International Designations				
RAMSAR Site listed under the Convention on Wetlands of International Importance	None within 10 km radius			
European Site within the meaning of regulation 10 of the Conservation (Natural Habitats etc) Regulations 1994 (i.e. Special Areas of Conservation (SAC) and Special Protection Areas (SPA))	River Usk (SAC)	The River Usk/Afon Wysg north of the Site flows through the Brecon Beacons National Park (BBNP) in an easterly and then southerly direction towards its discharge point in the Bristol Channel, some 15 km south of the Site. For its entire course within the 10 km radius of the Site it is designated as an SAC. It is approximately 7.5 km ENE at its closest point	Upstream and Downstream	Downwind/Crosswind
Candidate Special Areas of Conservation (cSAC) or potential Special Protection Areas (pSPA) given equivalent protection				
National Designations				
A **Site of Special Scientific Interest (SSSI)** under section 28 of the Wildlife and Countryside Act 1981 * designation for geological rather than ecological interest	Llandegfedd Reservoir	2.0 km (ENE)	Upstream	Downwind
	Cilwrgi Quarry *	4.0 km (E)	N/A	Downwind
	Cwm Ton Glascoed *	4.5 km (NE)	Upstream	Downwind
	Brook Cottage *	6.0 km (SE)	Downstream	Downwind
	Henllys Bog	7.1 km (SSW)	Downstream	Upwind
	River Usk (Lower Usk)/Afon Wysg (Wysg Isaf)	7.5 km (ENE)	Upstream/Downstream	Downwind/Crosswind
	Priory Wood	8.7 km (NE)	Upstream	Downwind
	Coed y Darren *	9.0 km (SW)	Downstream	Upwind
	Llanover Quarry *	9.5 km (N)	Upstream	Upwind

Categories of Part IIA Ecological Receptors	Part IIA Ecological Receptors within the 10 km Study Area	Approximate Distance and Direction from Site (at closest point)	General Direction in Relation to Afon Lwyd Flow	General Direction in Relation to Prevailing Wind *
	Blorenge	10.00 km (N)	Upstream	Upwind
National nature reserve (NNR) under Section 35 of the Wildlife and Countryside Act 1981 and Section 19 of the National Parks and Access to the Countryside Act 1949	Some NNRs are designated within Brecon Beacons National Park which at its closest point is located approximately 2 km north of the Site. However, no NNRs appear to be located within the 10 km search radius according to the Brecon Beacons National Park Adopted Local Plan May 1999.			
Marine nature reserve (MNR) under Section 36 of the Wildlife and Countryside Act 1981	None within 10 km radius			
Area of special protection for birds (AoSPs), established under Section 3 of the Wildlife and Countryside Act 1981	None within 10 km radius			
Sites of Regional/Local Importance				
Any habitat or Site afforded policy protection under Paragraph 13 of Planning Policy Guidance Note 9 (PPG9) on nature conservation (i.e. includes those Sites listed above plus those listed below)				
Local Nature Reserves (LNRs) designated by local authorities under Section 21 of the National Parks and Access to the Countryside Act 1949	None within 10 km radius			
Non-statutory Nature Reserves established and managed by a variety of public and private bodies eg county wildlife trusts Royal Society for the Protection of Birds	None within 10 km radius			

Categories of Part IIA Ecological Receptors	Part IIA Ecological Receptors within the 10 km Study Area	Approximate Distance and Direction from Site (at closest point)	General Direction in Relation to Afon Lwyd Flow	General Direction in Relation to Prevailing Wind *
Sites of Importance for Nature Conservation (SINCs) or equivalent. These are usually adopted by local authorities for planning purposes. The name and status of this type of Site varies considerably	Candidate habitats notified by Torfaen County Borough Council for Designation as SINCs			
	Afon Lwyd - proposed to be designated as a SINC because of records of otter, bat species, brown trout, salmon and bullhead	Approximately 20 m NE	Upstream, cross-stream and downstream.	Downwind/Crosswind
	Monmouthshire/Brecon Canal proposed to be designated as a SINC because of records of otter, white-clawed crayfish and yellow pond lily.	Approximately 750 m W	Upstream	Upwind
	Craig-y-felin Wood is an ancient woodland Site which has been partially replanted. The species it contained in 1977 were; wood meadow grass, aspen, figwort and wych elm. These species are listed in the SINC selection criteria.	Approximately 500 m S. The course of the Afon Lwyd downstream of the Site follows the edge of the woodland area.	Downstream	Crosswind
	Butchers Wood is an ancient woodland Site which retains a few species from the SINC selection criteria recorded in 1977. Species were; yellow pimpernelle, dog's mercury, wood sorrel and guilder rose.	Approximately 50 m W		Upwind

* Recorded meteorological data obtained for the purposes of dispersion modelling (see Volume 2, Chapter 11) includes information relating to wind speed and direction. Five years recorded data was obtained from the Rhoose Recording Station located at Cardiff International Airport, located some 40 km southwest of the Site. Yearly recorded data for 2000 to 2004 inclusive is presented as a series of windroses in Figure ERA2. These show the frequency of winds blowing from particular directions, whereas the length of each 'spoke' of the windrose relates to the frequency of time that the wind blows from a particular direction. As can be seen from Figure ERA 2, for all years presented, a westerly wind (NW–W-SW directions) prevailed for the most part with wind speeds between 3 to 8.3 m/s occurring for the majority of this time. Review of historical wind direction data recorded at the Monmouthshire station also showed that the dominant wind directions for years 2002 to 2005 inclusive were either southwesterly or northerly1. In considering the above data, sensitive receptors located in an easterly direction from the Site would be considered most likely to have received airborne emissions from the former HTI stack, being located generally downwind of the stack. However, it should be noted prevailing wind direction would not always have followed this pattern. Furthermore, the UEA report states that certain releases were fugitive rather than from the stack. Consequently, historical atmospheric deposition cannot be simply correlated with prevailing wind direction (also being dependent on factors such as building effects, topography etc.)

[1] http://www.thehendre.com/weather/noaa/noaa_data.htm

3.2.1 International designations

The River Usk is designated as a Special Area of Conservation (SAC) (EC Habitats Directive 1992) for its entire length in the 10 km study area. It is a Major River, some 120 km in length, sourced from the Mynydd Du, flowing eastwards along the Brecon Beacons, through Monmouthshire to the Severn Estuary. The Afon Lwyd enters the River Usk at Caerleon approximately 9.5 km south of the Site and thus this receptor is located downstream and both downwind/crosswind of the Site. At the confluence between the Afon Lwyd and the River Usk, the tidal influence of the Usk provides brackish water.

According to the Environment Agency Wales (2006), the Usk supports excellent habitat for the sea, river and brook lampreys and bullhead. In addition it also supports excellent habitat for salmon, for which it had the highest number of estimated egg deposits of any river to the south of Cumbria. The allis and twaite shads of the herring family both spawn in the Usk, although breeding populations are only found on four rivers in the UK and are rare throughout Europe. Another factor accounting for its designation as an SAC is the presence of otter, which use most parts of the River Usk and whose numbers have increased in recent years.

Outside of the study area (i.e. beyond a 10 km radius), the Usk discharges into the Severn Estuary which itself is designated as a RAMSAR Site (Ramsar Convention on Wetlands of International Importance Especially as waterfowl Habitat), Special Protection Area, (SPA) (EC Birds Directive 1979), pSAC (EC Habitats Directive 1992) and SSSI (Wildlife and Countryside Act 1981). There are environmental requirements for the Severn Estuary not withstanding its EC Directives and international marine wetland designations.

3.2.2 National designations

Brecon Beacons National Park (BBPN) at its most southern point is located approximately 2 km north of the Site (i.e. upstream and upwind). The Park covers an area of 522 square miles and has its own special authority set up to conserve and protect the countryside and to help people enjoy and understand the area. The majority of the park is owned and cared for by farmers; some land belongs to private estates and companies but more than a quarter of the land is owned or leased by public bodies or companies such as Welsh Water, Forest Enterprise, and the National Trust as well as by the National Park authority itself. This agricultural landscape is rich in wildlife habitats and supports numerous plants.

Ten SSSI have been identified within the 10 km extended study area; the nearest SSSI being located approximately 2 km northeast of the Site; the Llandegfedd Reservoir. This is the largest inland open water habitat in the County and has developed into one of the three regionally important over-wintering wildfowl refuges in Wales. The Site is particularly important for the overall numbers and variety of wintering wildfowl, with large numbers of wigeon *Anas penelope*, pochard *Aythya ferina* and mallard *Anas platyrhynchos*. Other

notable species include goosander *Mergus merganser*, teal *Anas crecca* and goldeneye *Bucephala clangula.* The reservoir is located upstream and downwind of the Site.

3.2.3 Sites of regional/local importance

Among the habitats to be afforded policy protection (TAN 5), the Afon Lwyd, proposed by TCBC to be designated as a SINC is located closest to the Site (approximately 20 m). This river flows from the heads of the valley in an approximately southerly direction, entering the River Usk at Caerleon. Within the study area it is therefore located both upstream/upwind and downstream/downwind of the Site. The Lwyd catchment is approximately 109 km^2 and is heavily urbanised. Large towns include Blaenavon, Pontypool (both upstream the Site) and Cwmbran (downstream the Site). Its catchment area was heavily mined, having mainly been worked in the past for iron. However, post-industrial reclamation programs have successfully converted large areas into common land and country and national parks.

Generally speaking the river quality has improved over recent years, both in terms of biological and chemical parameters, and is of a high enough standard to support a salmonid fishery (Environment Agency Wales, 2006). Based on samples of macro-invertebrates community, the Agency classified[1] stretches of the Afon Lwyd both upstream[2] and downstream[3] the former HTI Site as Class C (fairly good, i.e., biology worse than expected for unpolluted river).

The Lwyd catchment, together with Ebbw catchment, is valuable for butterflies, birds, amphibians, crayfish, fish and mammals. UK Biodiversity Action Plan (BAP) priority species recorded in the region include white-clawed crayfish, great crested newt, greater and lesser horseshoe bats, pipistrelle bats, otters, water voles, and various butterflies and moths. Otters have been recorded throughout the catchment. Wetland birds such as the dipper, kingfisher, reed bunting, curlew and grey wagtail occur at various locations. A number of dragonfly species have also been recorded throughout the catchment.

The Monmouthshire and Brecon Canal (proposed to be designated as a SINC) also runs through the lower section of the Lwyd and represents an important biodiversity resource in the catchment. The biodiversity of the canal channel, its towpath and associated habitats varies throughout its length partly due to levels of recreational use and management. The most prominent species are often water plants, whether submerged, floating or emergent species. There are also a wide variety of aquatic invertebrates including mussels, snails, water beetles, water boatmen and the larval stages of insects such as dragonflies, damselflies and mayflies. The plants and invertebrates in turn support a diverse fishery and a variety of water birds. Fish and insects borne from the water channel also support mammals such as otters and bats respectively (Environment Agency Wales, 2006).

[1] http://www.environment-agency.gov.uk/
[2] Conf.Nant Dare - Conf.Nant Ffrwdoer in 2000 and 2002
[3] Conf.Railway Str.-Conf.Nant Dare in 2000 and 2003

Craig-y-felin Wood and Butchers Wood are both located within a 0.5 km radius of the Site and are proposed to be designated as SINCs by TCBC. Both represent ancient woodland sites which retain species from the SINC selection criteria as recorded in 1977. The Afon Lwyd downstream wind of the Site flows along the northern and western boundaries of Craig-y-felin Wood. Butchers Wood (upwind of the Site) has been impacted by the construction of the A4042.

3.3 Review of Existing Information of Relevance for the ERA

3.3.1 Land use in the surroundings of the Site

The surrounding area comprises mixed purpose industrial, commercial and residential land use with occasional fields given over to agricultural (cattle and sheep grazing) use. The area to the north and west of the Site is heavily industrialised with a wide range of automotive, manufacturing and chemical industries present, including the Panteg Steelworks. The majority of the recorded trade entries lie upstream (or up/cross shallow hydraulic gradient) of the Site. These locations start adjacent to the Site and continue, without significant breakage, up to 1 km from the Site (Golder Phase 1 report, Volume 3).

The area to the south and east of the Site is largely free of significant development up to 0.5 km from the Site. Three small landfills are operated between 0.49 km and 0.55 km southwest of the Site, but these are not considered to pose a significant risk to the Site as they are down hydraulic gradient of the Site.

Torfaen as a County has had a long-standing history of industrial development. The TCBC contaminated land inspection strategy (2004) provides a useful context for the historical development and decline of local industrial development:-

Quotation from TCBC Contaminated Land Inspection Strategy April 2004

"The area's manufacturing reputation was established as early as the 16th Century when the Eastern Valley was renowned for its iron making, mines and tin-plate manufacture. The development of Blaenavon and Pontypool in particular was based upon the exploitation of iron and coal. As these industries declined, so too did the dependent valley communities. The challenge therefore for the north of the County Borough is to reverse the social and economic decline of the area through promoting its industrial heritage. Indeed, the 18th Century Iron Works at Blaenavon was awarded World Heritage Status in November 2000.

In contrast, Cwmbran in the south has been a focal point for growth since its designation as a 'new town' in 1949. Cwmbran is Wales' only new town and the sixth largest in the principality. The early to mid years of its evolution witnessed major housing developments and growth in population. The latter years of its development were characterised by industrial development and the promotion of the area as a key location for inward investors due to its

M4 corridor location. Cwmbran is home to some of today's most advanced electronics, automotive and engineering companies from the UK and overseas and the location of Torfaen with its excellent communications links are important factors in the area's continuing success.

The Strategy goes onto state:-

"The presence of heavy industries within the Blaenavon, Pontypool and Cwmbran areas of the County Borough has led to large areas of made ground containing a variety of elevated concentrations of metals and hydrocarbons. The specific location of many of these areas are known to the Council and the majority of these will be addressed through the development control process.

Information currently held does not suggest that these Sites are 'Contaminated' in accordance with the statutory definition and therefore will not warrant action under the Part IIA regime. However, it is important to note that such Sites may well be determined as Contaminated at a later date as new information comes to light and/or to reflect amendments to statutory guidance".

3.3.2 Former operational areas of the Site

The footprint of the former HTI Site comprises eight distinct areas of previous operation which are as follows (see detailed descriptions of the district areas in Golder Phase I report, presented in Volumes 3a and 3b):

- high temperature incinerator (HTI) plant;
- cooling tower structure;
- tank farm;
- transformer handling plant (THP);
- effluent treatment plant (still in operation and may be retained for future use);
- the lagoon;
- gate house/main offices/canteen (still in operation and may be retained for future use); and
- storage areas, buildings and landscaping.

Information regarding the historical use of the Site and specific details on the processes undertaken within the former HTI are detailed in the Golder Phase I Report, (Volume 3 of this submission).

