



REPORT OF THE NICOLE WORKSHOP

**State of the art of (Ecological) Risk Assessment
15-16-17 June 2005**

Stockholm, Sweden

www.nicole.org

**Compiled by Paul Bardos, NICOLE Information Manager
r³ Environmental Technology Limited
www.r3environmental.com**

NICOLE (*Network for Contaminated Land in Europe*) was set up in 1995 as a result of the CEFIC “SUSTECH” programme which promotes co-operation between industry and academia on the development of sustainable technologies. NICOLE is the principal forum that European business uses to develop and influence the state of the art in contaminated land management in Europe. NICOLE was created to bring together problem holders and researchers throughout Europe who are interested in all aspects of contaminated land. It is open to public and private sector organisations. NICOLE was initiated as a Concerted Action within the European Commission’s Environment and Climate RTD Programme in 1996. It has been self-funding since February 1999.

NICOLE’s overall objectives are to:

- Provide a European forum for the dissemination and exchange of knowledge and ideas about contaminated land arising from industrial and commercial activities;
- Identify research needs and promote collaborative research that will enable European industry to identify, assess and manage contaminated sites more efficiently and cost-effectively; and
- Collaborate with other international networks inside and outside Europe and encompass the views of a wide a range of interest groups and stakeholders (for example, land developers, local/regional authorities and the insurance/financial investment community).

NICOLE currently has 136 members. Membership fees are used to support and further the aims of the network, including: technical exchanges, network conferences, special interest meetings, brokerage of research and research contacts and information dissemination via a web site, newsletter and journal publications. NICOLE includes an Industry Subgroup (ISG) – with 27 members; a Service Providers Subgroup (SPG) with 35 members; 61 individual members from the academic sector/research community; and 13 members from other organisations, including research planners, non profit making organisations, other networks, funding organisations. Some members are involved in both the ISG and the SPG. For further general information, further meeting reports, network information and links to contaminated land related web sites, please visit NICOLE's web site: www.nicole.org.

Membership fees are currently 3,500 EURO per year for companies (1,750 EURO for smes), and 150 EURO per year for academic institutions. For membership requests please contact:

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- the overall assistance of Åsa Carlsson (Kemakta Konsult AB) and Marjan Euser (General NICOLE Secretariat).

Executive Summary

The acceptance of risk-based land management of contaminated land (RBLM) was an early priority of NICOLE. The advantages of RBLM are that it is systematic and objective, it provides a consistent basis for dealing with issues such as uncertainties and decision making and it leads to solutions that are appropriate to the risks posed by contamination. NICOLE believes that now is the time to revisit the status of risk assessment with respect to the credibility and transparency of the results and to the degree of harmonisation throughout Europe.

This report reviews a workshop convened to discuss these and other issues in the development of risk assessments. A key area that is still under development compared to other areas of risk assessment is the assessment of ecological risks. Owing to the uncertainties associated with the application of ecological risk assessments, this workshop has a special emphasis on the state of the art in this area. The workshop covered the following topics:

- identifying gaps in ecotoxicological risk assessment
- application of risk assessment
- how far can we get with modelling?
- implementation – examples from different countries
- European dimension.

This report provides summaries of the papers given, along with conclusions based on points raised during the meeting, and comments from a number of delegates after the meeting.

Concluding Remarks

These conclusions have been drawn from the concluding session of the workshop and from comments invited from NICOLE Steering Group members, the meeting organisers and speakers in the weeks following the workshop.

There is clearly potential for industrial activities to impact on ecological processes, and in a number of cases major impacts have occurred over large areas. Ecosystems are the engine of the world's biosphere and we are dependent upon them for our survival. For example, soil ecosystems support the agricultural and horticultural use of land, the condition of the soil (including its physical properties), the ability of soil to buffer and degrade contaminants and the ability of soil to support bioremediation or natural attenuation for the management of risks to human health or water. However, it is only recently that ecological risk assessment has begun to become a more regular part of contaminated land management, which has primarily focused on risks to human health and water.

There are uncertainties in the role of ecological risk assessment, and also in its execution. A major question implied by ecological risk assessment is: can we do anything with its findings, i.e. how do we manage ecological risks.

The context of many contaminated sites is that they are in industrial or urban areas, both of which are already highly disturbed from an ecological point of view. Hence, if the implication of ecological risk assessment is that there is a problem arising from a contaminated site that needs to be put right, the next question is what is the end-point desired. Even if it could be determined what the original status of an ecosystem was, is it appropriate to expend resources (that could be used for environmental protection elsewhere) to restore an ecosystem that does not exist elsewhere in the site's local environment. One could further argue that it may perhaps be inappropriate to make a further set of artificial interventions into local ecosystems. Furthermore, it is not yet well understood what those interventions might be. Perhaps the answers will lie in preventing further deleterious impacts and supporting some kind of ecological natural attenuation and regeneration.

The idea of “ecological risk management” would seem to be a natural consequence of the use of ecological risk assessment, but has scarcely begun as a discipline. Most at the NICOLE workshop were anxious that any requirements for ecological risk management were proportional, taking into account the geographical and urban context of a site and ongoing land use. However, it should not be that ecological risk assessment will inevitably lead to an increase in contaminated land management costs. A few presentations showed that an intelligent approach to ecological risk management could enable site re-use at a lower than expected cost.

The execution of ecological risk assessment as a site investigation process is also at emerging level of knowledge. In countries which have, or are on the process of establishing, ERA frameworks; a number of common principals are already apparent, such as the use of a tiered approach and a “weight of evidence”. Several presentations highlighted the role of the TRIAD approach (considering chemical analysis, ecotoxicity testing and ecological field work in parallel). A major problem in carrying out ecological risk assessment (and indeed human health assessment) is a paucity of technical data, and an inadequate consideration of existing information by some models. Delegates called for a better exchange of risk assessment know-how, and the creation of integrated datasets as a common basis for practioners across Europe. NICOLE could play a role in catalysing this development, for example by supporting a forum for the exchange of experiences about practical applications of ecological risk assessment (case studies), and supporting, in some way, an overarching review of available ecological risk assessment approaches, tools, models and datasets.

Ecological risk assessment is an important issue for NICOLE, which will seek to establish an overall technical viewpoint, with which to participate in the EC Soil Thematic Strategy and the HERACLES network¹.

The full report provides summaries of the papers given, along with a discussion based on points raised during the meeting, and comments from a number of delegates after the meeting.

¹ Human and Ecological Risk Assessment for Contaminated Land in European Member States, co-ordinated by JRC ISPRA

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1 Introduction

Management of contaminated land is an important issue throughout Europe, and one that involves many stakeholders: governments, regulatory bodies, the community, industry and the wide range of researchers and service providers who support the process. NICOLE supports two workshops a year and produces a meeting report for each. Past events and future workshops are listed in Table 1. Further information, for example reports or registration forms, is available on the NICOLE web site: www.nicole.org.

The acceptance of risk-based land management of contaminated land (RBLM) was an early priority of NICOLE. The advantages of RBLM are that it is systematic and objective, it provides a consistent basis for dealing with issues such as uncertainties and decision making and it leads to solutions that are appropriate to the risks posed by contamination.

Since the start of the network in 1996, NICOLE has adopted several approaches to support the RBLM approach. Following the NICOLE workshop in Helsinki in 2000, in 2002 NICOLE published a discussion paper on the role of risk assessment in sustainable land management. One of the questions posed in that document concerned the differences between Risk Assessment models when simulating similar issues. Taking up this issue, in the beginning of 2002 12 members of the Industry Subgroup launched a NICOLE supported comparative evaluation of risk assessment models used in different member states. This project was finalised and reported in 2004. NICOLE has also established communications with the European Commission through which it aims to assist and support policy-making through the provision of scientific and technical advice.

NICOLE believes that now is the time to investigate the status of risk assessment with respect to the credibility and transparency of the results and to the degree of harmonisation throughout Europe.

This report reviews a workshop convened to discuss these and other issues in the development of risk assessments. A key area that is still under development compared to other areas of risk assessment is the assessment of ecological risks. Owing to the uncertainties associated with the application of ecological risk assessments, this workshop has a special emphasis on the state of the art in this area.

This report provides summaries of the papers given, along with conclusions based on points raised during the meeting, and comments from a number of delegates after the meeting.