3.3.3 Existing sources of contamination on-Site – results of Phase II Report

During Phase II, samples of soil, groundwater and sediment were retrieved. During the Site investigation process, a number of compounds were assessed with similar nomenclature. In particular, this is the case for furans. The laboratory results refer to furan, dibenzofuran and

polychlorinated dibenzofuran (PCDF) and it is important that these compounds are not confused as their relative toxicity varies significantly.

Furan is a heterocyclic organic solvent, produced when wood, especially pine-wood, is distilled. It is a clear, colourless, very volatile and highly flammable liquid with a boiling point close to room temperature. It is used widely in the synthesis of a number of organic compounds that are used in the food and cosmetics industry. Furan was screened out as a potential compound of concern during the Tier 1 Screening Process.

Dibenzofuran is a polyaromatic hydrocarbon (PAH) found in oily and tarry wastes.

PCDDs and PCDFs are regularly known by the terms "dioxins" and "furans" respectively; however, their scientific names are polychlorinated dibenzo-*p*-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) which are two related families of organochlorine compounds. These families of persistent and lipophilic chemicals are considered to be of extremely high importance in environmental and health assessments. They are easily formed naturally and as unwanted by-products of many commercial reactions, including processes involving combustion, and they have become widespread throughout our environment, even in rural locations. They accumulate within the fat of animals and humans and once taken up by biological tissue, they are extremely difficult to eliminate. It is the introduction of chlorine to the dibenzofuran molecule that increases the relative toxicity and, along with polychlorinated biphenyls (PCBs), PCDDs and PCDFs were considered to represent the most significant potential contaminants of concern at the Site.

Based on the general public's recognition of PCDDs and PCDFs as dioxins and furans, Golder has referred to PCDDs and PCDFs as dioxins and furans respectively throughout this report and the associated risk assessments and remedial options appraisal reports.

3.3.3.1 Shallow Soil Covered with Buildings and Hardstanding

The main sources of contamination on-Site were identified during the Phase II Environmental Site Assessment and Intrusive Site Investigation (Golder 2006, See Volume 3). The sources were identified based on data obtained from the chemical analyses of soil samples as well as a detailed appraisal of historical activities on-Site. The general source areas of identified contamination have been named as 'Shallow Soil 1' and 'Shallow Soil 2'. Both source areas are covered by buildings and hardstanding (See Figure 11 in Golder Phase II Report, Volume 3).

The Shallow Soil 1 area is located around the former covered vestibule and roasting chamber named in the reports as Potential Area of Concern 12 (PAoC 12), central storage compound (PAoC 15) and tank farm (PAoC 19). This shows limited polychlorinated biphenyl (PCB) and semi-volatile organic compounds/volatile organic compounds (SVOC/VOC) contamination.

The Shallow Soil 2 area is located in and around the former transformer handling plant (THP) building (PAoC 16) with polychlorinated biphenyl PCB, polycyclic aromatic hydrocarbons (PAH) and SVOC/VOC contamination.

The data from shallow groundwater monitoring indicates that persistent contaminant zones are present in shallow groundwater, as consistent contaminant concentrations were noted in the data from both monitoring rounds. These "zones" vary in size dependant on the contaminant types, but they appear to be originating from three (3) discrete contaminated areas (see Figure 12 in Golder Phase II Report, Volume 3). These areas are:

- Shallow Groundwater 1 - the area around the former HTI front face, deslagger pit, covered vestibule and roasting chamber, central storage compound and the tank farm (PAoC 7, 11, 12, 15 and 19);
- Shallow Groundwater 2 - the area in and around the former THP building (PAoC 16); and
- Shallow Groundwater 3 – the area in and around the diesel fuel pump and covered storage area (PAoC 20 and 25).

The first two of these areas correspond with the areas of, and contaminant types noted in, Shallow Soil 1 and Shallow Soil 2. The third area corresponds with the TPH contamination noted in shallow soils within and adjacent to the covered storage area and external fuel tank AST.

In summary, it would appear that the historical use and operation of the Site has had an impact upon shallow groundwater. However, contaminants in groundwater appear to be constrained within three discrete areas and appear to be closely related to their likely sources.

3.3.3.2 Uncovered Shallow Soil

Soil samples across the Site with a marked grouping of detection of PAHs have been noted along the southeastern Site edge. Part of this area presents uncovered shallow soil[4]. The origin of such contamination is not clear and anecdotal evidence from Shanks employees that a bonfire was lit in that area shortly before sampling may provide an explanation for the source (at least in part) of the elevated PAH levels in this region of the Site. Another possibility is that those chemicals represent accumulated roadway run-off since PAHs are typical contaminants found in most areas adjacent to major roadways. Thus, the measured levels could simply reflect background contamination.

[4] Soil samples in uncovered soil areas: BH3, BH26, BH34, BH44, BH63, BH81, BH88, BH93, BH94, BH96, GS6, GS7 and GS9 (Golder 2006)

Additionally, dioxins and furans were also detected in soil samples taken along the southeastern Site edge.

3.3.3.3 On-Site Lagoon

In addition to the two main areas described above, isolated occurrences of shallow soil contamination have been detected which are not obviously attributable to a particular PAoC. These were considered as "hot spots". One of these hotspots is the on-Site lagoon which comprises a concrete lined settlement pond for receiving surface water drainage from all areas of the Site and a water treatment plant containing pumps and carbon filters for the treatment of waters received by the lagoon. Sediment samples from the lagoon showed elevated concentrations of metals and PCBs, which are the result of accumulation and concentration of contaminants in surface water and surface drainage from on-Site sources. The lagoon was designed to function in this way, trapping and concentrating any suspended contaminants that were present in surface water runoff and Site drainage waters in order to prevent these contaminants from leaving the Site. The surface water management system remains in place on-Site as does the treatment and controlled discharge of surface water to foul sewer under consent from Welsh Water (see Volume 2, Section 6.3).

Metals contamination was noted in soil from the eastern edge of the Site, within the lagoon sediment and from BH81 and GS6. The contamination recorded in the lagoon sediment and GS6 is likely to be due to accumulation and concentration of contaminants in surface water and surface drainage (from both on and off-Site sources). The contamination noted in BH81 appears to be an isolated "hot spot" of contamination.

Whilst it can be seen from the result that metals are ubiquitous in the soils across the Site, the concentrations identified on-Site are inconsistent with those identified off-Site, and as such, it is considered that the former HTI facility does not represent the principal source of the off-Site metal concentrations. The fact that metals appear throughout the Site may also reflect the fact that the Site resides on an area with previously elevated levels of metals.

Shanks Waste Management and Torfaen Borough Council have agreed to collaborate to assess further the off-Site metal concentrations in the soils adjacent to the Site boundary.

3.3.4 Environmental monitoring in the surroundings of the Site - The Panteg Project

Analysis of PCBs, dioxins and furans in soil in the vicinity of the incinerator (when operational) and within the residential areas of Lower New Inn was performed by the School of Environmental Sciences (SES) of the University of East Anglia (UEA) (Panteg Monitoring Project, Fifth Interim Report, January 1994). Results suggested that PCB levels in soils above 50µg/kg were almost entirely restricted to a strip of land approximately 200 m wide around the eastern Site boundary. Soil concentrations of dioxins and furans followed a similar

pattern to those of PCBs and their highest levels were found in the immediate vicinity of the incinerator.

Comparison of the data collected in 1992/1993 with measurements since 1994 (provided by Shanks to Golder) showed a generally downward trend in PCB concentrations in soils. According to the Environment Agency, a decline in concentrations of PCBs with time would be expected in line with reduced releases of PCBs from the Shanks Site.

Analysis of PCBs in grass showed a marked reduction in PCB concentrations with distance from the facility as well as a temporal downward trend. Concentrations of dioxins in grass also reduced with distance.

Analysis of milk and eggs of farm animals living in the surroundings of the incinerator plant was performed by the SES, (UEA) from 1978 to 1992 (Panteg Monitoring Project, Fourth Interim Report, April 1993). No significant differences in concentrations of PCBs and dioxins/furans in milk were found between any of the farms and the levels were comparable to those found in other urban areas.

Concentrations of PCBs in duck eggs sampled during 1989/90, and hen eggs sampled in 1992, from a farm located near to the eastern boundary of the plant (Pont-y-Felin House) were several times higher than the values found in eggs from the next farm. The likely explanation of the high results given by SES (UEA) was the ingestion by birds of soil and grass on that farm. Concentrations of dioxins/furans in eggs from Pont-y-felin House were also higher than in eggs from other farms.

Monitoring around the Site for dioxins and furans continues today and has recently been undertaken in conjunction with TCBC. The recent monitoring data (1998-2005) have been used in the Tier One ERA presented in later sections of this report.

3.4 Routes of Transport

Organisms can be exposed to contaminants present in different environmental media. In this study, the most relevant media are uncovered shallow soil[5], surface water, sediment, food (plant and animal parts) and air.

The routes of transport are defined as the physical routes by which a contaminant can move from a source to a biological receptor, which may involve exchange among multiple media. For instance, routes can include migration from soil to groundwater, adsorption from water to sediments, uptake from soil to plants etc. Fate processes, such as biodegradation (i.e. the breakdown of organic compounds by micro-organisms), should also be taken into account when evaluating transport routes.

[5] Including samples from the depths 0 – 1.5 m

Potential routes of transport to EPA Part IIA receptors located within the 10 km study area (as described in Section 2) are discussed below, including justification for screening certain routes in or out of the next steps of the ERA.

Route 1 : Soil – Groundwater - River Sediment/Water - Organisms

Some contaminants present in soil (in both covered and uncovered soil) at the Site may have the potential to migrate to shallow groundwater and thereafter potentially reach nearby surface water bodies such as the Afon Lwyd, a proposed SINC and therefore Part IIA receptor. The Afon Lwyd downstream traverses Craig-y-felin Wood (another proposed SINC) and discharges 9.5 km downstream into the River Usk (a SAC). The potential for migration will however, depend on the physical and chemical properties of each contaminant (e.g. hydrophobic properties and biodegradation).

The following chemicals were found in shallow groundwater on-Site (groundwater *above* the contact of the Raglan Marl mudstone and *within* the overlying made ground, fluvial and glacial sediments):

- metals;
- hydrocarbons (including MTBE, benzene, toluene, xylenes);
- PCBs;
- pentachlorophenol;
- bis(2-ethylhexyl)phthalate;
- naphthalene;
- hexachloroethane;
- 1,2-dichlorobenzene; and
- carbazole.

As already discussed, results of the Phase II investigations suggest that historical operations at the Site have had an impact upon shallow groundwater. Contamination has also been detected in deeper groundwater, although the provenance of this contamination is still unclear (refer to HRA, Volume 5 regarding deep groundwater). Although contaminants currently detected in shallow groundwater may migrate off-Site and reach surface water, results from Phase II investigation suggest that contaminants in groundwater appear to be confined within three discrete areas and appear to be closely related to their likely sources. Nevertheless, off-Site migration of contaminants via shallow groundwater into the Afon Lwyd (and thereby to this and other Part IIA receptors including Craig-y-felin Wood and the River Usk) is considered a plausible transport route in this assessment.

Water samples from the Afon Lwyd indicated the presence of metals, including copper, zinc, chromium and lead. Data suggests that these contaminants are present in the river water *before* it passes the Site, and indeed before passing within the likely influence of groundwater flow from beneath the Site. Such metals are also detected in samples from the Afon Lwyd after the river passes the Site (i.e. downstream). It should be noted that PCBs, dioxins, furans

and other compounds (see Volume 3) were not detected in surface water samples from the Afon Lwyd at concentrations above laboratory detection limits (upstream and adjacent to the Site).

Once in the aquatic environment, some of the detected chemicals tend to adsorb or precipitate (e.g. lead) in sediments. Some can also bioconcentrate, i.e. increase in concentration in relation to their ambient concentrations (e.g. lead, dioxins and furans). Some can even biomagnify, i.e. chemical levels in plants or animals increase from transfer through the food web, meaning that predators have greater concentrations of a particular chemical than their prey (e.g. PCBs).

*Based on the information described above, the route uncovered/covered soil – groundwater - surface water -sediment- organisms **is** considered relevant.*

Route 2 : Uncovered Shallow Soil - River Sediment/Water – Organisms

Contaminants present in shallow soils are unlikely to reach the Afon Lwyd by superficial run-off given that the entire Site area drains to the on-Site lagoon. Effluent from the lagoon enters an on-Site treatment process comprising a system of storage and granulated activated carbon (GAC) filters before discharge under trade effluent consent to foul sewer. Consequently, no water from the lagoon enters the Afon Lwyd under any circumstances.

*Based on the information described above, the route soil – surface water – sediment - organisms **is not** considered relevant.*

Route 3 : uncovered shallow soil - organisms

Chemicals present in uncovered shallow soils can be taken up by organisms (i.e. plants, invertebrates). Some of these could bioconcentrate and biomagnify in the food web. It should be noted however, that the uncovered soil zone represents only a small portion of the total area of the Site (~15%).

*Based on the information above the route uncovered shallow soil - organisms **is** considered relevant.*

Route 4 : Soil - Groundwater – Organisms

Shallow groundwater at the Site is impacted with metals, hydrocarbons and PCBs. In normal conditions, animals would have limited access to groundwater. However, plants may be exposed to shallow groundwater via root uptake. Since some trees are found in the southeastern edge of the Site where the groundwater depth is approximately 2 mbgl:

*The route soil - organisms (plants) **is** considered relevant in this study.*

Route 5 : Uncovered Shallow Soil - Air - Organisms

Chemicals detected in uncovered shallow soil could volatilize to air. However, chemicals identified on a preliminary basis as potential for concern in uncovered shallow soil (metals, PCBs, benzo(a)pyrene, benzo(a)anthracene and dibenzo(ah)anthracene) are not considered highly volatile (Henry's law constant lower than 1 x 10^{-5} atm-m^3/mol). Even if volatilization occurs, vapours would rapidly disperse outdoors.

Dust generation from contaminated soils could also be of concern. However, most of the soil which is not covered with buildings and hardstanding is covered by vegetation. Therefore dust generation will not be a major concern at the present time.

*Based on the information described above, the route uncovered shallow soil – air – organisms **is not** considered relevant in this study.*

Route 6 : Shallow Soil Covered with Buildings and Hardstanding - Air - Organisms

Chemicals detected in soil could volatilize to indoor air and some of them (i.e. TCE, PCE, benzo(b)fluoranthene) are considered volatile. Such sources are of potential concern in relation to human exposure within certain buildings proposed (i.e. the MBT building which is to be situated in the vicinity of the former tank farm). However, although indoor exposure is of concern to human health, it is not likely to occur for ecological receptors.

*Based on the information above the route covered shallow soil – air – organisms **is not** considered relevant in this study.*

Route 7 : Air (Former Industrial Emissions) - Uncovered Shallow Soil - Organisms

The Panteg Project, Fourth Report (1993) concluded that the relatively high concentrations of PCBs, dioxins and furans close to the plant and extending to approximately 500 m to the east and south appeared to be due to material leaving the Site. The variation with the time of existing air measurements correlated reasonably well with meteorological observations. However, the source of the local contamination associated with the Site was considered uncertain and the distribution of those chemicals on the Site itself was not attributed to the deposition from the stack. Furthermore the observed variation in concentrations close to the Site suggested drift (i.e. fugitive releases) from a source at low level, such as the tank farm.