Table 1: NICOLE Events and Publications from 2000

Date	Event / Report
January 2005	Report of the NICOLE Workshop: Unlocking the Barriers to the Recovery of Soil and the Rehabilitation of Contaminated Land. 15-16 November 2004, Sofia, Bulgaria see www.nicole.org/publications/library.asp?listing=1
2004	NICOLE Booklet on Communication on Contaminated Land, www.nicole.org/publications/library.asp?listing=2
2004	NICOLE News 2004 issue, www.nicole.org/publications/library.asp?listing=9
13-14 May 2004	Report of the NICOLE Workshop: <i>Sediments and sludges: an issue for industry?</i> , Frankfurt, Germany see www.nicole.org/publications/library.asp?listing=1 and <i>Land Contamination and Reclamation</i> 12 (4) 379-400
13 Feb 2004	Report of the NICOLE Workshop: <i>NICOLE Projects Reporting Day</i> , Runcorn, UK - see www.nicole.org/publications/library.asp?listing=1 and, <i>Land Contamination and Reclamation</i> 12 (3) 286 - 308
29-31 October 2003	Report of the NICOLE Workshop: <i>Sharing experiences in the management of megasites: towards a sustainable approach in land management of industrially contaminated areas</i> , Lille, France - see www.nicole.org/publications/library.asp?listing=1 and <i>Land Contamination and Reclamation</i> 12 (2)127-158
2003	NICOLE News 2003 issue, www.nicole.org/publications/library.asp?listing=9
12 – 14 March 2003	Report of the NICOLE Workshop: <i>Management of Contaminated Land towards a Sustainable Future: Opportunities, Challenges and Barriers for the Sustainable Management of Contaminated Land in Europe</i> , Barcelona, see www.nicole.org/publications/library.asp?listing=1 and <i>Land Contamination and Reclamation</i> 11 (3) 366-395
6 - 7 November 2002	Report of the NICOLE Workshop: <i>Financial Aspects of Site Restoration with an Emphasis on Central and Eastern Europe</i> , 6 - 7 November 2002, Budapest. see www.nicole.org/publications/library.asp?listing=1 , and <i>Land Contamination and Reclamation</i> 11 (3) 366-395
2002	NICOLE News 2002 issue, www.nicole.org/publications/library.asp?listing=9
18 – 19 April 2002	Report of the NICOLE Workshop: <i>Cost-effective Site Characterisation - Dealing with uncertainties, innovation, legislation constraints</i> , 18-19 April 2002, Pisa. see www.nicole.org/publications/library.asp?listing=1 , and <i>Land Contamination & Reclamation</i> 10 (3) 189-219
14-15 November 2001	Report of the NICOLE workshop: <i>ICT/Computing applied to contaminated land characterisation /remediation and MNA</i> , Rotterdam, the Netherlands (Port of Rotterdam) in conjunction with the Network on Natural Attenuation in Groundwater and Soil (NNAGS). see www.nicole.org/publications/library.asp?listing=1 , and <i>Land Contamination & Reclamation</i> 10 (1) 33-59
2001	NICOLE News 2001 issue, www.nicole.org/publications/library.asp?listing=9
17-18 May 2001	Report of the NICOLE workshop: <i>Cost-effective clean-up technology; quality assurance and acceptance</i> , Paris, France. see www.nicole.org/publications/library.asp?listing=1 , and <i>Land Contamination and Reclamation</i> 9 (4) 377-395
January 2001	Special Issue of <i>Land Contamination and Reclamation</i> , outlining NICOLE and CLARINET work, www.nicole.org and www.btInternet.com/~epppublications/ and <i>Land Contamination and Reclamation</i> 9 (1)
9 and 10 November 2000	Report of the NICOLE workshop: <i>Brownfields: How to Change a Potential Threat into an Asset</i> , IJmuiden, The Netherlands. see www.nicole.org/publications/library.asp?listing=1 , and <i>Land Contamination and Reclamation</i> 9 (2) 252 – 256
2000	NICOLE News 2000 issue, www.nicole.org/publications/library.asp?listing=9
September 2000	Joint Statement of NICOLE, CLARINET, ETCA and SENSPOL: Sustainable Management of Contaminated Land for the Protection of Water Resources, www.nicole.org
22-23 May 2000	Report of the NICOLE Workshop: <i>Source Management</i> , Helsinki, see www.nicole.org/publications/library.asp?listing=1 , <i>Land Contamination and Reclamation</i> 8 (4) 67 – 68.

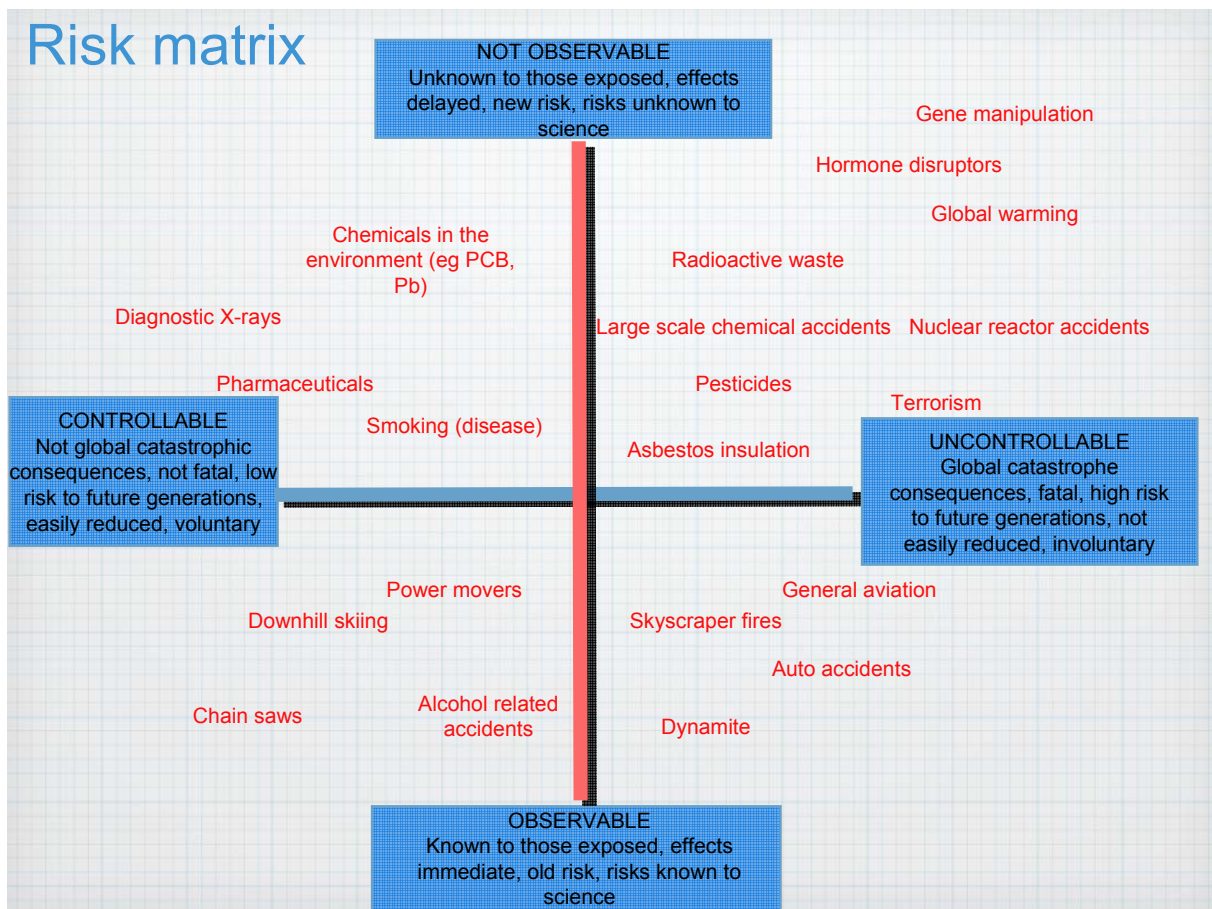
2 Presentations

Management of soil pollution issues in industry, *Torbjörn Brorson, Trelleborg Group, Sweden*

The focus of this presentation was on understanding, communicating and managing risks from the perspective of mitigating soil/groundwater pollution in everyday work. In particular the value of environmental management systems and environmental due diligence audits were highlighted.

Risks are a fact of life. However, different types of risk are perceived with varying degrees of “dread”. Risks are often classified on the basis of how knowable (or observable) they are, and how controllable they are, as illustrated in Figure 1. The more unknowable and uncontrollable a risk, the higher the “dread” in which it is held by most people. It seems possible that soil pollution was originally seen as an issue that was not knowable and not controllable. However, as knowledge has advanced, soil pollution is now more easily observed and is seen as more readily controllable. This has reduced the “dread” with which it is regarded, at least in the technical community. However, those not directly involved with contaminated land may not have the same level of detailed knowledge, and so may still react strongly to contaminated land problems. This can include a number of people involved in business and industry. The situation is further complicated because often key decision makers may not have the time to assimilate detailed knowledge about contaminated land management. Hence communication is all important.

Figure 1 Example Risk Matrix



For a large number of professionals managing soil pollution issues has become a part of everyday work, for example those involved with property development; mergers and acquisitions; and safety, health and the environment. Environmental management systems (EMS) have become a useful tool to mitigate soil and groundwater pollution, linked to ISO 14001. The EMS is a part of an organization's management system used to develop and implement its environmental policy and manage its environmental aspects. The environmental management system should cover all environmental aspects, e.g.:

- Air emissions
- Energy consumption
- Risks with chemicals
- Generation of waste
- Historic and current soil pollution.

Merger and acquisition of companies is a major part of economic activity in Sweden and elsewhere. Mergers and acquisitions are subject to a range of financial risks, arising, for example, from:

- Negative attitude of management in the acquired company.
- Bad planning of the integration process.
- Insufficient knowledge about the acquired company and their business.
- Bad management of the acquired company.
- Limited experience of how to acquire and integrate companies.
- Environmental risks (e.g. soil pollution, missing permits).
- Liabilities related to the acquired business (e.g. products, asbestos).

Of these contaminated land issues can pose substantial financial risks to the economic success of a merger or acquisition. Hence, soil pollution issues are particularly high on the agenda for mergers and acquisitions. A common tool used in the merger and acquisition process is the *environmental due diligence audit*, which aims to identify potential risks and forms a basis to develop strategies for risk management. The environmental due diligence audit seeks to:

- Identify environmental risks during mergers, acquisitions and divestitures (industries, properties).
- Identify risks for soil pollution and cost for soil remediation.
- Check legal compliance and identify cost for compliance measures.
- Identify special risks (asbestos, PCB, hazardous waste, radon, etc).
- Clarify the responsibilities after the transaction between seller and buyer.

Audits tend to be phased. The first phase is based on desk studies and interviews and a site inspection. It may find that there are no or only limited environmental risks, in which case the audit concludes that environmental risks will not interfere with the business transaction. Alternatively, it may conclude that there are open issues and/or identified risks, in which case the audit proceeds to a second phase. In this second phase additional investigations, such as soil/groundwater analyses, take place. The interpretation of an environmental audit is a staged process. Firstly, an identification of significant environmental effects must be made, based on a specific set of evaluation criteria. Secondly, the consequences of these environmental effects on the business transaction must be evaluated, again based on a specific set of criteria.

Soil and groundwater pollution problems are of increasing interest to industry. Firstly, there is both an increasing awareness of potential problems, and more stringent policy and regulatory requirements should problems be conformed. Secondly, remediation costs tend to be high, and remediation work can go over time and over budget. Therefore, there is increasing shareholder concern that environmental risks can impact profitability. Soil and ground water pollution issues tend to be complicated, which is not conducive to the "black and white" condensed information preferred by top level business decision makers. The available information can be confused by the number of technical experts needed to evaluate an environmental problem. It is not easy to quantify and communicate risks. Industry needs good tools to be able to improve internal and external communication.

The NICOLE Strategy, questions and answers on risk assessment, *Divyesh Trivedi, BNFL, UK / NICOLE chairman*

Since its inception in 1996 NICOLE has been a successful, industrially driven network concerned with the management of contaminated land. It has provided a European forum for the dissemination and exchange of knowledge, identified research needs, promoted collaborative research e.g. risk assessment model inter-comparison project; and collaborated with other international networks inside and outside Europe. So the question might be asked: *Why does this need to change?* In short, the realignment of NICOLE recognises that there is now nine years of European experience in the issues that were the initial focus of the network, for example: risk-based management, natural attenuation.

- What was emerging nine years ago is now more or less established, and NICOLE's members interests have changed in line with a changing structure in the commercial world as markets mature. A consequence of this changing structure is an increasing number of service providers, while the number of industry problem holders has remained relatively static.
- EU Policy issues are now increasingly affecting remediation: for instance the Waste Framework Directive changes and the Water Framework Directive. Hence there is an increasing interest in NICOLE in policy and its impacts on soil and groundwater management.
- NICOLE now focuses much more on applied technologies and knowledge transfer rather than more basic research. The consequence of this is that there is less direct involvement of academics in the network.

Recognising these changes, NICOLE commissioned a study of its members' interest and views on how NICOLE should be taken forward. Based on this the study would suggest a future path for NICOLE. The study was carried out by Tauw and Royalhaskoning: They produced a questionnaire based on the four principal aims of NICOLE to date (see Table 1), which was sent to ISG and SPG members. They also interviewed several companies not (at the time) members of NICOLE.. The questionnaire consisted of: 50 statements about what NICOLE was or might be. Respondents could score the questions depending on their level of agreement with the statement: from 0 (completely disagree) to 10 (completely agree). The scores were compiled and analysed statistically. Examples of statements include:

- "The most important issues for NICOLE are developments in policy that influence contaminated land management within the EU and member states".
- "I have no time or interest for working groups because soil and groundwater is but a small part of my portfolio. That is why we hire first-class consultants".

Detailed feedback was obtained from 18 ISG members, 15 SPG members and 10 companies not (at the time) members of NICOLE.

Key points emerging from this consultation included:

- Strong support for NICOLE intervention in EC policy development, to ensure that its members' opinions are taken into account.
- The development of working groups with special themes and remits to address NICOLE tasks, such as preparing opinions on policy developments, and for sharing knowledge, with a focus on application of knowledge rather than fundamental research
- Strong support for NICOLE as vehicle for collaborative learning.

The conclusions for NICOLE's way forward are therefore that:

1. NICOLE should take a stronger role in the provision of advice and support to EU research and legislation, using focused working groups, whose findings are and endorsed by the wider membership at NICOLE workshops.
2. There is still a place for "themed" workshops IN NICOLE, but perhaps that their focus should shift towards application/best practice. The same may also be true for NICOLE projects.

Table 1 Principal Aims of NICOLE

- | |
|---|
| <ul style="list-style-type: none">• Provision of (technical) input to the European Commission• Sharing knowledge between members• Directing research on contaminated land issues• Providing a means to share costs |
|---|

Views of the Common Forum on risk assessment, Joop Vegter, Common Forum

The “Common Forum” is a network of contaminated land policy experts and advisors, which began in 1994. Its mission is to be a platform for the exchange of knowledge and experiences; to establish a discussion platform for policy, research, technical and managerial concepts of contaminated land; to act as a focus for initiating and following-up of international projects among members; and to support exchange of expertise with the European Commission and other European networks. The Common Forum has made a strong contribution to the contaminated land debate in Europe and has established several successful initiatives:

- Development of the state of the art in risk assessment: the CARACAS project (1996-99), www.caracas.at
- Developing the concept of Risk Based Land Management (RBLM) through the CLARINET project (1998- 2001), www.clarinet.at
- Placing contaminated land in the EC Soil Strategy

The future focus of the Common Forum is seen as being towards system oriented holistic approaches.

The improvement of risk assessment practice was the major influence for the Common Forum when it was initiated. Risk assessment follows the source-pathway-receptor paradigm, all three components must be in place for a risk to exist (illustrated in Figure 2). The state of the art in risk assessment is still well summarised by the CARACAS publications². At the end of the 1990s the Common Forum interest shifted towards solutions, and the CLARINET project was born.

Risk Based Land Management is primarily a framework for the integration of two key decisions for remediation of contaminated land:

1. The time frame: this requires an assessment of risks and priorities, but also the consideration of the longer term effects of particular choices.
2. The choice of solution: this requires an assessment of overall benefits, costs and environmental side effects, value and circumstances of the land, community views and other issues.

These two decisions have to take place at both an individual site level and at a strategic level, especially as the impact of contaminated land on the environment can have not only a large scale regional dimension but also potentially wide ranging long term impacts. The decision making process needs to consider three main components which form the core of the RBLM concept: (1) fitness for use, (2) protection of the environment and (3) long-term care. The first two components describe goals for safe use of land, including prevention of harm and resource protection. The third allows for a more

² Ferguson, C., Darmendrail, D., Freier, K., Jensen, B.K., Jensen, J., Kasamas, H., Urzelai, A. & Vegter, J. (1998) “Risk Assessment for Contaminated Sites in Europe. Volume 1. Scientific Basis”, Report of CARACAS Project: Concerted Action on Risk Assessment for Contaminated Sites in the European Union. LQM Press, Nottingham. See also: www.caracas.at

rigorous assessment of the way in which these goals are achieved, to ensure that it is a sustainable way. The three components need to be in balance with each other to achieve an appropriate solution. Figure 3 illustrates an example of RBLM, the “contact zone” concept. In this concept only a relatively shallow layer of the surface is seen as in direct potential contact with receptors, so this is where remediation work should be focused, with efforts for deeper layers focusing only on the mitigation of problems caused by spreading contamination.