The fugitive emissions (rather than the stack emissions) during the times when the former HTI was operating could have contaminated off and on-Site soils via atmospheric deposition (from air to land and/or water). Since some of the contaminants previously emitted could be persistent, terrestrial organisms could theoretically still be exposed to contaminants derived from former on-Site sources.

Both Gemmell and the SES (UEA, Panteg Monitoring Project, Fifth Interim Report, January 1994) results suggest that there was a low impact on soils distant from the Site. However, soils on the nearby farm at Pont-y-felin House may have been impacted by atmospheric emissions during the times when the former HTI was operating. Contaminants present in soil can bio-accumulate in plants and animals.

Based on those observations, the route air (former plant emissions) - uncovered shallow soil (on-Site and nearby off-Site) – organisms ***is*** *considered relevant in this study.*

In summary, the routes of contaminant transport retained for the next steps of the risk assessment are as follows:

- **Route 1** - soil – groundwater – river sediment/water – organisms;
- **Route 3** - soil – groundwater – organisms;
- **Route 4** - uncovered shallow soil – organisms; and
- **Route 7** - air (former industrial emissions) **-** uncovered shallow soil – organisms.

3.5 Exposure Pathways

Exposure pathways are the routes by which organisms can be exposed to contaminants. A contaminant represents a potential risk only if it can reach receptors through an exposure pathway at a concentration that could potentially lead to adverse effects. If there are no pathways for a contaminant to reach a receptor, then, there is negligible risk, regardless of the contaminant concentration.

Potential exposure pathways are discussed below, together with the rationale behind whether or not they are retained in the next steps of the risk assessment. Since the routes dust generation and volatilization from soil were not considered of major concern (see discussion in previous section), inhalation of dust and vapours are not included here.

Pathway 1 : Ingestion of Soil

Occasional ingestion of soil by animals visiting the Site was considered possible in areas not covered with buildings and hardstanding (i.e. limited areas of the Site). The incidental ingestion could occur, for instance, via consumption of soil-covered plant roots or during grooming and preening after visiting the area, even if the uncovered soil area is relatively small and if events that would lead to the exposure can be considered rare. Animals could also be exposed to contamination in soil located the off-Site, nearby the plant. Therefore, this pathway was considered ***plausible***.

Pathway 2: Ingestion of Water

Ingestion of water from the Afon Lwyd or even further downstream (River Usk) by animals such as birds and mammals was considered a ***plausible pathway***.

Occasional ingestion of water from the on-Site lagoon by animals visiting the Site was also considered possible, but it would most likely represent a rare and short-term exposure to contaminants present in that waterbody. This hypothesis has been confirmed by Shanks' employees. Therefore the ingestion of water from the lagoon ***was not considered a plausible pathway.***

Pathway 3 : Ingestion of Sediment

Occasional ingestion of sediment from the Afon Lwyd or even further downstream (River Usk) by animals such as fish, birds and mammals feeding on benthic organisms was considered a ***plausible pathway***. The incidental ingestion could occur during searches for food items.

Occasional ingestion of sediments from the lagoon by animals visiting the Site was also considered possible, but would most likely represent a short term exposure. Therefore the ingestion of sediments from the lagoon ***was not included a plausible pathway***.

Pathway 4 : Ingestion of Food

Ingestion of food items, including plant parts, terrestrial invertebrates and aquatic organisms, was considered a ***plausible pathway***, especially for those chemicals known to bioaccumulate.

Pathway 5 : Direct Exposure To Soil

Plants, soil invertebrates and soil microbes are assumed to be directly exposed to whole soil and therefore this was considered a ***plausible pathway***.

Pathway 6 : Direct Exposure To Surface Water And Sediment

Fish, aquatic invertebrates and aquatic plants are assumed to be exposed to potential contaminants in water and sediment. For this reason this was considered a ***plausible pathway***.

Pathway 7 : Dermal Contact With Soil, Sediment And Water

Feathers and fur prevent dermal exposure to potential contaminants for birds and mammals. However, this pathway can be significant for amphibians and thus is considered a ***plausible pathway***.

Pathway 8 : Root Uptake Of Water

As already mentioned, trees are found in the northeastern, southern, and southeastern Site edges and where root systems are present in the vicinity of shallow groundwater, these trees could be exposed to contaminants via root uptake. For this reason, this was considered a ***plausible pathway***.

In summary, all of the above exposure pathways were considered plausible and are to be retained for the next steps of the assessment.

3.6 Ecological Receptors

Receptors are ecological entities which can be exposed to stressors (e.g.; potential contaminants, changes in habitat, noise, introduction of new species). Ecological receptors can be species, populations, communities or entire ecosystems. For this assessment, plants and animals that are potentially at risk of direct or indirect exposure to contaminants have been identified with specific reference to the EPA Part IIA as discussed in Sections 1 and 2.

Table A of DETR Circular 01/2006 lists four types of receptors:

- human beings;
- property in form of crops, including timber; produce grown domestically, or on allotments, for consumption; livestock; other owned or domesticated animals; wild animals which are the subject of shooting or fishing rights;
- property in form of buildings; and
- any ecological system or living organism forming part of such a system, within certain protected habitats.

The following 10 protected habitats (including those which are shortly to receive designation as SINCs) have been identified within the 10 km study radius (the list excludes SSSI designations for geological interest):

1. River Usk (SAC);
2. Llandegfedd Reservoir (SSSI);
3. Henllys Bog (SSSI);
4. River Usk (Lower Usk) / Afon Wysg (Wysg Isaf) (SSSI);
5. Priory Wood (SSSI);
6. Blorenge (SSSI);
7. Afon Lwyd (proposed SINC);
8. Monmouthshire/Brecon Canal (proposed SINC);
9. Craig-y-felin Wood (proposed SINC); and
10. Butchers Wood (proposed SINC).

Of these 10 protected (or proposed protected) habitats the only ones located downstream of the Site which may have received (be receiving, or have the potential in the future to receive) an input of contaminants released from the Site to surface water and sediments are (for further details refer to Table 1):

1. River Usk (SAC);
2. River Usk (Lower Usk)/Afon Wysg (Wysg Isaf) (SSSI);
3. Afon Lwyd (proposed SINC); and
4. Craig-y-felin Wood (proposed SINC).

For these protected habitats, the types of harm that are to be regarded as significant are:

- harm which results in an irreversible adverse change, or in some other substantial adverse change, in the functioning of the ecological system within any substantial part of that location; or

- harm which affects any species of special interest within that location and which endangers the long-term maintenance of the population of that species at that location.

In addition, in the case of the River Usk, an SAC, significant harm is defined as harm which is incompatible with the favourable conservation status of natural habitats at that location or species typically found there. Any other description of harm to ecological receptors of the three kinds of significant harm mentioned above should be disregarded.

The ecosystem components considered to be relevant within the Part IIA receptors listed above are presented in Table 2.

Table 2 - Ecosystem Components Considered as Relevant Receptors

Receptors	Relevance
Terrestrial plant community	Food supply for animal species.
Soil invertebrates community	Food supply for animal species.
Soil microbial community	Nutrient supply for plant growth.
Aquatic community	The **River Usk** is important for its populations of Annex II fish species. Sea lamprey *Petromyzon marinus*, mainly restricted to lower reaches of the catchment; brook lamprey *Lampetra planeri*; river lamprey *Lampetra fluviatilis*; twaite shad *Alosa fallax* (protected under The Wildlife & Countryside Act 1981 Damage/destruction of place of shelter/protection S.9(4)(a) only); Atlantic salmon *Salmo salar*; Bullhead *Cottus gobio*. Records of brown trout, salmon and bullhead are known in the **Afon Lwyd** and are evidence for proposed designation as a SINC by TCBC. Protected species such as white-clawed crayfish (Schedule 5 of the Wildlife and Countryside Act 1981, and priority species in UK Biodiversity Action Plan); records upstream of Site in **Afon Lwyd.** A River Corridor Survey (RCS) was undertaken in May 2006 which provided further information on the aquatic community present within the Afon-Lwyd, up to 500m The results of the survey are presented in Volume 2, Chapter 7 of the ES, and a copy of the RCS report is presented in Appendix 4 of this report. In summary, evidence and/or sightings of kingfisher, dipper, mink and otter were noted over the course of the survey. In addition, the potential for white-clawed crayfish *Austropotamobius pallipes* and salmonids was noted.
Amphibian populations	Protected species such as Great Crested Newt (European Protected Species under The Conservation (Natural Habitats, &c.) Regulations 1994; protected under Schedule 5 of the Wildlife and Countryside Act 1981 (as amended); Priority species in UK Biodiversity Action Plan) may be present in local Part IIA receptor Sites although no records are available.
Vegetarian mammals and birds populations	Protected species such as water voles (protected under Schedule 5 of the Wildlife and Countryside Act 1981 (as amended) in respect of Section 9(4)) - records known upstream of Site in the Afon Lwyd. Mallard *Anas platyrhynchos* (diet mainly comprises aquatic plants, seeds and insects); present along Afon Lwyd. Greenfinch *Carduelis chloris* (diet mainly comprises berries and seeds); present within the Site works area and may use other Part IIA receptor Sites.
Insectivorous mammals and birds populations	Protected species such as badger *Meles meles* (Protection of Badgers Act 1992) have been recorded in the local area and may be using Part IIA Sites. Pied Wagtail *Motacilla alba*; blackbird *Turdus merula* i.e. birds on-Site eating predominantly insects and may be using Part IIA Sites nearby such as Butchers Wood.

Receptors	Relevance
Piscivorous mammal and bird populations	Protected species such as otter (Schedule 5 of the Wildlife and Countryside Act 1981, and priority species in UK Biodiversity Action Plan) – records on Afon Lwyd. Heron *Aredea cinra* (mainly fish based diet) may be using Afon Lwyd. Dipper *Cinclus cinclus* (diet based on aquatic organisms) (Wildlife and Countryside Act 1981). Kingfisher *Alcedo atthis* (fish and aquatic insects based diet) WCA 1981 may be using Afon Lwyd - (Schedule 1) Royal Society of the Protection of Birds (RSPB) – Amber List Species.

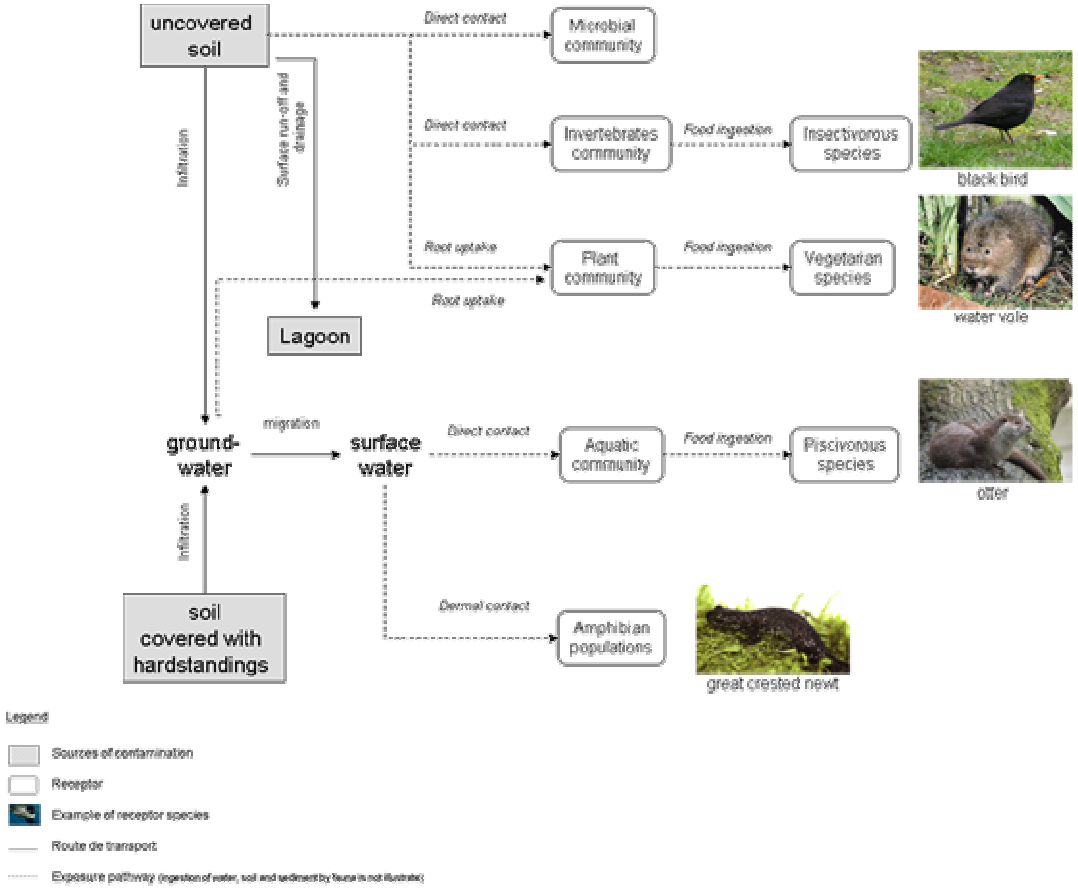
3.7 Spatial and Temporal Boundaries

The UK framework for ERA advocates use of conservative principles such that selected receptor species should be assumed to have a 100% spatial and temporal overlap with identified contamination sources. This assumption will inevitably often result in an overestimation of risk, since some species may have a home range larger than the contaminated area and others may migrate to other regions during several months of each year. This conservative assumption is considered appropriate in the early tiers of the ERA, although it is recommended that these boundaries are refined in the subsequent tiers of the assessment, (if warranted).

3.8 Preliminary Conceptual Site Model

A preliminary Tier Zero CSM is presented in Figure 2 below. This is based on the initial identification of potential major contaminants, routes of transport and pathways of exposure as well as the characteristics of the selected Part IIA ecological receptors.

Figure 2: Preliminary Conceptual Site Model – (presented also in Figure ERA3 in Appendix 1)



The main sources of contamination identified in the Tier Zero are:-

- soils covered by on-Site buildings and hardstanding;
- uncovered soils in soft landscaped areas and within the ditch external to the Site; and
- waters and sediments within the on-Site lagoon.

Contaminants present in soils may have the potential to migrate to groundwater and thereafter potentially, to the surface waters of the Afon Lwyd. Chemicals present in soils cannot reach such surface water bodies via surface water run-off however, given that the entire Site area drains to the on-Site lagoon and contaminated waters are subsequently treated on-Site and discharged under trade effluent consent to the Welsh Water foul sewer. There is therefore considered to be no connection between the lagoon and the Afon Lwyd.