Figure 2: The Source-Pathway-Receptor Paradigm

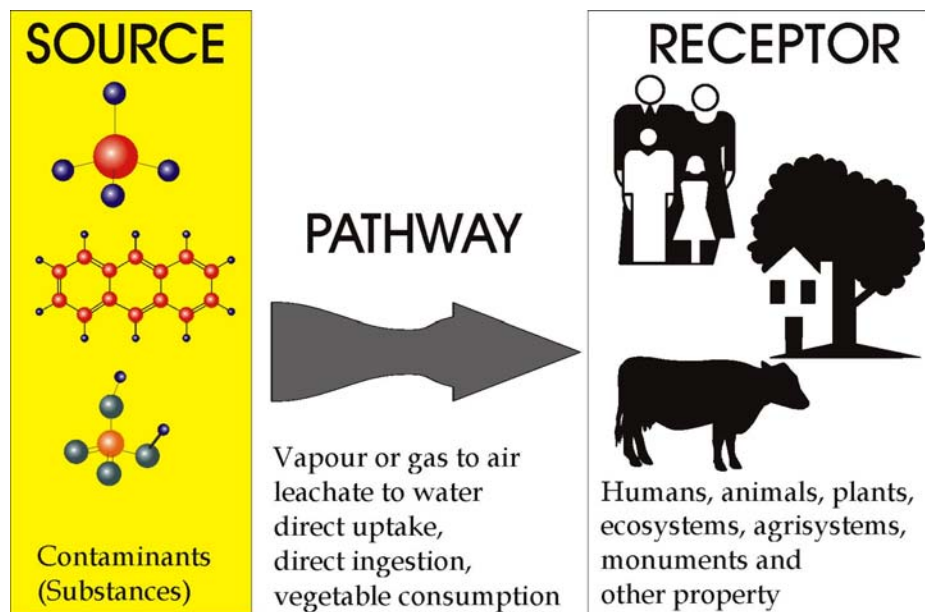
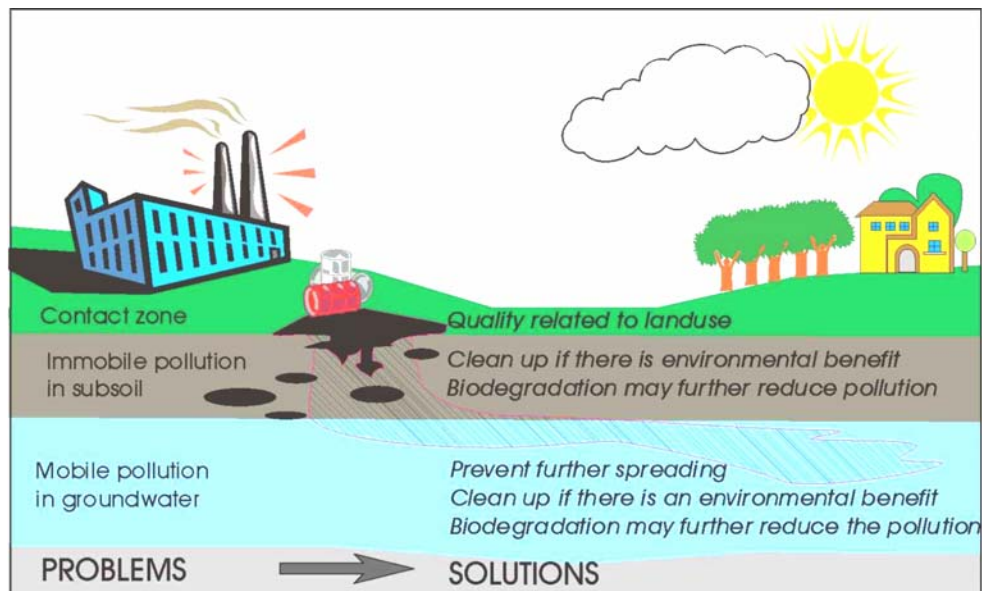


Figure 3: The Contact Zone Concept



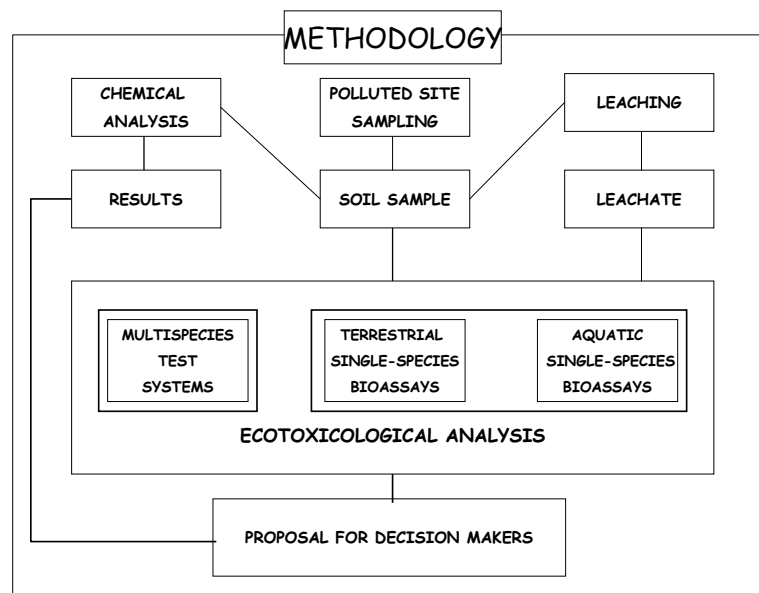
The Common Forum view on ecological risk assessment is shaped by the concept of Risk Based Land Management. Ecological risk assessment (ERA) should be used to understand risks related to the sustainable management of soil and water resources, encompassing:

- Soil as a life support system (the *Vital Soil* concept)
- Water and Nutrient cycles
- Decomposition of organic matter
- Biodiversity and Stability of ecological functions.

There are a range of relationships between ecology and contaminated land management. Risk management through bioremediation and natural attenuation depend on soil ecosystems. Different land uses and functions have specific ecological requirements. Hence ecological fitness for use is more than the achievement of acceptable human health risks, it needs to encompass issues such as phyto-toxicity, toxicity for domestic animals, and the function of soil microbial processes. Ecological risk assessment has on site considerations (such as level of contamination, bioavailability, size of the area, persistence of contaminants, and off site considerations, such as food chain effects and disruption of wider ecological relationships, for example off site birds feeding on contaminated soil insects on site.

Comparing human health and ecological risk assessment, one can draw the following conclusions. Human health risks concerns the health of an individual. Assessments are largely based on laboratory experiments with animals, and a framework for their interpretation based on medicine, sociology and psychology. Ecological risk assessment has to address the health of populations of a multitude of species and ecosystems. ERA is still based based on the concept of *No Observed Effect Concentration* (NOEC) , derived from the results of toxicity testing in the laboratory. However, there is no general ecosystem theory that can serve as a framework for interpretation of NOEC data in an ecosystem context. The current state of the art is that a tiered approach should be taken, such as that illustrated in Figure 4.

Figure 4 Generic Approach to Ecological Risk Assessment



A theoretical framework for ecotoxicological risk assessment and its uncertainties, *Celia Jones, Kemakta Konsult AB, Sweden*

The presentation was based on the results of a Swedish project *Better Assessments of Risks to the Environment*. The project was carried out as part of the Swedish Environmental Protection Agency’s

programme *Sustainable Remediation*. The aim of the project was to suggest ways of improving the methods and underlying data which are currently used to assess risk to the environment from contaminated areas. The project focused on addressing the following questions:

- Are the methods used today suitable for assessing risk to the environment from contaminants areas?
- Is the underlying database reliable and relevant to Swedish environmental conditions?
- Can site specific risk assessments be carried out?
- Can ecotoxicological investigations be incorporated into site specific assessments?

The conclusions from the study include a preliminary framework for the ecological risk assessment of contaminated land. The framework describes a sequential risk assessment methodology in three levels; a preliminary risk assessment (screening), a detailed risk assessment and a complete site-specific risk assessment. As the assessment progresses from the screening level to more detailed levels, the strategy for risk assessment changes. At the lower levels, the aim is protection of all the organisms and processes that occur in the environment. This is achieved by generalising from available data from ecotoxicological tests; single species tests or tests on selected ecological processes, often by deriving a concentration-based guideline value. A sufficiently large safety margin is adopted to ensure that the environmental risks are not underestimated. Guideline values will continue to be important tools for environmental risk assessment. Therefore, several measures have been suggested to improve the underlying database and the methods used for derivation of guideline values. These improvements should facilitate risk evaluation.

At higher levels in the risk assessment process, the aim of the assessment is limited to the protection of relevant organisms and relevant ecological functions for the actual site. The need for site-specific information and relevant ecotoxicological data is much greater, but in return, the risk assessment will give a better evaluation of the actual risks.