Soil invertebrates and microbes may be directly exposed to soil, especially in the limited areas of the Site not covered by hardstanding and in nearby soil off-Site including the drainage ditch. Plants can be exposed to contaminants in soil and groundwater via root uptake.

The aquatic community, including plants, invertebrates and fish can be directly exposed to contaminants where these are present in water and sediment. Some fish species can also be exposed by ingestion of food (algae, invertebrates and other fish). Amphibians, if present, can be exposed via dermal contact with water and sediment.

The aquatic ecosystem most likely to be affected by on-Site contaminants is the Afon Lwyd (a proposed SINC) due to its proximity to the Site. If contaminants are present in the River and are transported further downstream, other receiving water bodies such as the River Usk, an SAC, could also be affected. It is considered that there is no direct connection downstream of the Site into the Monmouthshire and Brecon Canal (also a proposed SINC) and therefore this receptor would not be affected.

Mammals and bird species can be exposed by ingestion of food (insects, plants and/or fish), depending on their diets. Although not illustrated in Figure 2 above, all wildlife can be exposed via ingestion of soil, water and, occasionally, sediment, depending on their feeding habits and habitats.

Due to the rapid throughput of water into and out of the on-Site lagoon, permanent aquatic fauna and flora are not expected to be found in the lagoon. Therefore it is not considered to be a relevant source of food for wildlife. Occasional visits to the Site can also expose animals to contaminants present in the lagoon if they ingest water from this source, but such events are likely to be rare.

3.9 Uncertainty Within the Tier Zero

Uncertainty is inherent within all risk assessment work and it is important to make clear where uncertainties are present (as discussed below) in order to enable targeted efforts towards reducing uncertainties during subsequent tiers of the ERA.

Where uncertainties have been present within Tier Zero ERA, conservative assumptions have been made in order to ensure that risks have not been underestimated and only negligible pathways and receptors have been screened out from further assessment in Tier One (presented in Section 4.0).

3.9.1.1 Definition of the Study Area

The study area was preliminarily defined by a 10 km radial area, with the Site lying at its centre. The study area thus included the entire footprint of the Site as well as areas which might reasonably be anticipated to have received an impact from former Site activities (soils downwind from the Site which may have received airborne particulate deposition from the former incinerator stack; areas downstream from where contaminants may have previously been released to surface water and sediments; and any other areas or ecological receptor communities that may be affected indirectly from on-Site sources of contamination.

This definition of the study area is likely to be very conservative. This is because the transportation evaluation route suggests that air dispersion of contaminants; even when the incineration processes at the plant were active, was likely to be much smaller than a 10 km radius. Studies performed by School of Environmental Sciences (SES) of the University of East Anglia (UEA) (Panteg Monitoring Project, Fifth Interim Report, January 1994) suggested that contamination was almost restricted to a strip of land approximately 200 m wide around the eastern Site boundary.

The CSM shows that the aquatic ecosystem most at risk from any potential effects is the Afon Lwyd, due to its close proximity to the Site. However, in line with the conservative approach adopted for this ERA, other potential receiving water bodies, such as the River Usk some 9.5 km downstream, have also been considered in the risk assessment. Considering the large distance from the Site to this waterbody, as well as the low concentrations of contaminants found in samples from the Afon Lwyd during the Phase II investigation, impacts to the River Usk from contaminants originating from the Site are considered unlikely (particularly when dilution/degradation and dispersion is considered).

3.9.1.2 Sources of Contamination

The area surrounding the Site comprises mixed purpose industrial, commercial, residential and limited agricultural land uses. The area to the north and west of the Site is heavily industrialized. The majority of the recorded local industrial and commercial activities (refer to Volume 3 for further information) lie upstream (or up/cross shallow hydraulic gradient) of the Site. The influence of these off-Site sources of potential contamination in the concentrations of chemicals found in soil (especially uncovered soil), groundwater (especially deep groundwater) as well as water and sediment samples from the Afon Lwyd cannot be fully understood at Tier Zero.

Further investigations should be undertaken in further Tiers of the ERA to determine the likely provenance of these chemicals.

One of the identified on-Site sources of contamination was uncovered shallow soil along the southeastern Site edge. The origin of such contamination is not clear and anecdotal evidence from Shanks employees that a bonfire was lit in that area shortly before sampling may provide an explanation for the source (at least in part) of the elevated PAH levels in this region of the Site. Another possibility is that those chemicals represent accumulated roadway run-off since PAHs are typical contaminants found in most areas adjacent to major roadways. Thus, the measured levels could simply reflect background contamination.

Further investigations should be undertaken in further tiers of the ERA to determine the likely provenance of these chemicals.

3.9.1.3 Chemicals of Potential Concern

A preliminary evaluation of chemicals of potential concern was derived from the findings of the Phase II Investigations, where concentrations of chemicals found in soil samples were subject to Tier One screening (i.e. Soil Guidance Values). The screening values used were mostly based on human health criteria and are therefore not fully applicable to the protection of ecological receptors.

A revised screening process, using screening values for the protection of ecological receptors, will be undertaken within the Tier One ERA in order to corroborate or revise the list of potential chemicals of concern.

3.9.1.4 Routes of Transport

Potential routes of transport were identified during the Tier Zero ERA. Some fate processes were preliminarily discussed, but a more detailed evaluation is required in further tiers of the ERA.

Once all chemicals of concern have been identified, fate processes such as biodegradation will be evaluated in further tiers of the ERA.

The potential for the contaminants to migrate was investigated by means of detailed groundwater and controlled waters modelling by Golder as part of the HRA which is presented in Volume 5 of this ES.

3.9.1.5 Spatial and Temporal Boundaries

It has been considered that selected receptor species have 100% spatial and temporal overlap with contamination sources in the Tier Zero ERA. As already mentioned this assumption may result in an overestimation of risk, since some species may have a home range larger than the contaminated area and others may migrate to other regions during several months per year.

Spatial and temporal boundaries should be refined in the subsequent tiers of the ERA

3.10 Conclusions and Recommendations of Tier Zero

The Tier Zero ERA has been completed according to the framework proposed by the Environment Agency. The assessment has been based upon current knowledge of the Site, including available chemical analytical data, ecological surveys and a desk based review in order to identify existing protected habitats within the study area.

Theoretical linkages between contaminants originating from the Site - pathways of exposure - ecological receptors of relevance under Part IIA of the Environmental Protection Act 1990 were identified. Conservative assumptions were used and only negligible pathways of exposure and receptors were excluded.

3.10.1 Sources of contamination

The main on-Site sources are as follows:

- contaminated soils covered by buildings and hardstanding;
- uncovered contaminated soils; and
- contaminated waters and sediments within the on-Site lagoon.

Chemicals of potential concern preliminarily identified include the following:

- metals;
- dioxins and furans;
- TPH;
- PCBs;
- PAHs; and
- TCE and PCE.

3.10.2 Receptors of potential concern

The following protected habitats have been identified as been of potential concern. They are located downstream of the Site within a distance of the 10 km:

- River Usk (SAC);
- River Usk (Lower Usk)/Afon Wysg (Wysg Isaf) (SSSI);
- Afon Lwyd (proposed SINC); and
- Craig-y-felin Wood (proposed SINC).

Within the protected habitats listed above, the ecosystem components considered to be relevant receptors are listed below. These were selected for their ecological (e.g. nutrient supply for plant growth food supply for other animals) or social importance (e.g. protected species or wildlife which is subjected of shooting or fish rights).

- terrestrial plant community;
- soil invertebrates community;
- soil microbial community;
- aquatic community;
- amphibian populations;
- vegetarian mammals and birds populations;
- insectivorous mammals and birds populations; and
- piscivorous mammal and bird populations.

For those populations, community and protected habitats, the types of harm that should be regarded as significant are as follows:

- harm which results in an irreversible adverse change in the functioning of the ecological system within any substantial part of that location; or
- harm which affects any species of special interest within that location and which endangers the long-term maintenance of the population of that species at that location.

In addition, in the case of the River Usk (an SAC), significant harm is defined as harm which is incompatible with the favourable conservation status of natural habitats at that location or species typically found there.

3.10.3 Potential pathway of exposure

The following pathways of exposure were considered plausible and should be further evaluated:

- ingestion of contaminated water by wildlife from surface water bodies, especially the Afon-Lwyd but also River Usk;
- ingestion of contaminated soil on-Site and off-Site (nearby the plant) by wildlife;
- accidental ingestion of contaminated sediment by fish and wildlife feeding on aquatic organisms;
- ingestion of contaminated food such as plant parts, soil invertebrates and aquatic organisms;
- direct exposure of plants, soil invertebrates and soil microbes to soil;
- direct exposure of aquatic organisms to contaminated surface water and sediment;
- dermal contact of amphibians with contaminated soil, sediment and water; and
- root uptake of contaminated groundwater by plants.

3.10.4 Need for Tier One

The results of the Tier Zero ERA suggest that there is a potential risk to microbial, invertebrates and plant communities in direct contact with relatively small areas of impacted uncovered soil on-Site, as well as bird and mammal populations feeding on invertebrates or plant parts from the Site. Furthermore, the aquatic community living in rivers potentially impacted by chemicals originating from the Site, as well as wildlife whose diets are based on aquatic organisms, could also be at risk.

According to those preliminary findings, a Tier One ERA is warranted. Measured chemical concentrations in uncovered shallow soil, surface water and sediments should then be compared against thresholds for individual chemicals (e.g. soil, sediment and water guideline values) for protection of ecological receptors.

4.0 TIER ONE ASSESSMENT FOR THE SITE

4.1 Introduction

According to the Environment Agency (2003, 2004a), a Tier One ERA should aim to use as much existing data and information as possible to support decision-making at minimum cost. Tier One ERA is designed to be conservative and during this stage the emphasis is on a chemical-specific risk assessment. Essentially, Tier 1 includes two activities:

- screening of chemicals of concern; and
- estimation of hazard indexes (HIs).

During screening of chemicals of concern, concentrations of known contaminants present in the study area are compared to published thresholds for individual chemicals. These thresholds are referred to generically as environmental guidelines values, i.e. concentrations of chemicals below which no adverse effects on the specific ecological receptor groups are expected. According to the Environment Agency (2003), screening values that are below background levels are unusable. Therefore the evaluation of background levels is also incorporated into the Tier One ERA process.

For this Tier One ERA, measured chemical concentrations in uncovered shallow soil[6] at the Site, soil/sediment within the shallow drainage ditch located outside the Site boundary[7] and surface water[8] and sediments[6] of the Afon Lwyd have been compared with soil, sediment and water guideline values for protection of ecological receptors, derived from a range of UK and international guidance documents. The aim of this screening is to eliminate chemicals that pose no risk to identified receptors (refer to the CSM) and conversely, to identify those chemicals where risks to ecological receptors, according to the screening criteria, warrant further assessment according to the Environment Agency methodology (2003, 2004a).

The soil, sediment and water quality guideline values used for screening are described in Section 4.2.1. It should be noted that environmental guidelines concerned with ecological protection can be an order of magnitude lower than the ones which have been developed for the protection of human health. This is due to factors such as species sensitivity, exposure pathways and/or exposure time and the inherent differences between human and non-human species.

The second activity of the Tier 1, estimation of hazard indexes (HIs), is undertaken by comparing the predicted (or measured) environmental concentrations (PECs) to predicted no-effects concentrations (PNECs) which can be used to assess potential risk to ecological receptors. The aim of this stage is to evaluate which chemicals at the Site are present in

[6] Soil samples identified as BH3, BH26, BH34, BH44, BH63, BH81, BH88, BH93, BH94, BH96 – see sampling location in the Figure ERA4 of this report
[7] GS6, GS7, GS9 and GS 10 (Golder 2006)
[8] Surface water and sediment samples identified as GS11, GS 12 and GS 13 (Golder 2006)

concentrations potentially high enough to cause effects on ecological receptors which use the Site and form component parts of the Part IIA ecological Sites (refer to Tier Zero).

The HI method is widely used to express risk, but is best suited to assessing high risk (potentially adverse exposure) or low risk (reasonable safe exposure) situations. According to the Environment Agency (2003), when quotients are close to unity or within an order of magnitude, it becomes difficult to make decisions based on this value alone. Additional data and information may be necessary.

In this study, PECs correspond to available measured concentrations in soil at Site and measured sediment and water from the Afon Lwyd. PNECs are literature-based values which indicate the lowest environmental concentrations at which the absence of any adverse effects is expected.

As a way to link the hazard quotient approach to the receptors identified in the Tier Zero ERA, PNEC values specifically developed for different groups of organisms must be used, namely:

- PNEC values for soil, for effects on on-site and off-site terrestrial microbes, invertebrates, plants, mammals and birds, which may have a home range that includes the Part IIA receptor sites identified in Section 3.2;
- PNEC values for water, for effects on aquatic plants, invertebrates and fish inhabiting the Afon Lwyd, a proposed SINC site; and
- PNEC values for sediment, for effects on dwelling organisms inhabiting the Afon Lwyd, a proposed SINC site.

The PNEC values used for Tier 1 ERA are described in Section 4.1.3. HIs for amphibians could not be calculated due to the lack of appropriate PNECs for that group.

It is important to note that the ERA Guidance published by the UK Environment Agency (2003 and 2004 a and b) focuses on contaminants present in soil. No clear guidance is available regarding ecological risk assessment for contaminants present in surface water and sediments. Therefore, best international practice and the professional judgement of the author, a Golder experienced ecological risk assessor, has been adopted with respect to the evaluation of potential risks to aquatic receptors.

Following execution of the Tier One ERA methodology, the need for a Tier Two ERA is evaluated.

4.2 Methods

4.2.1 Selection of environmental quality guideline values (EQGVs)

The first step of the Tier One ERA involved screening of contaminants of potential concern for the Site. These were defined as chemicals with concentrations in soil, surface water and sediment samples (collected by Golder in 2005 and 2006) which were above soil, water and/or sediment guidelines values for protection of ecological receptors and thus warranted further consideration.

International documents were consulted in order to select EQGVs for screening of chemicals of potential concern (see lists and descriptions in following sections). The majority of ecological EQGVs have been based on an assessment of toxicity to either aquatic or terrestrial organisms and, less frequently, to wildlife from either drinking water exposures or food chain bioaccumulation.

Soil screening values were derived using several approaches and were usually based on the lowest value determined from soil toxicity to terrestrial plants, invertebrates, wildlife, and sometimes microbes. Soil screening values based on toxicity to wildlife were determined from modelled incidental soil ingestion or chemical accumulation in terrestrial organisms.

Surface water screening values were primarily derived for the protection of aquatic organisms using two general approaches: (1) a statistical assessment of toxicity values using species sensitivity distributions, or (2) extrapolation of a lowest observed adverse effect level (LOAEL) determined from more limited toxicity data using an uncertainty factor. The surface water screening values in several sources were also based on toxicity to wildlife from drinking water exposure or chemical accumulation in aquatic prey.

Sediment screening values were primarily derived for the protection of benthic invertebrates using two approaches: (1) statistical interpretations of databases on the incidence of biological effects and chemical concentrations in sediment; or (2) equilibrium partitioning-derived values based on surface water screening values.

According to Barron and Wharton (2005) variation in the approaches used to develop screening values, as well as variable conservatism and uncertainty, has resulted in a range in media-based screening values that span several orders of magnitude for individual chemicals. The largest variation in screening values between different sources is attributed generally to inclusion or exclusion of wildlife toxicity in the derivation of screening values. A short overview of the approaches adopted by the different jurisdictions to derive the screening values used in this ERA is presented in the following sections.

4.2.1.1 Soil Quality Guideline Values (SQGV)

The existing soil guideline values (SGVs) developed by Defra and the Environment Agency (Defra 2002 a, b, c, d) are related to the protection of human health. Similar values do not yet exist for the protection of ecosystems in UK. Therefore, as recommended in the document produced by the UK Environment Agency ("Soil Screening Values for use in UK Ecological Risk Assessment", EPA 2004b), SQGV from other jurisdictions were applied in the absence of UK guidelines.

The international soil guidelines used in this assessment, included three reference sources recommended by the Environment Agency (2004a): Oak Ridge National Laboratory (ORNL) preliminary remediation goals, the Canadian Soil Quality Guidelines (CSQG) and the Dutch values, as discussed below**.**

- **Oak Ridge National Laboratory (ORNL 1997a,b)** has developed a compilation of preliminary remediation goals (PRGs) for 54 chemicals in soils. The PRGs were derived from the lowest value for either the direct toxicity to soil organisms or from dietary toxicity to wildlife of bioaccumulative chemicals. General strengths of the ORNL PRGs and toxicological benchmarks include the rigor of their derivation, a comprehensive review of toxicity databases, consideration of multiple receptors and pathways and transparency in their technical basis (Barron and Wharton 20005). A general limitation is their basis on older (1996 and 1997) compilations of environmental and toxicity data that have not been updated.

- **Canadian Soil Quality Guidelines (CSQG) (CCME 2005)** were determined by the intended land use (industrial, commercial, residential/parkland and agriculture) with agricultural uses generally having the lowest SQGs. The SQGVs for agricultural land were determined as the lowest soil value protective of adverse effects from (1) direct contact to plants, invertebrates, and microbes; (2) ingestion of soil and plants by grazing wildlife and livestock; or (3) human exposure. The direct contact value was derived from available soil toxicity data, and the ingestion value was derived from toxicity to animals and bioaccumulation in plants. Consideration of wildlife exposure was an attribute of the soil EQGs, but could lead to a variable level of conservatism if receptors and pathways were present or absent at a site (Barron and Wharton 20005). CSQG for 87 chemicals are available.

- **Netherlands Soil Quality Guidelines (VROM 2000).** The Dutch ministry of Housing, Spatial Planning and the Environment (VROM) has set a number of intervention values and target values for the assessment of soil and groundwater contamination.

  The soil remediation intervention values indicate when the functional properties of soil for humans, and for plant and animal life, are seriously impaired or threatened. The values represent the level of contamination above which there is serious soil contamination. The intervention values are based on extensive studies of both human and ecotoxicological effects of soil contaminants. The ultimate intervention values for soil are based on a harmonisation of the human and ecotoxicological effects. In principle, the most critical effects are definitive.

Soil *target values* indicate the level at which there is a sustainable soil quality. In terms of contaminated land, the target values indicate the level that has to be achieved to recover fully the functional properties of the soil for humans, plants and animal life. The target values also give an indication of the benchmark for environmental quality in the long term, based on the assumption of negligible risks to the ecosystem. Again, the final target values for soil and sediment are based on an integration of the human and ecotoxicological effects, with the lowest value being adopted.

In order to screen those chemicals of concern for ecological receptors, the Dutch soil target values were selected. It should be noted that the Dutch intervention values are no longer appropriate in the UK for screening where human receptors are concerned, these having been replaced by the CLEA framework.

There is no international SQGV available for total petroleum hydrocarbons (TPH). The Dutch guidance provides target and intervention levels for mineral oil. According to the Environment Agency (2004a, page 53), "*… in the absence of a TPH SQGV, the Dutch Guidelines are the most relevant guidelines available"* and therefore these have been adopted in the Tier One ERA.

The **Dutch and Canadian guideline values were only used when no guideline value was available in the other documents**, given that a number of the soil quality values listed in both documents may be based on human health as opposed to ecological endpoints. Where this is the case, the guideline in question has been highlighted as such within the tables of this ERA.

- **US EPA Region 5 (2003), Ecological Screening Levels (ESL)**. The ESL reference database consists of Region 5 media-specific (soil, water, sediment, and air) values. The majority of soil ESLs were derived using no-observed adverse effect level (NOAEL) toxicity reference values for wildlife and a food chain model for the masked shrew and, secondarily, the meadow vole. A few soil ESLs were based on toxicity to plants or earthworms. In general, USEPA Region 5 ESLs represent a combination of both independently derived and dependent values, with an extensive update reported in August 2003. The SVs were derived using a diversity of methods, including reliance on state water quality values that may not be toxicity based, resulting in varying conservatism and, in some cases, an uncertain technical basis. Other limitations included extensive use of professional judgment in applying uncertainty factors where data were limited. General strengths include SVs for a broad range of chemicals (215), including many that have not been available in other references.

- **The Oregon Department of Environmental Quality (ODEQ 2001)** developed a comprehensive reference source of screening level values (SLV) in soils for plants, invertebrates, birds, and mammals for 137 chemicals. The invertebrate and plant SLVs were based on ORNL (Efroymson, Will, Suter 1997; Efroymson, Will, Suter, Wooten 1997) summaries of the toxicity to earthworms and plants. ORNL values for soil microbes were used as the SLV for soil invertebrates when earthworm values were not available (Efroymson, Will, Suter 1997), but differences in sensitivity between microbes and earthworms may lead to variable levels of conservatism in the SVs. The soil SLVs for birds and mammals were based on NOAELs from Sample et al. (1996) and exposure from only incidental soil ingestion. Bioaccumulation in prey was not considered in the soil SLVs, which leads to uncertainty in screening for food chain risks (Barron and Wharton 2005).

- **Derivation of SQGV using the European Commission approach (EC 2003).** When SQGVs were not available, screening values were derived using the European Commission Technical Guidance Document (TGD) approach (EC 2003), as recommended by UK Environment Agency (2004b).

  The derivation is based on the application of assessment values on existing toxicity data. The size of the assessment factor depends on the type of data that are available i.e. short-term or long-term toxicity tests, the number of trophic levels tested and the general uncertainties in predicting ecosystem effects from laboratory data (Table 3). Toxicity values were obtained from the US EPA ECOTOX database.

  This was the case for Di-n-butyl phthalate for which toxicity data available in the US EPA ECOTOX database was a NOEC (no observed effects concentration) of 32 mg/kg (14 days test; lettuce growth). An assessment factor of 100 was applied, as there is a NOEC for one long-term-toxicity test for one trophic level. The derived SQGV is thus 0.32 mg/kg.

Table 3 - Assessment Factors for Derivation of Soil Quality Guideline Values (SQGV) (EC 2003)

Information available	Assessment factor
L(E)C50 short-term toxicity test(s) (e.g. plants, earthworms, or microorganisms)	1000
NOEC for one long-term toxicity test (e.g. plants)	100
NOEC for additional long-term toxicity tests of two trophic levels	50
NOEC for additional long-term toxicity tests for three species of three trophic levels	10
Species sensitivity distribution	5 – 1, to be fully justified on a case-by-case basis
Field data/data of model ecosystems	case-by-case

4.2.1.2 Sediment Quality Guideline Values (SedQGV)

The following values from other jurisdictions were applied in the absence of UK guidelines specific for protection of ecological receptors:

- **U.S. National Oceanographic and Atmospheric Association (NOAA) 1999**. threshold effect level (TEL);

- **Canadian Council of Ministers of the Environment (CCME). 2002 Interim Sediment Quality Guideline (ISQG);** and

- The values for both sets of sediment guidelines (CCME and NOAA) were equal, with the exception of nickel, which is not included in the CCME guidelines. CCME and NOAA have two sets of sediment standards. NOAA's threshold effect level (TEL) is equivalent to CCME's Interim Sediment Quality Guideline (ISQG) and represents the upper limit in the range of sediment chemical concentrations that is dominated by no-effect results. Sediment quality values below the TEL are regarded as presenting no significant hazards to aquatic organisms. The probable effect level (PEL) for both NOAA and CCME represents the lower limit of the range in sediment chemical

concentrations that is usually or always associated with adverse biological effects. In the present case, a more conservative approach was used in which chemical screening in sediment was based on NOAA's TELs and Canada's ISQGs.

In addition to the above documents, the following documents were consulted:

- **Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario (OMEE, 1993) - lowest effect level**. These guidelines indicate the level of contamination that has no effect on the majority of sediment-dwelling organisms. The sediment is considered clean to marginally polluted;

- **US EPA (1996). Predicted Effect Concentration (PEC).** Concentrations greater than the PEC are likely to result in adverse effects to may result in adverse effects to for an amphipod (*Hyalella azteca*) and for a midge (*Chironomus riparius*);

- **US EPA Region 5 (2003), Ecological Screening Levels (ESL).** Sediment ESL are primarily based on equilibrium portioning (EqP) and secondarily on other sediment thresholds; and

- **Netherlands Soil Quality Guidelines (VROM 2000) – soil/sediment target levels.** As already mentioned, the Dutch target values are based on an integration of human and ecotoxicological effects. Only the target value for mineral oil (for screening of TPH) was used.

4.2.1.3 Water Quality Guideline Values (WQGV)

As already mentioned, clear guidance for risk assessment of contaminants present in surface water and sediment for ecological receptors is not provided in UK. For the Tier One ERA, an approach similar to the one recommended for soil by the Environment Agency (2003, 2004a and b) was adopted for the screening of chemicals of potential concern for aquatic receptors. WQGVs do not exist yet for the protection of ecosystems in UK. Therefore values from other jurisdictions were applied in the absence of national guidelines.

- **The EC Dangerous Substances Directive (76/464/EEC and Daughter Directives).** This Directive controls the release of dangerous substances to water across the EC area. Every listed dangerous substance has a concentration limit, an 'Environmental Quality Standard' (EQS). According to the UK Environment Agency[9], EQSs must not be exceeded in any controlled watercourse in England and Wales. The following tables were consulted:

  - Table 1: Environmental Quality Standards (EQS) for List 1 dangerous substances, EC Dangerous Substances Directive (76/464/EEC);

  - Table 2a: Environmental Quality Standards (EQS) for List 2 dangerous substances, EC Dangerous Substances Directive (76/464/EEC); and

  - Table 2b: Environmental Quality Standards (EQS) for hardness related List 2 dangerous substances, EC Dangerous Substances Directive (76/464/EEC).

[9] http://www.environment-agency.gov.uk

- **The EC Nitrates Directive (91/676/EC).** This is a directive designed to reduce water pollution by nitrate from agricultural sources and to prevent such pollution occurring in the future. The criterion for identification of nitrate polluted surface fresh waters was used as a screening level;

- **US EPA (2004) - Chronic National Ambient Water Quality Criteria (NAWQC).** The chronic criteria are intended to prevent significant toxic effects in chronic exposures and are used as a lower screening benchmark. NAWQC for several metals are functions of water hardness. Values for hardness-dependent metals default to 100 mg $CaCO_3$/l, but equations are provided to obtain values based on specific hardness values. Recommended values for metals are expressed in terms of dissolved metal in the water column;

- **US EPA Region 5 (2003), Ecological Screening Levels (ESL).** The ESLs for surface water are initial screening levels with which the Site contaminant concentrations can be compared.

In addition to the above documents, the following documents were consulted:

- **Tier II Secondary Chronic Value (SCV) for Surface Water - Screening Benchmark (Suter and Tsao 1996).** Tier II values were developed so that aquatic benchmarks could be established with fewer data than are required for NAWQC;

- **Water Quality for British Columbia (BC 2005).** The Guidelines have been approved by the province and are given to protect six major water uses: Drinking Water, Aquatic Life (freshwater and marine), Wildlife, Recreation and Aesthetics, Agriculture (Irrigation and Livestock Watering), and Industrial (e.g. Food Processing Industry). The Fresh Water Aquatic Life criteria was used as WQGV for this Tier One ERA; and

- **Canadian Water Quality Guidelines (CWQG) for freshwater (CCME 2002).** In deriving Canadian water quality guidelines for aquatic life, all components of the aquatic ecosystem (e.g. algae, macrophytes, invertebrates, fish) are considered if the data are available. Guidelines may need to be modified on a Site-specific basis to account for local conditions (pH and hardness).

4.2.2 Calculation of hazard index

Parameters that are predicted to be present at concentrations greater than the guidelines were considered of potential concern and carried forward in the Tier One ERA quantitative analysis. If no guideline was available for a chemical, it was also retained for further evaluation in the risk assessment in order to apply precautionary principles.

The next step of the assessment comprises the calculation of risk. This was completed by comparison of the measured predicted environmental concentrations (PEC) to toxicity reference values (PNEC) (Environment Agency, 2004a). The ratio of measured concentrations to toxicity reference values resulted in the derivation of the hazard index (HI).

$$HI = \frac{PEC}{PNEC}$$

Where:

HI = Hazard Index;
PEC = Predicted Environmental Concentration (i.e. measured or predicted concentrations in soil, sediment and water) (i.e. mg/kg or mg/L); and
PNEC = Predicted No Effect Concentration (i.e. the lowest environmental concentration at which the absence of any adverse effects is expected) (i.e. mg/kg or mg/L).

Based on this conservative approach, the potential risk of adverse effects to ecological health in each of the media (soil, sediment and water in the Afon Lwyd) was rated as follows:

negligible: HI≤1;

low to negligible: HI>1 and ≤10;

potentially elevated: HI>10; harmful effects are possible due to the chemical in question.

4.2.3 Selection of Predicted No Effect Concentrations (PNECs)

4.2.3.1 Soil

When available, specific toxicity values for microbes, terrestrial invertebrates, terrestrial plants, avian and mammalian species were adopted as PNECs. The following documents were consulted:

- EPA, Office of Solid Waste Emergency Response (OSWER) Ecological Soil Screening Level (Eco-ESL) Guidance (US EPA 2003a,b, 2005a, b, c, d, e);
- Oak Ridge National Laboratory (ORNL 1997a and b) – Preliminary Remedial Goals;
- Oregon Department of Environmental Quality (ODEQ 2001) - Level II screening level values; and
- Netherlands Soil/Sediment Intervention Values (VROM 2000).

4.2.3.2 Water

Toxicity reference values for freshwater biota were the Lowest Chronic Value (LCV) for aquatic plants, invertebrates (daphnids) and fish (Suter 1996). Alternatively Tier II secondary acute values (Suter and Tao 1996) were used.