There is an urgent requirement for the development and standardisation of ecotoxicological tests. Methods are needed for ecotoxicological tests on a large number of contaminants in order to fill some of the gaps in the database used for guideline derivation. Tests are also required which will enable biological investigations to be included as a part of site specific assessments. Suggestions for future developments in this field include calibration and standardization of existing, but as yet non-standard tests, adjustment and application of tests which are today used within other areas (e.g. sediment tests), and the identification of relevant organisms for the development of new tests as well as the development of a hierarchical system for ecotoxicological testing of contaminated land.

Biological investigations are included in the framework as a complement to the evaluation of existing ecotoxicological data. The biological investigations suggested include studies of organism-groups with important ecological functions (e.g. species composition), ecotoxicological tests and tests of bioavailability.

The development of a guidance document around the suggested framework structure is recommended. The guidance document is intended to contain everything from the definition of the object of protection to the selection of suitable methods and criteria for decision making.

Ecotoxicological risk assessment – the European way, *Frank Swartjes, Leo Posthuma, Michiel Rutgers, RIVM, NL*

There are a number of reasons why ecological risk assessment may be necessary, connected with the “value” of ecosystems. Ecosystems may carry out important functions, for example in maintaining soil fertility, structure and condition, important “life support” functions; or may be exploited in risk management roles, such as *in situ* bioremediation.

Ecosystems may have an intrinsic value based on a desire to preserve organisms and biodiversity. These desires have been made explicit in Earth summit (Rio de Janeiro), 1992 which established a Framework Convention on biological diversity. The European Environmental Agency has set biodiversity targets to be achieved by 2010. Other policy drivers for the protection of the ecosystem include parts of the Water Framework Directive, which discusses protection of the groundwater ecosystem and hence, of other aquatic and terrestrial ecosystems, and the developing EC Soil Strategy.

Ecosystems may be a visible part of the landscape and quality of life, even in industrial areas, where attractive landscapes add commercial value. Soil ecosystem function underpins the sustainable use of soil. The resilience ecosystems is an indicator of how sustainable soil use will be in the long-term, and an indicator of how well soil can respond to changed land-use in the future.

Species vary in their sensitivity to toxic substances. Concentration can be mapped against the *potentially affected fraction (PAF)* of an ecosystem. RIVM has collated available information in a database: *e-toxBase*. This includes >166,000 data entries covering 2,900 species, 5,100 compounds and 910 modes of action. The system is based on meta-data (i.e. it tells a user where information is held rather than reproducing information). The available information is scored for quality, dated and the data owner is identified. The system provides outputs that can be exported to *MS Excel*, and outputs transferable to *ETX*³. It may be made available on the Internet but is not yet posted. This information can be applied to making an assessment of Potentially Affected Fractions, which in turn can be used in the setting of generic soil quality standards for ecological risk assessment. The system also supports the consideration of combined exposure to several contaminants.

Generic soil guidelines have limitations for ecological risk assessment, in that their “one size fits all” approach may not adequately take into account species of special significance for particular sites, or specific site circumstances that may affect ecological risks. Specific ecological risk assessment is used for a more tailored assessment. A widely adopted approach to risk assessment is the *Triad Approach*, which assesses risk as a function of chemistry, toxicity and ecology in combination. The Triad Approach looks at impacts on ecology on the basis of weight of evidence from a several sources, i.e. not just on a single test method. It is a tiered approach. Initial steps are based on limited measurements, but with a highly conservative set of general assumptions, so that if a site “passes”, it does so with a high degree of confidence, and with limited ERA costs. Successive steps become less generic, and more specific so the degree of conservatism can be reduced. Successive steps also tend to become more complex and costly. Each tier of the assessment is converted into a series of scores to allow the comparison of different types of information and data. The aim of the tiered approach is to avoid the use of complex, costly and time consuming investigations, unless there is no realistic alternative. On an overall basis this acts to minimise the costs of ERA. Ecological assessments can be show a high degree of variability. Within the Triad Approach results are considered too ambiguous to result in a proper assessment.

The general state of the art for ERA in Europe has been set out in publications by the CARACAS and CLARINET projects mentioned in the Vegter paper above, and downloads of this information are available from the CARACAS and CLARINET web sites. In Europe today most countries are using or developing ERA protocols, although relatively few (e.g. the Netherlands, Norway and Sweden) have adopted ERA in regulatory frameworks. Standardised tools are under widespread development, but there are relatively few final tools available. ERA is likely to play an increasing role in EC environmental policy, as described above. European Research projects have begun to develop ERA tools, e.g. *LIBERATION* and *HERACLES* (see www.eugris.info for project information). Their overall aspiration is to provide a common tool box for ERA tools across Europe, encompassing: standardised tools; more flexible tools that take into account political, geographical and ethnological differences; and supporting guidance.

³ ETX is a computational tool to derive statistical species sensitivity distributions and related statistics from toxicity data

Standardised tools would include:

- A database for species sensitivity distributions (SSD) and function (ecological process) sensitivity distributions (FSD)
- A procedure on Bioavailability
- A framework based on the TRIAD approach.

Flexible tools would include:

- A protocol to assess the risk for predators due to biomagnification taking into account the type of birds/ mammals
- A selection of bioassays that take into account: soil type, soil characteristics and organisms of interest.

Hence research needs for ERA in Europe include: developing common databases (like the RIVM example), knowledge of the impacts of climate, soil types, species on soil ecosystems, the development of country specific general soil quality standards, and site specific assessment frameworks, and a common “tool-box” of bioassays.

Of special interest to NICOLE members might be relationship between soil ecology and surface functions (including those exploited in risk management) and the increasing policy significance of ecology in built up areas. Bioavailability changes over time as contamination ages, but can change rapidly in disturbed soils. The science of ERA is complex, and so may be difficult to explain to non-technical stakeholders. An important way NICOLE might help is in facilitating communication between scientists involved with ERA and their “client” stakeholders.

Ecotoxicological risk assessment – the American way, *Terry Walden, BP, USA*

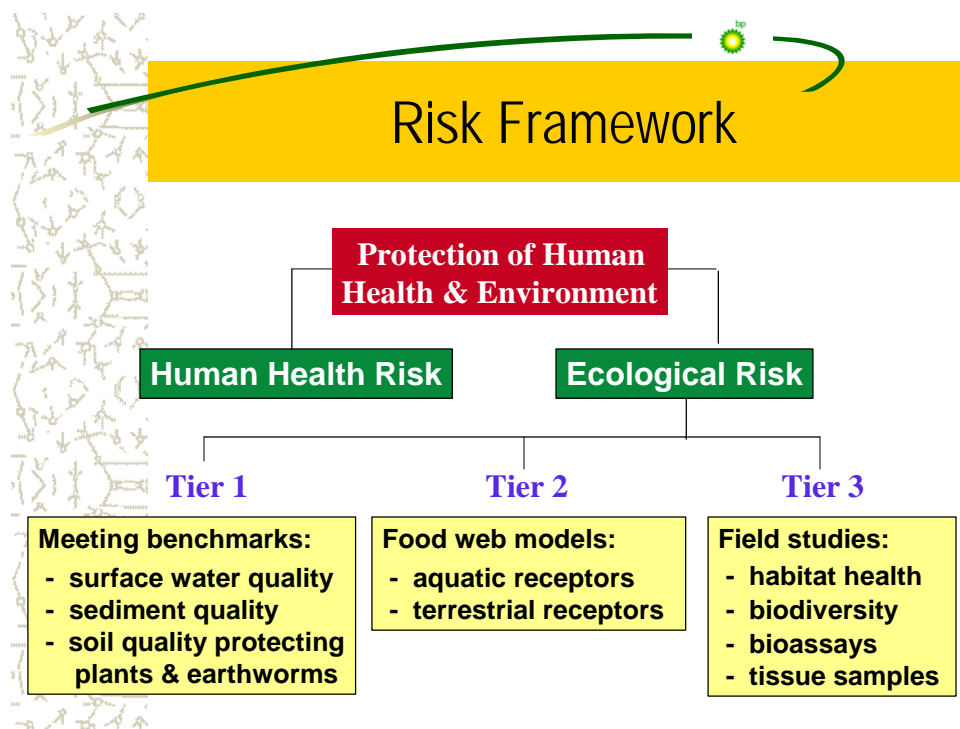
While the approach for conducting human health risk assessments is fairly well defined and agreed across both national and international boundaries, this is less the case for ecological risk assessment (i.e. protection of the non-human health environment). The primary dilemma in the latter category is deciding what ecological receptor, or group of receptors, merit protection. European practice is mostly geared towards assuring the functional vitality of the ecosystem, such as demonstrating that soil microbial processes remain intact for supporting plant growth and soil invertebrate survival. The practice in the U.S. is generally more concerned with protection of wildlife (birds and mammals), with plants and earthworms considered part of the wildlife food chain but not endpoints that must be protected in their own right.

The reason behind this disparity is primarily economic. A law passed in December 1980 in America, termed Natural Resource Damages, allows companies to be held liable for the restoration of natural resources, including land, fish, wildlife and biota, injured by releases of hazardous substances that may not totally be removed by the clean-up remedy. As a result, there is a longer history of assessing ecological risk than in Europe. While soil process protection has regulatory and scientific appeal, it becomes less attractive when it is translated into clean-up goals where cost/benefit analyses values wildlife more favourably. It could be argued that ERA in the USA is more concerned with *actual* damage assessment from recent accidental contaminant spills and leakages, while in Europe ERA is more concerned with prioritising *potential* damage from “historical” contamination and potential barriers for redevelopment. It is very important to keep differences in the key questions in risk assessment in mind when comparing ecological risk assessment approaches.

Like human health risk assessment, a tiered approach is generally used in ecological risk assessment, with nationally published benchmarks forming Tier 1, food chain modelling using dose/response relationships constituting Tier 2 and field testing comprising Tier 3. Figure 5 illustrates the general principles of a tiered ERA developed for BP by its consultants.

A couple of case studies are provided below. In both cases the wildlife receptor to be protected has both policy and scientific uncertainties, and there is no universally accepted protocol or practice for making this selection

Figure 5 Tiered approach to Ecological Risk Assessment



At the BP Sugar Creek Refinery ERA was carried out to evaluate impacts on water courses and forest. The site was a closed BP refinery near Kansas City, Missouri. Parts of refinery were left as habitat including forests and streams. The primary contaminants of concern were metals and polynuclear aromatic hydrocarbons (PAHs). The ERA identified several animals as primary eco-receptors: two mammalian: raccoon (omnivore) and deer (herbivore) and two birds: robin (omnivore) and mallard duck (herbivore:). A Tier 2a screening exercise was carried out on the basis of a hazard quotient (HQ), defined as the *dose from diet, soil and water ingestion* divided by a *Toxicity reference value (TRV)*. Where the HQ was less than 1 no risk was implied, whereas if the HQ equal to or exceeded 1 then a Tier 2b assessment was carried out with the Tiers “a” and “b” set out in Table 2. At the Tier 2b assessment no ecological risk for the site was determined.

At the BP Casper Refinery ERA was carried out to evaluate impacts on prairie and river areas. The site was a closed BP refinery in Wyoming. Parts of refinery were left as habitat including prairie and riparian (river) areas. The primary contaminants of concern were metals and PAHs. The ERA identified the following eco-receptors:

- Communities: aquatic plants, soil invertebrates, benthic organisms and fish (trout)
- Wildlife: birds (omnivore: robin; herbivore: mourning dove; carnivore: osprey, red-tailed hawk) and mammals (omnivore: raccoon, deer mouse; herbivore: prairie vole, muskrat and carnivore: red fox).

ERA at the Casper Refinery site proceeded to a Tier 3 Assessment. Table 3 sets out the basis and outcome of this assessment. In this case ERA found some marginal effects, not all related to the refinery. In this case the decision was that the marginal failures did not justify the high economic cost of remediation, and the environmental impacts of remediation work.

Table 2 Sugar Creek Tier 2 Ecological Risk Assessment -

a) Assessment

Parameter	Tier 1	Tier 2
Wildlife area use factor	100%	Habitat survey
Compound bioavailability	100%	Compound-specific
Wildlife dietary composition	100% food diet contaminated	Species-specific diet composition
Media concentration	Maximum concentration	Central tendency (95% UCL)
Wildlife toxicity value (TRV)	NOAEL ⁴ (individual)	LOAEL ⁵ (population)

b) Outcomes

Compound	Key Receptor	Hazard Quotient Tier 2a (all failures)	Hazard Quotient Tier 2b (all passes)
Arsenic	American robin	3.0	0.13
Chromium	American robin	8.6	0.19
Lead	American robin	545	0.63
Selenium	White-tailed deer	3.0	0.29

Table 3 Casper Refinery Tier 3 Ecological Risk Assessment -

a) Assessment

Assessment Endpoint	Measurement Endpoint
Plant community	LOAEL phyto-toxicity data
Soil invertebrate community	Earthworm benchmarks
Benthic invertebrate community	Sediment + pore water screening criteria
Fish	Fish tissue concentration + surface water quality criteria
Birds and mammals	<u>soil + water + diet dose</u> toxicity reference value

b) Outcomes

Assessment Endpoint	Result
Plant community	Chromium fails benchmark (1.5 mg/kg) but background is 19 mg/kg
Soil invertebrate community	No benchmarks exceeded
Benthic invertebrate community	Only selenium exceeds benchmark but source is not refinery-related ⁶
Fish	Only selenium found in fish tissue; no surface water above benchmark
Birds and mammals	Marginal risk from lead to deer mouse (HQ = 7.6) & cobalt to raccoon (HQ = 4.2)

⁴ No observable adverse effect level

⁵ Lowest observable adverse effect level

⁶ Elevated selenium was also found at off site locations

How can we compare and value uncertain ecotoxicological effects against human toxicological effects in risk assessments, *Martin Peterson, Luleå Technical University, Sweden*

This presentation argued that industry and authorities are often faced with decisions where a “value” must be placed on the effects of contamination on humans or on Nature. This value is used to decide whether it is “worth” proceeding with a remediation project, and relates to likely impacts if no action is taken, based on technical risk assessment techniques. This valuation is also used in assessing the urgency of remediation work.

The value of remediation work itself is typically expressed in economic or cost terms. Whether or not to proceed is conventionally decided on the basis of costs versus benefits. However, it can be difficult to convert the “value” of human health or ecological impacts to economic terms, especially as these economic valuations are perceived as not encompassing the totality of the circumstances that need to be considered. Furthermore, it can be very hard to compare one valuation with another, particularly in comparing ecological “value” against human health “value”. Such comparisons are typically open to substantive criticism. As an example the presenter posed the question: “let’s say for a contaminated site there is a 1 in 10,000 excess cancer risk to human health, on another site there is an unspecified probability that a particular species of beetle will become extinct. In a world of limited resources, how can one impact be compared with the other?” In both cases site owners and regulators are seeking an optimal risk level, i.e. one that provides an adequate level of protection. This is typically decided on the basis of whether a certain quantity of a particular chemical can be accepted in a piece of land. These are often set out in generic soil quality standards.

The speaker felt that the use of official guideline values for soil quality was inefficient from an economic point of view, as sometimes a site might be “under” remediated and sometimes it might be “over” remediated. He also drew delegates’ attention to the use of safety factors in risk assessment. He questioned whether there was a rational basis to say, for example, that a 1 in 100,000 excess cancer risk was justifiable, compared say with a 1 in 75,000 excess cancer risk. He also pointed out that risk assessments will use other general unsubstantiated factors, for example, 10 to account for possible differences between animal and human models.

Two other approaches to determining the “value” of human health and ecological impacts were suggested: environmental economics and environmental ethics.

The environmental economics approach is predicated on the basis that if too many environmental risks can be imposed on others for free, then this is inefficient. Hence environmental economics considers *negative external effects* as a cost to Society. The external effect is the coincidental imposition of environmental risk on others relating from a particular activity. The concept is illustrated in Figure 6. Several approaches have been applied in trying to value people’s concern for Nature:

- Willingness To Pay (WTP) also known as Contingent Valuation Method (CVM)
- Travel Cost Method (TCM)
- Hedonic Pricing

Willingness To Pay consists of surveying people by asking the explicit questions about how much they would be willing to pay to for Nature, for example to maintain an area in its present condition, or to improve it. The *Travel Cost Method* is based on asking people how far they have travelled to a particular area for recreation, and inferring a value for nature based on those travel costs. An example of *hedonic pricing* is comparing the value of property in one location with another. If the properties being compared are similar, then the variation in prices is due to differences in desirability including, for example, local amenities, transportation and landscape. If all factors, except for “Nature” can be controlled for in the samples, then it is possible to make an estimate of the economic value of “nature” based on its contribution to relative differences in property prices.