4.2.3.3 Sediment

PNEC values for benthic invertebrates were Probable Effects Levels (PELs) for freshwater sediment (NOAA 1999 and CCME 2002). These are considered to be less conservative than TELs and ISQGs. Use of PELs to calculate risk estimates provides a basis to interpret likelihood for effects; TELs provide a good basis for screening COPCs but also provide a useful comparison to the PEL-derived hazard quotient and effectively delineate the upper range of potential risk. The severe effect level (OMEE 1993) was also used as an alternative reference. In summary, the following PNEC values were used:

- U.S. National Oceanographic and Atmospheric Association (NOAA) 1999. Probable Effects Levels (PEL);
- Canadian Council of Ministers of the Environment (CCME). 2002 Probable Effects Levels (PEL);
- Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario (OMEE, 1993) - Severe effect level; and
- Netherlands Soil/Sediment Intervention Values (VROM 2000).

4.2.4 Evaluation of potential impacts in Afon Lwyd based on groundwater modelling

4.2.4.1 Results of the Groundwater Modelling

A quantitative risk assessment for soils and shallow groundwater contamination was undertaken as part of the Hydrogeological Risk Assessment (Volume 5). The model predicted contaminant concentrations in groundwater at the point of entry into the Afon Lwyd. The groundwater modelling results were taken at the 90^{th} percentiles (or 95^{th} percentiles in the case of dioxins and furans). The results given at the 90^{th} percentile indicate that there is considered to be a 90% chance that concentrations will not exceed screening criteria for water and a 10% chance that concentrations will exceed criteria (UK Environment Agency, Freshwater Environmental Quality Standards, UK Drinking Water Standards, EU Drinking Water Standards; United States Environmental Protection Agency Regions 3, 6 and 9; and World Health Organisation Drinking Water Standards). Chemicals whose peak concentrations did not exceed the screening criteria were excluded from the Tier One ERA.

4.2.4.2 Tier One approach

Where screening criteria were exceeded, the predicted concentrations at the point of entry into the river were compared to Water Quality Guidelines for Protection of Aquatic Life (WQGV, Section 4.2.1). Where the predicted concentrations exceeded the WQGVs, an appropriate dilution factor for groundwater/surface water needed to meet guidelines was estimated.

4.2.5 Evaluation of background levels

During the screening of chemicals of potential concern, the evaluation of background levels is important, given that screening values that are below background levels should not be used (EA 2003).

Background levels of contaminants are those concentrations found in areas surrounding a site, but which are unrelated to site releases (US EPA 2001).

Contributions to background contaminant concentrations originate from two major sources:

- natural sources (i.e. geologically derived concentrations of chemicals in the environment not influenced by human activity), and
- ambient or anthropogenic sources (i.e. concentrations present due to human activities, such as automobile use or air emissions in industrial areas).

Background levels for PCBs, dioxins/furans and metals (lead, cadmium, copper and zinc) in soils have been derived from samples and measurements upwind from the Site (Shank's soil monitoring data from 1998 to 2005, Sampling Point 18). The locations of Shank's monitoring stations are presented in Figure ERA5. Average levels of dioxins in soil of residential, industrial, rural and mixed areas in UK (AEAT 1999) were also considered in the evaluation of background levels.

Background levels for metals in stream sediment and water were obtained from the British Geological Survey (1999). Data from Pontypool or within 2 km of the Site were used. Average levels of dioxins in river sediments in UK (AEAT 1999) were also considered in the evaluation of background levels.

4.3 Tier One ERA Results

4.3.1 Chemicals measured in soil, water and sediment above detection limits

Only chemicals for which measured concentrations were above detection limits in at least one of the samples were included in the analysis (see Appendices 5, 6 and 7). These are summarised in Table 4.

Surface soil samples were split into two groups: BH (boreholes) and GS (grab samples). BH represent surface soil samples collected on-Site. GS were obtained from the shallow drainage ditch surrounding the northeastern and southeastern boundaries of the Site. It should be noted that Shanks understand that this ditch has been cleaned and sediments have therefore likely been removed since completion of the Phase II Ground Investigation (2005). Given this fact and the absence of chemical specific data subsequent to cleaning of the ditch, it is recommended that additional sampling and analysis be undertaken to confirm or otherwise disprove previous

assessment results. As a precautionary approach, however, available GS analysis were retained in the Tier One ERA.

Table 4 - Parameters for which Concentrations were Above Detection Limits (●)

	On Site Soil (BH)	Soil from drainage ditch (GS)	Water	Sediment
METALS AND TRADITIONALS				
Sulphate	●	●	●	●
Aluminum	●	●	●	●
Arsenic	●	●	●	●
Barium	●	●	●	●
Cadmium	●	●	-	●
Chromium	●	●	●	●
Copper	●	●	●	●
Lead	●	●	●	●
Lithium	-	-	●	-
Mercury	●	●	●	●
Nickel	●	●	●	●
Selenium	-	-	●	-
Vanadium	●	●	●	●
Zinc	●	●	●	-
Sodium	●	●	●	●
Nitrate (soluble) as NO_3	●	●	●	●
Acid Soluble Sulphide	●	●	na	●
Chloride	●	●	●	●
Fluoride	●	●	na	-
Free Cyanide	-	●	na	-
Bromide	●	-	na	●
pH Value	●	●	●	●
HYDROCARBONS				
Toluene	●		-	●
Ethylbenzene	●		-	●
Total Xylene	●		-	-
TPH	●	●	-	●
PCBs				
Total PCBs	●	●	-	●
OCP/OPP				
pp DDT	-	-	-	●
PAHs				
2-Methylnaphthalene	●	●	●	-
Acenaphthene	●	●	-	-
Acenaphthylene	●	-	-	-
Anthracene	●	●	-	-
Benzo(a)anthracene	●	●	-	●
Benzo(a)pyrene	●	●	-	●
Benzo(b)fluoranthene	●	●	-	●
Benzo(ghi)perylene	●	●	-	●
Benzo(k)fluoranthene	●	●	-	●
Chrysene	●	●	-	●
Dibenzo(a,h)anthracene	●	●	-	●
Fluoranthene	●	●	-	●
Fluorene	●	●	-	-
Indeno(1,2,3-cd)pyrene	●	●	-	●
Naphthalene	●	-	-	-
Phenanthrene	●	●	-	●
Pyrene	●	●	-	●
Phthalates				
Bis(2-ethylhexyl) phthalate	-	●	-	-

	On Site Soil (BH)	Soil from drainage ditch (GS)	Water	Sediment
Di-n-butyl phthalate	-	●	-	-
Other Semi-volatiles				
Carbazole	-	●	-	-
Dibenzofuran	●	●	-	-
Volatile Organic Compounds				
cis-1-2-Dichloroethene	●	-	-	●
Trans-1-2-Dichloroethene	-	-	-	●
Chloroform	●	-	-	●
Trichloroethene	●	-	-	●
Tetrachloroethene	●	-	-	-
Bromoform	●	●	-	●
1.2.4-Trimethylbenzene	●	-	-	-
1.3.5-Trimethylbenzene	●	-	-	-
Vinyl Chloride	-	-	-	●
1.1 dichloroethene	-	-	-	●
Dioxins and Furans				
Dioxins	●	●	-	-
Furan	●	●	-	-

Notes: '-' = measured concentration < detection limit, na = not analysed

4.3.2 Chemicals of potential concern

For each parameter, the maximum measured concentrations were compared to EQGVs. Where an appropriate screening or guidance value was absent for a chemical detected at the Site, the substance was retained for further evaluation. The resulting list of chemicals of potential concern (CoPC) is presented in Table 5 (see further details in Appendices 5, 6 and 7). These chemicals were retained for further assessment.

Shanks' monitoring data on metals (lead, copper, zinc and cadmium), PCBs and dioxins/furans off-Site were also assessed against soil screening values (Table 6) (refer to Appendix 12 for further details).

It should be noted that the selected screening value for dioxins and furans (0.004 µg. TEQ 2378 TCDD/kg, CCME 2004) is very conservative and is based on human health risks, albeit, recommended for ecological protection. Indeed, the screening value is lower than UK background levels for rural areas (AEAT 1999). For this reason, its use should be viewed with caution.

If the UK background levels for industrial areas were instead used as a screening value, dioxins and furans would remain in this assessment as chemicals of potential concern since several soil and grab samples from the Site presented concentrations above the background.

Table 5 - Parameters for which Concentrations were Above Environmental Quality Guideline Values (EQGVs) (■)

	On Site Soil (BH)	Soil from drainage ditch (GS)	Water	Sediment
Metals and traditionals				
Sulphate	*			*
Aluminium				
Arsenic	■	■		■
Barium	■	■		*
Cadmium				■
Chromium	■	■	■	
Copper	■	■	■	■
Lead	■	■		■
Lithium			■	
Mercury	■	■		■
Nickel	■	■		■
Selenium			■	
Vanadium	■	■		
Zinc	■	■	■	■
Sodium	*		*	*
Nitrate (soluble) as NO3	*			*
Acid Soluble Sulphide	*			*
Chloride	*			*
Bromide				*
Fluoride				*
Free Cyanide		■		
pH Value	*			*
TPH (Aliphatics and Aromatics C5-C35)	■	■		■
Total PCBs				■
Benzo(a)anthracene				■
Benzo(a)pyrene				■
Benzo(b)fluoranthene				■
Benzo(ghi)perylene				■
Benzo(k)fluoranthene				■
Chrysene				■
Dibenzo(a,h)anthracene				■
Fluoranthene				■
Naphthalene	■	■		
Phenanthrene				■
Pyrene				■
Bis(2-ethylhexyl) phthalate		■		
Di-n-butyl phthalate		■		
Carbazole	*	*		
Dibenzofuran	*	*		
1.2.4-Trimethylbenzene	*	*		*
1.3.5-Trimethylbenzene	*	*		*
Cis-1-2Dichloroethene				*

Notes:
Screening based on maximum measured values
"*" Environmental Quality Guideline Value not available

Table 6 - Chemicals Monitored by Shanks in Soil off-Site in which Concentrations were above Environmental Quality Guideline Values (■)

	Sampling Point 18	Sampling Point 20A	Sampling Point 20B	Sampling Point 21	Sampling Point 22	Sampling Point 33
Cadmium						
Copper		■	■			■
Lead	■	■	■	■	■	■
Zinc	■	■	■	■	■	■
Total PCB						
Dioxins/furans	■	■	■	■	■	■

Notes:
Screening based on average measured values (1998-2003 for metals and 2000-2005 for PCBs and dioxins/furans).
Sampling point 18 = upwind the Site
Sampling points 20A, 20B and 33 = downwind the Site
Sampling points 21 and 22 = crosswind the Site

4.3.3 Hazard indices

A summary of the hazard index (HI) estimations are presented in the Appendices 8, 9 and 10. Based on the conservative approach, the risk of adverse effects to ecological health was rated as follows:

negligible: HI≤1

low to negligible: HI>1 and ≤10

potentially elevated: HI>10 - harmful effects are possible due to the chemical in question.

4.3.3.1 On-Site Soil

HI>10

Similar HIs were found in soil/sediment samples from the drainage ditch (GS) and on-Site soil (BH). The following compounds were found to have HI>10 (Table 6) for at least one of the groups of terrestrial receptors suggesting **potential risks**:

- chromium;
- lead;
- mercury (BH samples only);
- nickel;
- vanadium;
- zinc (GS only);
- di-n-butyl phthalate; and
- dibenzofuran.

HI>1 and <10

The following chemicals presented HI for soil between one and ten for at least one of the receptors, suggesting **low to negligible risks**:

- arsenic;
- barium;
- copper;
- bis(2-ethylhexyl) phthalate; and
- dioxins and furans.

HI<1

The following chemicals presented HI for soil lower than one for all the receptor groups, suggesting **negligible risks**:

- TPH; and
- naphthalene.

HIs were not calculated for free cyanide, carbazole, 1.2.4-trimethylbenzene and 1.3.5-trimethylbenzene since Predicted Non-Effect Concentrations (PNEC) were not available for any of the receptors of concern.

Table 7 - Hazard Index (HI) for Microbes, Invertebrates, Plants and Wildlife – On-Site Soil

	BH Samples PEC(max) /PNEC					GS Samples PEC(max) /PNEC				
	Microbes	Invertebrates	Plants	Mammalian	Avian	Microbes	Invertebrates	Plants	Mammalian	Avian
Arsenic	–	–	○	–	–	–	–	○	–	–
Barium	–	–	○	–	○	–	–	○	–	○
Chromium	○	●	●	–	○	●	●	●	●	●
Copper	–	○	–	–	–	○	○	○	○	○
Lead	–	–	○	○	●	–	–	○	○	●
Mercury	–	●	○	–	○	–	○	○	–	–
Nickel	○	○	●	–	–	●	●	●	○	●
Vanadium	○		●	–	○	○		●	–	●
Zinc	○	○	○	–	○	●	●	●	–	●
Free cyanide										
TPH				–					–	
Naphthalene			–	–				–	–	
Bis(2-ethylhexyl) phthalate				–	○				–	○
Di-n-butyl phthalate			–	–	●			–	–	●
Carbazole										
Dibenzofuran				●					●	
1.2.4-Trimethylbenzene										
1.3.5-Trimethylbenzene										
Dioxins and furans				○	○				○	○

Notes
– = HI lower than one
○ = HI between one and ten
● = HI greater than ten
Empty cells: HI not calculated (PNEC not available)

4.3.3.2 Off-Site Soil

HIs were also calculated for off-Site soil samples.