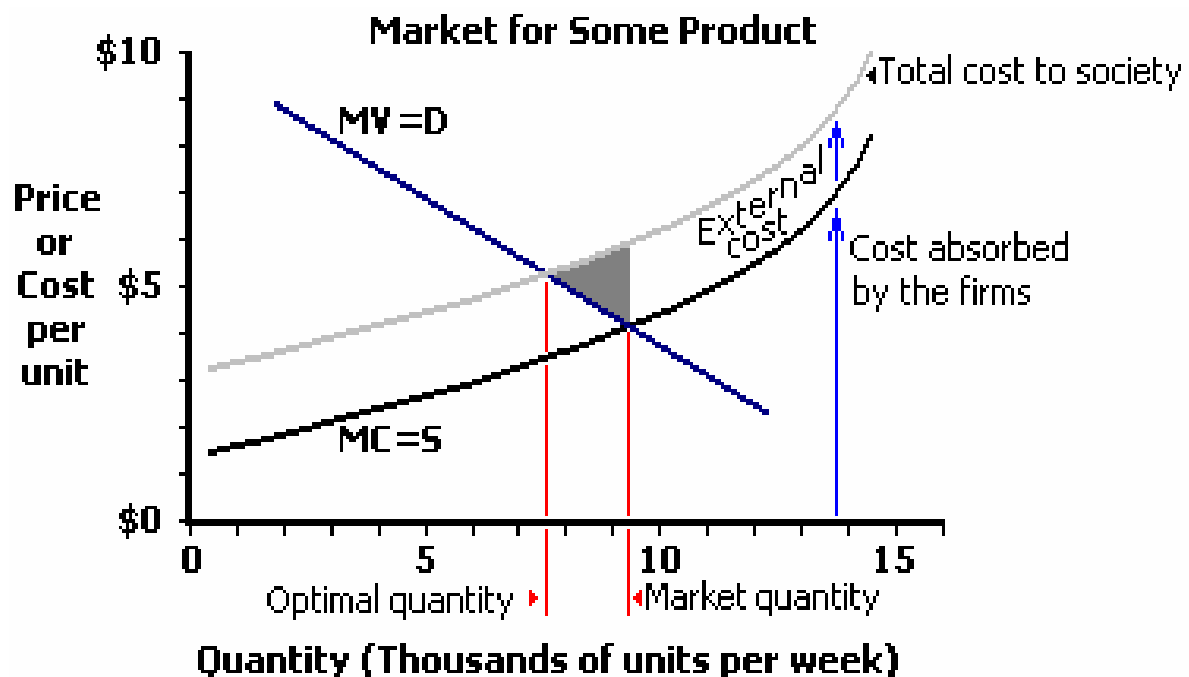
All of these economic tools suffer from a philosophical flaw, are based on the *instrumental* economic value of Nature, i.e. that Nature is used as a means of achieving something else that people want (money). Environmental ethics argues that Nature has a value in its own right, an intrinsic value, in economic terms, a *final* value which is not considered by economic valuation tools.

The speaker explored three assumptions from an environmental ethics point of view.

1. Some parts of nature have final value. For instance, a non-contaminated piece of land (free from chemical risks) is valuable even if no one is willing to pay for this.
2. The value of a whole might differ from the sum of the value of its parts, i.e. $V(\text{ecosystem}) \neq V(\text{land}) + V(\text{bird}) + V(\text{flower})$
3. The final value approach is readily understandable: " $V(\text{ecosystem}) = x$ " is meaningful proposition, and it communicates information that is either correct or not

The traditional view to deriving a final value is considering its replacement cost (the cost of replacing or restoring a damaged asset such as a forest). However, it is not certain that the final value of the asset will be as much as the combined restoration cost and the original value of the asset. The speaker suggests that the value of the restoration of the site (encompassing both human health and ecotoxicological improvements) can be modelled probabilistically by considering the restoration cost most likely to maximise final value.

Figure 6 The Concept of Negative External Effects (after van Ravenswaay)



The Rotterdam risk assessment method, Monique van Alphen, Public Works Rotterdam, NL

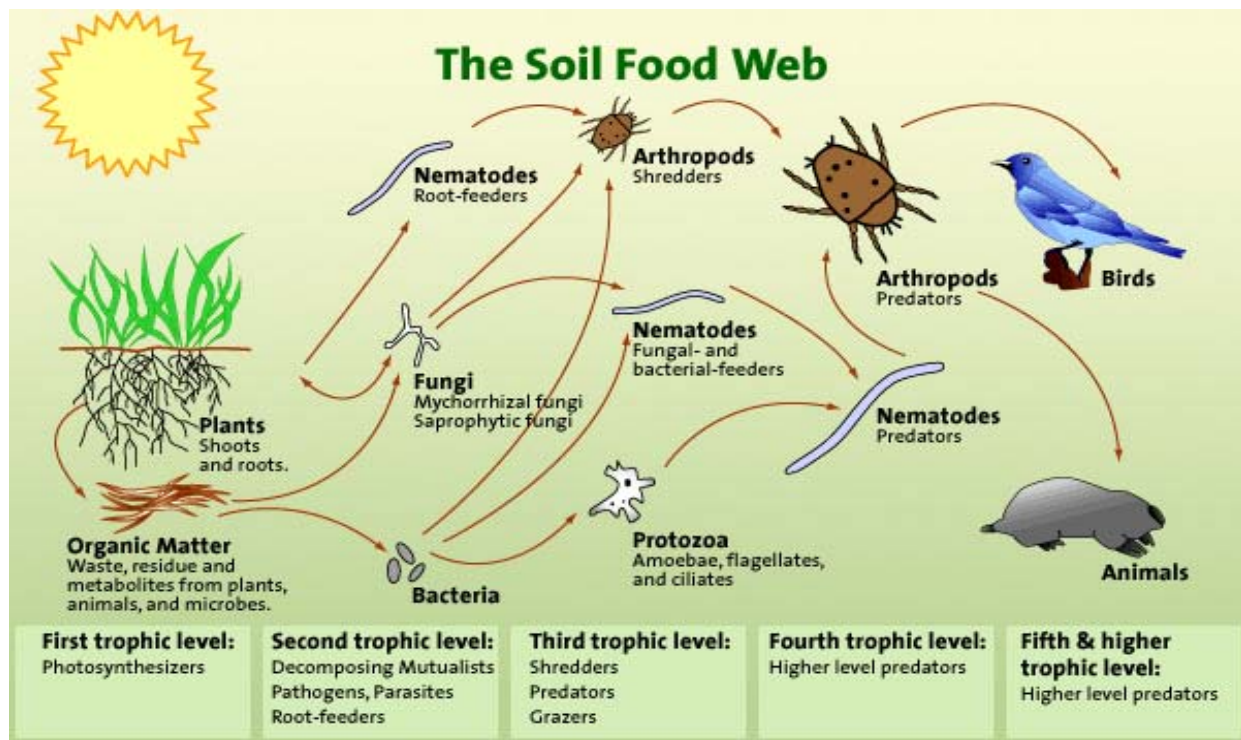
Soil contamination may have a negative effect on the (soil) ecosystem. This depends on the actual exposure. Aging and natural attenuation may strongly decrease exposure and effects. Nowadays assumptions that old contaminants still have adverse effects are mainly based on theoretical knowledge. But is this really true? The best answer is given by the ecosystem itself.

In the city of Rotterdam (the Netherlands) an investigation was conducted to look into this question. A selection was made of rural locations within the city used as public areas, such as: parks, gardens and forest. Both relatively “clean” sites and polluted sites have were selected. The chemical quality of the soil (are there pollutants?), the vegetation on a site, the soil fauna as the nematode population and the earthworms where investigated.

Looking at the first data, comparing ecological status, no significant differences between the relatively clean sites and the polluted sites could be found. One possible conclusion is that effects are only visible with more detailed investigation. However, another possibility is that the effect of soil contamination on ecosystems is not as large as thought, and that other environmental processes could have a more substantive effect on the ecosystem, such as: the frequency of mowing, the intensity of use by humans, type of land use and so on. In short, the soil environment and soil functions also depend on vegetation, climate, soil type, soil biota, landscape structure, water and time.

An ecosystem is a dynamic system which will adapt to the circumstances of the environment. It could very well also adapt to soil contamination. Evaluating food webs is a possible means of looking at true perturbations in ecosystems. By using a food web-model it is possible to look at the trophic levels of the various species found at a site and their relationships with each other (like predator, bacteria eater, fungi eater, herbivore, and omnivore). When all trophic levels are occupied an ecosystem is functioning. Figure 7 illustrates a generalised soil food web. However the next question to ask could be: “how well is the ecosystem functioning?” This depends on the number of species found per trophic level, if many species represent the same trophic level a loss of one of them may have no impact on the functioning because other species can take over. If only one species represents a trophic level and goes extinct, then the ecosystem is out of balance and does not function. In addition, other soil processes like the nutrient cycles and bioavailability are important and have an effect on the food web. This means that a risk assessment for ecology based on chemical concentrations of soil pollutants alone is not useful. A soil fauna research in the field could be much more accurate.

Figure 7 A Generalised Soil Food Web.



The presenter suggests that investigating food webs is a more reliable tool in ecological risk assessment than carrying out a range of individual bioassays. A system level investigation is more reliable than investigations based on individual species. She also suggested that it is important that the function of the risk assessment needs to be clearly defined, i.e. what it is seeking to determine. In the case of Rotterdam ERA was important in prioritising sites for action, reliable comparison of different and in comparing alternatives to site management, including allowing the ecosystems on sites to continue without remediation.