HI>10

Lead at 20A, 20B and 33 (all locations generally interpreted as downwind* of the Site) recorded HI>10 (Table 8) for at least one of the groups of terrestrial receptors (avian), suggesting **potential risks**:

Table 8 - Hazard Index (HI) for Microbes, Invertebrates, Plants and Wildlife – Off- Site Soil

	Sampling point 18 PEC(mean) /PNEC					Sampling point 20 A PEC(mean) /PNEC					Sampling point 20B PEC(mean) /PNEC					Sampling point 21 PEC(mean) /PNEC					Sampling point 22 PEC(mean) /PNEC					Sampling point 33 PEC(mean) /PNEC				
	Microbes	Invertebrates	Plants	Mammalian	Avian	Microbes	Invertebrates	Plants	Mammalian	Avian	Microbes	Invertebrates	Plants	Mammalian	Avian	Microbes	Invertebrates	Plants	Mammalian	Avian	Microbes	Invertebrates	Plants	Mammalian	Avian	Microbes	Invertebrates	Plants	Mammalian	Avian
Copper	–	–	–	–	–	–	○	–	–	–	○	○	○	–	–	–	–	–	–	–	–	–	–	–	–	–	○	–	–	–
Lead	–	–	–	–	○	–	–	○	○	●	–	–	○	○	●	–	–	–	○	○	–	–	–	○	○	–	–	○	○	●
Zinc	○	○	○	–	○	○	○	○	–	○	○	○	○	–	○	○	○	○	–	○	○	○	○	–	○	○	○	○	–	○
Total PCBs			–	–				–	–				–	–				–	–				–	–				–	–	
Dioxins and furans				–	–				–	○				–	–				–	–				–	○				–	○

Notes
Screening based on average measured values (1998-2003 for metals and 2000-2005 for PCBs and dioxins/furans).
Sampling point 18 = generally interpreted as upwind of the Site
Sampling points 20A, 20B and 33 = generally interpreted as downwind of the Site
Sampling points 21 and 22 = generally interpreted as crosswind of the Site
– = HI lower than one
○ = HI between one and ten
● = HI greater than ten
Empty cells: HI not calculated (PNEC not available)

*As stated previously, recorded meteorological data obtained for the purposes of dispersion modelling (see Volume 2, Chapter 11) includes information relating to wind speed and direction (Figure ERA2). This shows the frequency of winds blowing from particular directions, and illustrates that for all years presented, a westerly wind (NW–W-SW directions) prevailed for the most part with wind speeds between 3 to 8.3 m/s occurring for the majority of this time. Review of historical wind direction data recorded at the Monmouthshire station also showed that the dominant wind directions for years 2002 to 2005 inclusive were either southwesterly or northerly10. In considering the above data, areas located in an easterly direction from the Site would be considered most likely to have received airborne emissions from the former HTI stack, being located generally downwind of the stack. However, it should be noted prevailing wind direction would not always have followed this pattern. Furthermore, the UEA report states that certain releases were fugitive rather than from the stack. Consequently, historical atmospheric deposition cannot be simply correlated with

[10] http://www.thehendre.com/weather/noaa/noaa_data.htm

prevailing wind direction (also being dependent on factors such as building effects, topography etc.).

Whilst it can be seen from the results of the Phase II that metals are ubiquitous in the soils across the Site, the concentrations identified on-Site are inconsistent with those identified off-Site, and as such, it is considered that the former HTI facility does not represent the principal source of the off-Site metal concentrations. The fact that metals appear throughout the Site may also reflect the fact that the Site resides on an area with previously elevated levels of metals.

HI>1 and <10

None of the compounds assessed presented a HI >1 and <10.

HI<1

None of the compounds assessed presented a HI<1.

4.3.3.3 Sediment of the Afon Lwyd

HI>10

None of the compounds assessed presented an HI higher than ten.

HI>1 and <10

The following compounds presented HI between one and ten (Table 9), suggesting **low to negligible risks**:

- arsenic;
- cadmium;
- mercury; and
- nickel.

Table 9 - Hazard Index (HI) for Benthic Invertebrates - Sediment

	HI Sediment (PEC/PNEC)					
	GS11	GS11	GS12	GS12	GS13	GS13
Arsenic	–	–	○	–	○	–
Cadmium	–	–	–	–	○	–
Chromium*	–	–	–	–	–	–
Copper	–	–	–	–	–	–
Lead	–	–	–	–	–	–
Mercury	–	○	–	○	–	○
Nickel	–	○	○	–	○	○
Zinc	–	–	–	–	–	–
TPH	–	–	–	–	–	–
p,p'-DDT	○	○	–	○	–	○
Benzo(a)anthracene	–	–	–	–	–	–
Benzo(a)pyrene	–	–	–	–	–	–
Benzo(b)fluoranthene	–	–	–	–	–	–
Benzo(ghi)perylene	–	–	–	–	–	–
Benzo(k)fluoranthene	–	–	–	–	–	–
Chrysene	–	–	–	–	–	–
Dibenzo(a,h)anthracene	–	–	–	–	–	–
Fluoranthene	–	–	–	–	–	–
Indeno(1,2,3-cd)pyrene	–	–	–	–	–	–
Phenanthrene	–	–	–	–	–	–
Pyrene	–	–	–	–	–	–

Notes
– = HI lower than one
○ = HI between one and ten
● = HI greater than ten
Empty cells: HI not calculated (PNEC not available)

HI<1

None of the compounds assessed presented a HI<1.

4.3.3.4 Water

HI>10

The following compound presented a HI greater than ten (Table 10), suggesting **potential risks**:

- copper (HI > 10 for aquatic plants at GS 13 and for fish at GS12 and 13).

HI>1 and <10

The following compounds presented a HI between one and ten, suggesting **low to negligible risks**:

- zinc; and
- lithium.

The sample presenting the highest HIs was GS13 (Sept-05) which is located downstream of the Site. However, the sample collected six months later at the same location (GS13, Mar-06) presented HIs similar to the ones assessed upstream of the Site (GS 11 and GS 12).

Table 10 - Hazard Index (HI) for Aquatic Plants, Invertebrates And Fish - Water

	HI Aquatic Plants (PEC/PNEC)							HI Aquatic Invertebrates (PEC/PNEC)							HI Fish (PEC/PNEC)						
	GS11	GS11	GS11-DUP	GS12	GS12	GS13	GS13	GS11	GS11	GS11-DUP	GS12	GS12	GS13	GS13	GS11	GS11	GS11-DUP	GS12	GS12	GS13	GS13
Chromium Dissolved	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Copper Dissolved	○	○	○	○	○	●	○	○	○	○	●	○	●	○	–	–	–	–	–	○	–
Lithium Dissolved	○	–	–	○	○	○	○	○	–	–	○	–	○	–	○	–	–	○	–	○	–
Selenium Dissolved	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Zinc Dissolved	–	–	–	–	–	○	–	–	–	–	–	–	○	–	–	–	–	–	–	○	–
Sodium Dissolved								–	–	–	–	–	–	–							

Notes
– = HI lower than one
○ = HI between one and ten
● = HI greater than ten
Empty cells: HI not calculated (PNEC not available)

4.3.4 Evaluation of potential impacts on aquatic communities of Afon Lwyd based on groundwater modelling

The predicted contaminant concentrations in groundwater at the point of entry into the Afon Lwyd, obtained from the modelling undertaken in the HRA (Volume 5) are summarised in Appendix 11. Only the results taken at 90th percentiles (or 95% percentiles in the case of dioxins and furans) are included. Table 11 illustrates the predicted concentrations of contaminants at 1,000 years for chemicals that exceeded WSGVs for the protection of ecological receptors.

Table 11 - Comparison of Predicted Concentrations (µg/L) at the Point of Entry into the Afon Lwyd with Water Screening Guidance Values (WSGV)

Source	Chemical	Concentration at 1000 years (µg/L)	WSGV (µg/L)	Necessary dilution to meet WSGV
Soil	Zinc Dissolved	238 (1,000)	75 (1)	3
Groundwater - Source 1	Selenium Dissolved	9.8 (1,000)	5 (2)	2

Source	Chemical	Concentration at 1000 years (µg/L)	WSGV (µg/L)	Necessary dilution to meet WSGV
Groundwater - Source 3	Benzene (5)	38 (1,000)	30 (3)	1
	Toluene (5)	890 (1,000)	50 (3)	18
	Xylene (5)	50 (1,000)	30 (3)	2
	MTBE (5)	140 (1,000)	11.07 (4)	13

Notes:

(1) EQS (76/464/EEC) freshwater suitable for all salmonid species (hardness > 100-150) (value for total Zn)
(2) US EPA Region 5 (2003) Ecological Screening Levels (value for Total Se)
(3) EQS (76/464/EEC) freshwaters (value for annual average)
(4) EPA Region 6
(5) modelled without biodegradation processes

Zinc and selenium are predicted to exceed their relevant WSGVs within 1,000 years at the 90th percentile. In the event that a dilution factor of three is applied however, zinc and selenium concentrations in the Afon Lwyd would meet the WSGV.

Benzene, toluene, and xylene are all predicted to exceed their relevant WSGV within 1,000 years at the 90th percentile (modelled without biodegradation processes). However, all of these compounds are known to biodegrade in the environment. Where biodegradation is taken into account in the model, results indicate that at the 90th percentiles, none of these chemicals will exceed their WSGV within 1,000 years.

MTBE is also predicted to exceed its relevant WSGV within 1,000 years at the 90th percentile (modelled without biodegradation processes). In this case, a dilution factor of 13 would be necessary to meet the WSGV. With biodegradation processes taken account of in the modelling, MTBE still exceeds its WSGV within 1,000 years.

In summary, it can be concluded the risks to the aquatic communities of the Afon Lwyd may be considered **low to negligible**, as a consequence of migration of chemicals currently found in soil and groundwater at the Site**.** It must, however, be borne in mind that the modelling includes a high degree of conservatism, i.e. the exclusion of dilution effects in the river as well as biodegradation processes.

4.4 Uncertainties of the Tier One ERA

The primary areas giving rise to uncertainty in the risk calculations presented within this Tier One ERA are summarised below.

4.4.1 Environmental quality guideline values (EQGVs) and predicted no effects concentrations (PNECs)

In the absence of UK specific EQGVs and PNECs, the Environment Agency recommends the use of international guidelines. Therefore, the EQGVs and PNECs presented in this Tier One ERA are mostly based on toxicity data for species found in Canada, the US and the

Netherlands. Consequently, it must be borne in mind that the guidelines may not be fully applicable to aquatic and terrestrial species in UK and in particular, the environments surrounding the Site in Pontypool, SE Wales.

Variation in the approaches used to develop the international screening values used in this Tier One ERA, as well as variable conservatism and uncertainty, has resulted in a notable range in media-based screening values, that span several orders of magnitude for individual chemicals (Barron and Wharton 2005).

The approach taken within this Tier One ERA provides a useful framework to interpret potential ecological risks posed by the contaminants on-Site to the Part IIA receptor Sites including the Afon Lwyd. However, results for particular parameters relative to the EQGVs and PNECs used should be treated with caution. If warranted, a Tier Two ERA may provide a useful follow-up framework in which to corroborate the Tier One ERA results.

4.4.2 Issues specific to metals

There are specific issues related to risk assessment of metals that present uncertainty in the Tier One ERA findings. Firstly, all metals are naturally occurring in the environment given that they are a natural component of the Earth's crust. Background concentrations of metals in the environment are hence above zero and vary greatly in different media (e.g. soil, sediment, water) and under different geological and environmental conditions. Secondly, the surroundings of the Site comprise mixed purpose industrial, commercial and residential land use and the area to the north and west of the Site is heavily industrialised. TCBC in their Contaminated Land Inspection Strategy (2004) acknowledge that the local area surrounding the Site (including upstream) has developed on the basis of iron-making, mining and tin-plate manufacture and that "the presence of heavy industries within the Blaenavon, Pontypool and Cwmbran areas of the County Borough has led to large areas of made ground containing a variety of elevated concentrations of metals and hydrocarbons".

It is therefore of course, possible than the high HI values calculated for several metals in soil reflect natural geological conditions or else impacts associated with other former industrial activities rather than being attributable to activities associated with the Shanks former HTI Site.

In this study, concentrations of metals measured at Shanks' Monitoring Point 18 were selected as background levels. However, data was available only for lead, cadmium, copper and zinc from this source.

Whilst it can be seen from the result that metals are ubiquitous in the soils across the Site, the concentrations identified on-Site are inconsistent with those identified off-Site, and as such, it is considered that the former HTI facility does not represent the principal source of the off-

Site metal concentrations. The fact that metals appear throughout the Site may also reflect the fact that the Site resides on an area with previously elevated levels of metals.

In the light of the uncertainty regarding the provenance of metals, Shanks and TCBC have agreed to collaborate to further assess the off-Site metal concentrations in the soils adjacent to the Site boundary in order to evaluate background levels and the potential influence of other sources of contamination.

4.4.3 Concentrations of chemicals used in the assessment

Due to the limited number of samples available for statistical analysis (which is warranted by the Tier One ERA), it was not possible to calculate the upper 95th percentile confidence level of the mean (95UCL) for soil, sediment and surface water concentrations. Therefore, calculations in this Tier One ERA were based upon maximum measured concentrations. Use of the maximum measured concentrations is considered a data limitation that has the potential to have resulted in an overestimation of the risks to ecological receptors presented in this report.

Results of analysis of soils from the banks of the Afon Lwyd were not available within this Tier One ERA. Therefore, the potential risks to terrestrial receptors living on the banks of the Afon Lwyd have been predicted using on-Site (approximately 20 m from the western margin of the river; Phase II report) and off-Site (approximately 50 to 100 m from the eastern margin) soils data. This results in some uncertainty regarding the actual levels of exposure for the receptors of concern that occupy the banks of the Afon Lwyd.

Sampling of soils along the Afon Lwyd banks will be undertaken in order to provide greater certainty regarding risks to terrestrial species within this Part IIA receptor Site.

4.4.4 Influence of total suspended soils in water analysis

A large variation was found between water samples collected at GS13 and GS12 in different sampling campaigns. It is possible that the presence of suspended solids in the water samples could have influenced the analytical results obtained. This hypothesis cannot be evaluated further at the present time given that total suspended solids was not measured in the water samples.

If additional surface water samples are collected in the future, total suspended solids should be included in the analysis in order to test this hypothesis.

4.4.5 Bioavailability

Although widely used for screening purposes (and thus deemed appropriate by the Environment Agency at the Tier One ERA stage), the use of chemical concentrations alone

cannot provide accurate predictions of potential biological and ecological effects. This is because the percentage of a chemical that may be bio-available to an ecological receptor can range from 0% to 100%. Consequently, the use of chemical concentrations to evaluate risks to aquatic and terrestrial organisms is likely to overestimate the true risk. Such an evaluation is normally only performed at Tier Two ERA stage and was therefore outside of the scope of this Tier One ERA.

If a Tier Two assessment is warranted, eco-toxicity testing should be undertaken to take account of the bioavailability of individual chemicals of potential concern.

4.4.6 Interactions among chemicals

The HI estimation is normally undertaken for each chemical of concern, independently of the presence of other chemicals in the same media (e.g. sediment). This procedure does not consider interactive effects among the chemicals such as antagonistic (less than additive) or synergistic (more than additive) effects. Such an evaluation is normally only performed at Tier Two ERA stage and was therefore outside of the scope of this Tier One ERA.

If a Tier Two assessment is warranted, eco-toxicity testing should be undertaken to take account of the potential interactions between chemicals.

4.4.7 Significance of the Tier One findings at the population and community levels

Although the Tier One ERA results suggest that there may be potential risks for terrestrial organisms living or using the Afon Lwyd banks nearby the Site, this does not necessarily mean that significant harm at population levels or significant changes in the functioning of ecological systems of identified Part IIA Ecological Receptors is occurring or will occur in the future. This is particularly the case given the relatively small area of impacted soil (on-Site), the subsequent removal of soils from within the ditch (off-Site) and the absence of soils data from the banks of the Afon Lwyd with which to further test these initial results. Furthermore, species behaviour (e.g. migration) which is likely to act to limit exposure, is not taken account of at the Tier One ERA stage. Such evaluation is normally only performed at Tier Three ERA stage and was therefore outside of the scope of this Tier One ERA.

Potential effects that identified levels of contamination (including the results of further testing recommended within this Tier One ERA) might have on species at the population, community and ecosystem levels should be evaluated at Tier Three stage, if this is found to be warranted.

4.4.8 Exposure route - root uptake of groundwater

One of the exposure routes identified as plausible in the preliminary CSM was root uptake of groundwater. This route was not qualitatively assessed in the Tier One ERA since there are no applicable toxicity values.

The only trees that could be exposed in this case are the ones located between the Site and the Afon Lwyd, on the western margin of the river. That would include only a few individual specimens in relation to the entire riparian vegetation available. Therefore, despite the uncertainties, the risk at the plant community level would be considered negligible.

4.4.9 Risks to wildlife due to food ingestion

Food ingestion (plants, insects and fish) has been identified as a potential exposure pathway for receptors of concern that may be occupying the Afon Lwyd (e.g. otter and kingfisher). Some (but not all) of the soil and water screening values used in this Tier One ERA are based on toxicity to wildlife and have been determined by modelling incidental soil or water ingestion or chemical accumulation in organisms. Therefore, there is a degree of uncertainty in the conclusions related to wildlife exposure.

The significance of the ingestion exposure pathway can only be appropriately evaluated using food-chain modelling which takes account of measured or predicted concentrations of chemicals in food items. Such an evaluation is normally only performed at Tier Three ERA stage and was therefore outside of the scope of this Tier One ERA.

Potential effects on piscivorous, insectivorous and vegetarian species should be evaluated during a Tier Three ERA, if this is deemed to be warranted.

4.4.10 Risks to amphibians

Amphibians (e.g. great crested newt) have been identified as potential receptors of concern (although this species was not identified either on-Site or in the Afon Lwyd River Corridor Survey in the ecological survey work undertaken within this ES (Golder 2005, 2006). Toxicological data for amphibians are very scarce and therefore EQGV and PNECs are not available for this group of organisms. Consequently, the risks for potential amphibians occupying the Afon Lwyd could not be evaluated in this assessment.

The constraints (near absence of toxicological data for amphibians available in literature), which have prevented the evaluation of risks to amphibians (due to e.g. dermal contact with contaminated water and/or sediment) must be recognized as having provided a limitation of this study.

4.5 Conclusions and Recommendations of Tier One

The following conclusions and recommendations are based on the hazard quotients predicted in this Tier One ERA, information on background levels and off-Site monitoring data obtained during the course of this assessment and existing biological survey information.

4.5.1 Evaluation of risks to the Part IIA receptors related to Site releases

4.5.1.1 Potential Risks to Aquatic Life Related to the Afon Lwyd water and Sediment Quality

The Afon Lwyd is proposed to be designated as a SINC given the records of otter, bat species, brown trout, salmon and bullhead within its reaches. The Environment Agency Wales (2006) classified stretches of the Afon Lwyd both upstream[11] and downstream[12] the Site as Class C (fairly good, i.e. biology worse than expected for unpolluted river) based on samples of macro-invertebrates community. The CSM presented within the Tier Zero ERA identified the aquatic community of the Afon Lwyd as receptors of potential concern.

The estimation of HIs suggested a **potential risk** to aquatic plants and invertebrates due to copper in water. The sample presenting the highest HIs for copper in water was GS13 (Sept-05) which is located downstream of the Site. However, the sample collected six months later (Mar 06), at the same location presented HIs similar to the ones located upstream of the Site. The presence of suspended solids in the water samples could have influenced the analysis in September 05. It should be noted that copper was not considered a chemical of major concern in either sediment or on-Site soil samples.

With the exception of copper, HIs predicted **low to negligible risks** for aquatic plants, invertebrates, fish and benthic organisms for all other chemicals.

The modelled concentrations of zinc, selenium, benzene, toluene, xylenes and MTBE in groundwater at the point of entry into the Afon Lwyd within 1000 years exceed their relevant screening guidance values for protection of aquatic life. These concentrations have been modelled using measured soil and groundwater concentrations derived from samples on-Site. However, based on the high degree of conservatism within the modelling, i.e. the exclusion of dilution effects in the River as well as biodegradation processes which are known to be relevant for a number of these compounds**,** the risks to the aquatic communities of Afon Lwyd due to migration of chemicals currently found in soil and groundwater at the Site is considered **low to negligible**.

In conclusion, the results indicate that the above chemicals would be unlikely to detrimentally affect the long-term maintenance of the aquatic communities of the Afon Lwyd.

[11] Conf.Nant Dare - Conf.Nant Ffrwdoer in 2000 and 2002
[12] Conf.Railway Str.-Conf.Nant Dare in 2000 and 2003

4.5.1.2 Potential Risks to Terrestrial Receptors using the Afon Lwyd Banks

The preliminary CSM identified the following terrestrial receptors of potential concern:

- terrestrial plants;
- soil invertebrates;
- microbes;
- birds; and
- mammals.

These groups of organisms could be exposed to impacted soils in the limited areas of the Site not covered by hardstanding and, most importantly, where soils have been impacted off-Site.

Previous studies (Panteg reports and Shanks' monitoring data) illustrate that impacts (in terms of soil contamination) from the Site are almost entirely restricted to a strip of land approximately 200 m wide around the eastern Site boundary. This strip includes the Afon Lwyd banks and for this reason, organisms living or using the river banks are considered to be of particular concern.

Results of analysis of soils data from the Afon Lwyd banks are not available. There are, however, data on soils quality on-Site (approximately 20 m from the western margin of the river; Phase II Report) and off-Site (approximately 50 to 100 metres from the eastern margin: sampling points 20A, 20B, 33, 21 and 22).

HIs calculated for soils sampled on western margin of the river (on-Site) suggested **potential risks** for terrestrial receptors due to the presence of chromium, lead, mercury, nickel, vanadium, zinc, di-n-butyl phthalate and dibenzofuran. HIs calculated for soil samples on the eastern margin of the river suggest **potential risks** to birds from lead (n.b. data for chromium, mercury, nickel, vanadium, di-n-butyl phthalate and dibenzofuran was not available). However, concentrations of lead upwind of the Site (sampling point 18) present **low to negligible** risks for terrestrial receptor groups.

The results presented above indicate that it is possible that terrestrial organisms living on or visiting the banks of the Afon Lwyd near to the Site could be affected by the above chemicals in soil. The presence of these chemicals could be attributable to former Site activities, but could also be attributable to other sources of contamination unrelated to Site activities. Such sources may include former (including historical) industrial activity (mining, steel working etc), road base materials (depending upon source), emissions and deposition of atmospheric pollutants from the highway network etc.

Two important sources of further information should be considered. Firstly, the results of a detailed ecological survey of the range of wildlife habitats and vegetation types performed by Gemmell (1991), within a radius up to 1000 m from the plant stack when operational, showed no evidence of pollution impacting on plant communities or soil-dwelling invertebrates.

Secondly, even if organisms using the banks of the River near to the Site could be affected by the contaminants present, an impact at community level would be improbable. This is because large mammals (e.g. otter) or birds would have a larger home range than any impacted areas of soils near to the Site. Smaller species (e.g. water voles) could be affected at the individual level, but probably not at the population level. Migrating species would only be exposed during the months of the year that they occupy this habitat. A study which takes such factors into account is normally only undertaken at Tier Three ERA stage (if warranted) and would require food-chain modelling. Thus, consideration of such factors is outside of the scope of this Tier One ERA.

The risks at the plant community level due to root uptake of groundwater by plants located between the Site and the river was considered **negligible**.

4.5.2 Risks to other Part IIA receptors than Afon Lwyd

In addition to the Afon Lwyd, the following protected habitats have been identified:

- River Usk (SAC);
- River Usk (Lower Usk)/Afon Wysg (Wysg Isaf) (SSSI); and
- Craig-y-felin Wood (proposed SINC).

Since the Tier One ERA results suggest that the long-term maintenance of the aquatic communities of the Afon Lwyd would be unlikely to be affected by the chemicals which have formed the basis for this assessment, it can be assumed that the same conclusion should apply to the other Part IIA receptor sites listed above which are located at some distance downstream (9.5 km in the case of the River Usk).

Terrestrial organisms occupying these other protected (or proposed protected) sites are also not considered to be at risk since soil impacts from the Site are almost entirely restricted to a strip of land approximately 200 m wide around the Site (Gemmell).

4.5.3 Revised conceptual Site model

A revised CSM is presented in Figure 3, based upon the results of this Tier One ERA. This illustrates that the only Part IIA receptor potentially at risk is the Afon Lwyd. Former HTI activities remain considered as a potential source of off-Site soil contamination together with other anthropogenic activities in the region. The main route of transport identified is historical air deposition. Local geological conditions can also influence the concentrations of chemicals in soil, water and sediments, particularly of metals.

Migration of chemicals currently found in soil and groundwater at the Site to the river is not considered of major concern. Therefore this route is not illustrated in the revised CSM.

The Tier One ERA predicts low to negligible risks for aquatic organisms (plants, invertebrates, fish and benthic community). Consequently, those organisms are not illustrated in the revised CSM. Amphibians, if present, could be exposed via dermal contact with water and sediment, but risks to these organisms has not been evaluated given the near absence of toxicological data for this receptor group in literature.

Soil invertebrates and microbes living within the river banks may be directly exposed to contaminated soil. Riparian vegetation could also be exposed via root uptake from soil.

Mammals and bird species could be exposed by ingestion of food (plants, invertebrates and fish), depending on their diets. Although not illustrated in Figure 3, all wildlife could also be exposed via ingestion of soil, water and, occasionally, sediment, depending on their feeding habits and habitats.

The Tier One ERA has predicted potential risks for vegetarian and insectivorous species, but probably not at population level. Risks for piscivorous species could not be evaluated. The ingestion pathway could be better evaluated using food-chain modelling and measured or predicted concentrations of chemicals in food items, however, such an analysis is normally only undertaken at Tier Three stage where this is warranted and was therefore outside of the scope of this study.

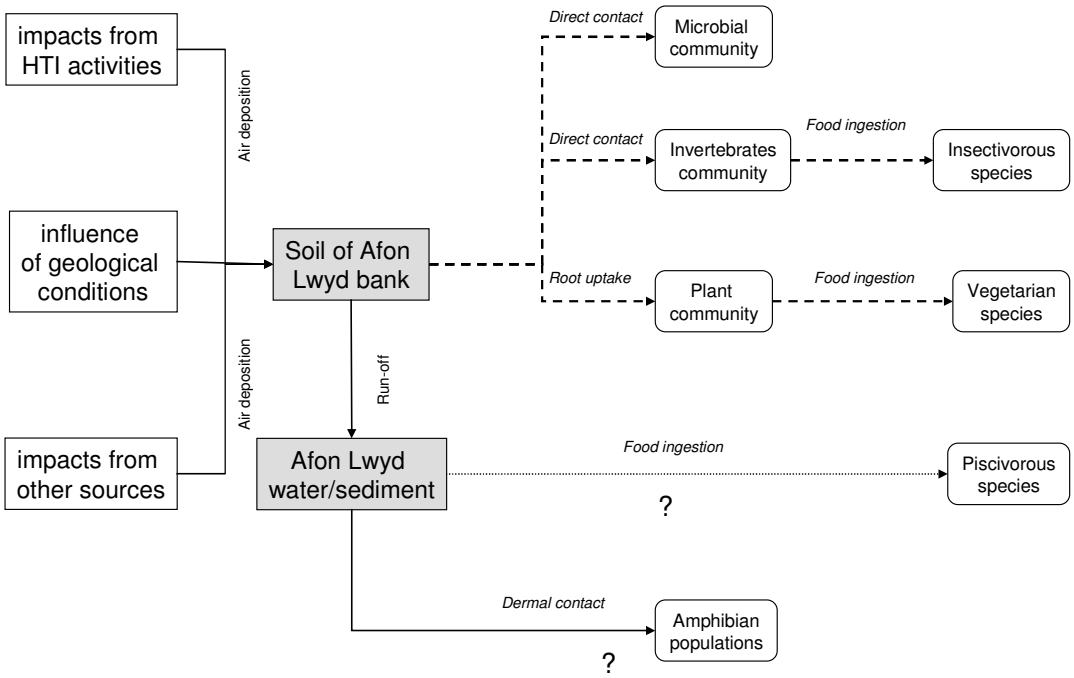
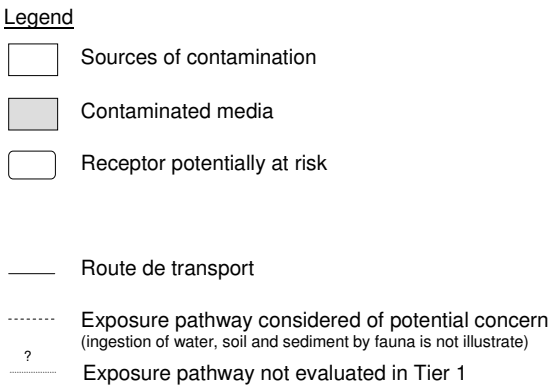


Figure 3: Revised Conceptual Site Model (CSM)

(Ingestion of water, soil and sediment not represented.)
(Other sources: road, local industries past and present etc.)



4.5.4 Recommendations

Additional soil sampling from the Afon Lwyd banks, both upstream and downstream of the Site is recommended in order to decrease uncertainties related to the risks to identified terrestrial receptors occupying this habitat. Sampling will be discussed with TCBC and undertaken by Shanks early in 2007, subject to agreement with land owners.

Re-sampling of the drainage ditch is recommended as soil removal has already been conducted and the residual levels are not known. Additional sampling of off-Site surface soil should also be undertaken in order to evaluate background levels and the influence of other anthropogenic sources which may have contributed to the presence of the soil contaminants detected as it is considered that the former HTI facility does not represent the principal source of the off-Site metal concentrations. Sampling should include locations upwind of the Site as well as the river banks upstream of the Site. Analysis should comprise all chemicals identified as potential concern in soil during this Tier One ERA. This will include chromium, lead, mercury, nickel, vanadium, zinc, di-n-butyl phthalate, dibenzofuran (chemicals in soil presenting HI > 10) as well as PCBs, dioxins and furans (chemicals associated with former Site activities). Shanks and TCBC have agreed to collaborate to assess further the off-Site metal concentrations in the soils adjacent to the Site boundary. Sampling will be discussed with TCBC and may be undertaken early in 2007, subject to agreement with land owners.

Further sampling of surface water within the Afon Lwyd should be undertaken including at a number of locations upstream and downstream of the Site in order to confirm copper concentrations and to provide data relating to suspended solids. Sampling will be discussed with TCBC and will be undertaken early in 2007.

In the light of the additional sampling proposed, a revised Tier One ERA will be produced using the additional analytical data yielded from the investigations above. If concentrations in the River banks suggest potential high risk (i.e. HIs greater than 10) and if the assessment of background levels suggests impact from the Site, rather than from other sources, a Tier Two risk assessment would be warranted.

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