The Igelsta sawmill. low contaminations of arsenic and dioxin – a big problem for city development, *Einar Schuch, Södertälje City Urban Planning and Building Authority, Sweden*

This presentation was given from the perspective of a local authority planning department faced with both a major urban development opportunity and a problem of site contamination. The site in question is a riverside location of 10 hectares in the vicinity of the major Swedish city of Södertälje, with major commercial redevelopment potential for housing and business. The principal contamination problems on the site are a limited number of locations with high levels of arsenic and of pentachlorophenols. Dioxin is present also on the site, in some locations at significant levels, but also more extensively at low levels.

The background to the site is that a sawmill was established in the area in 1895, and in 1942 wood impregnation also started. Two fires occurred in 1950 and 1970. In 1967 the local authority purchased the land, and in 1978 the sawmill was closed down. In 1979 the former site operators contracted a service provider to carry out site remediation. By 1990 a temporary remediation solution had been put in place, a cover system consisting of a geotextile beneath 0.5 m of gravel. Over the 1990s several site investigations were carried out focusing on arsenic problems, and in 2000 an arsenic hotspot was fenced in. In the late 1990s a proposal for housing redevelopment was rejected. Over 2000 to 2002 attempts were made to make the sawmill operator pay for remediation works (to restore the site to a condition suitable for industrial use). These ultimately failed.

Since 2003 discussions about the site have taken place between the local authority and a Swedish property development company (JM AB). While removal of the “hot spots” is seen as urgent, dealing with large areas of low level contamination is not seen as a pressing environmental issue. It is however an obstacle to site redevelopment. Site redevelopment would be economically feasible if the “hotspot” locations alone required management (estimated cost 25 to 50 million Swedish Kroner). However, including removal of the low level contaminated material from site would be very expensive (200 million Swedish Kroner) because of local waste management costs and regulations, and there are few, if any, viable treatment routes for the site. The value of the site redeveloped for housing is estimated to be 63 million Swedish Kroner.

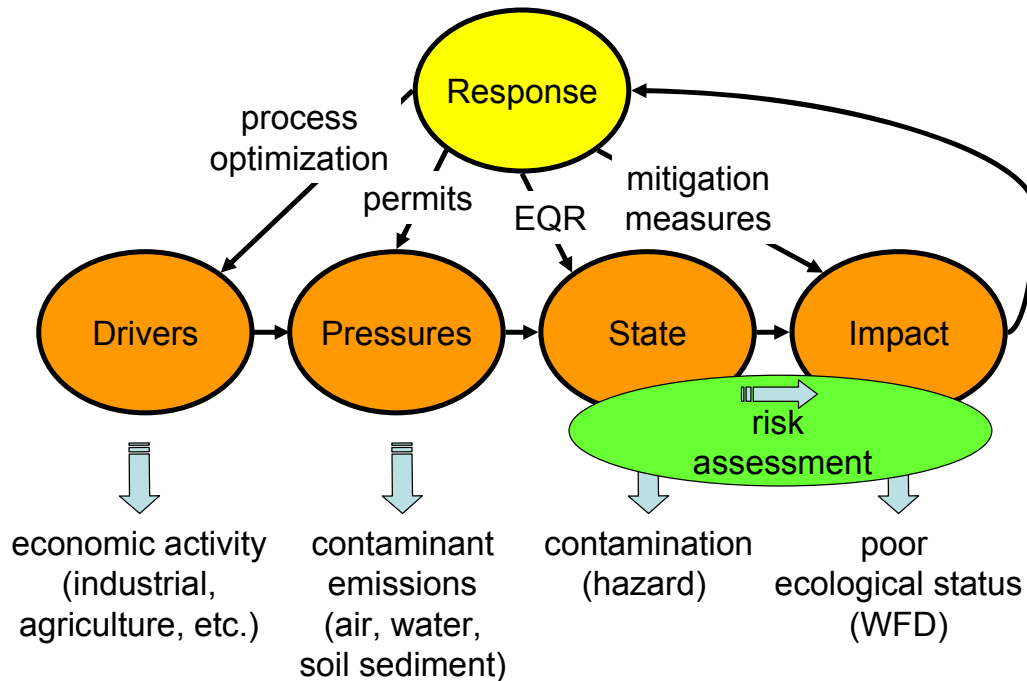
The site is also an area that could be used as a “green lung” for the surrounding urban areas. The complexity of the regulatory and policy situation for this site; linked to the questions about liability, the future use of the site and its economic value compared with remediation costs have so far prevented development.

Risk assessment of a river basin, *Jos Brils, TNO, NL*

The Water Framework Directive has highlighted the importance of considering the impacts of land contamination at a river basin scale. Risk assessment takes on a new perspective at the scale of river basins, where multiple direct and indirect inputs of contaminants may occur. The EC AquaTerra

project has begun to apply the DPSIR⁷ model is often used to evaluate potential impacts at a river basin scale. Risk assessment plays an important role in this process, as illustrated in Figure 8.

Figure 8 Role of Risk Assessment in Considering DPSIR at the River Basin Scale



The Water Framework Directive has a strong focus on ecosystems in its appraisal of river basin quality. It ranks the ecological status of river basins as being: *high, good, moderate, poor, bad*, based on *ecological quality ratios* (EQR). This is defined as the ratio between measured values of biological function and reference values deemed to indicate a high quality status. Hence *high* corresponds with a ratio of 1, and *bad* with a ratio of zero.

Conditions for deriving reference values are as follows. The measurement (value) corresponds to a condition in which a water body has suffered no, or only very minor anthropogenic impacts to its hydromorphology, physico-chemistry and biology. This can relate to the river basin's condition in the past or the present. Reference values can be derived from observations, historical data, modelling, or, where necessary, expert judgement. The status of river basins must be prevented from deterioration. Where the status is found to be *moderate, poor, or bad*, the basin must be restored to *good* status.

Contamination is one of the pressures that can result in impacts on ecological status, such as: decreased abundance of species, decreased biodiversity. Effects need not be localised, for example distant ecological impacts might occur through secondary poisoning after consumption of contaminated species. The role of ecological risk assessment in a river basin context is therefore to determine at what level of contamination these negative effects have an unacceptable impact on the river basin ecological status. However, ERA is an incomplete tool in the river basin context.

- There is insufficient knowledge to allow a reliable prediction of risks from hazards and of impacts from risks.
- Measurements used as a basis for ERA show high temporal and spatial variability.

⁷ Drivers, Pressures, State, Impacts, Responses

The speaker introduced the concept of *ecological risk management*. The Sednet network (www.sednet.org) suggested definition a for this term: *to reduce risk posed by contaminated matrices⁸ to ecological receptors to a level, deemed tolerable by society and to control and monitor the quality of these matrices with the final aim of complying with the Water Framework Directive.*

Ecological risk management encompasses the following ideas:

- Establishing a conceptual model for a river basin
- Understanding ecological risks (ERA) in the context of the conceptual model,
- Adapting the conceptual model in the light of new information to develop a working river basin model
- Integrating the views of different river basin stakeholders in determining aims for risk management (stakeholder involvement in environmental policy development and implementation processes will become more and more important)
- Determining which ecological impacts need to be addressed and prioritising them for action (on the basis of risk rather than hazard)
- Carrying out remedial work in the context of an overall basin management plan, based on removing the most significant impacts identified in the river basin model.

Overall the Water Framework Directive is changing the scope of risk management from local to river basin scale management, and from matrix specific (sediment, soil, water) towards integrated, system management. River basin quality criteria have tended to be set on the basis of hazard, comparing concentrations in a matrix with thresholds related to hazard, rather than considering whether or not these hazardous levels in particular measurements are actually indicative of an environmental risk. However, consensus is growing that it is better to look at actual risks or impacts, rather than on checking whether pre-defined quality standards are exceeded.

Conceptual site model, general approach on risk assessment: bottlenecks, missing links, key factors, *Karen Van Geert, Arcadis-Gedas, Belgium*

The site conceptual model (SCM) is a tool to support rational thinking. It is a vital part of risk management decision making, as it sets out the critical source-pathway-receptor linkages for a particular land contamination problem. It also serves a means of summarising measurements and assumptions, certainties and uncertainties, calculations and modelled data. It provides a focus for the collation of knowledge about a site. SCMs can start simple using generic risk assessment guideline values, and “grow” to site specific risk assessment, if this is required. An SCM allows different risks to be compared and prioritised and aids a progression from risk assessment to risk management. Factors to be considered in an SCM are as follows.

Source

- A measurement strategy for contaminants- considering the availability of data, interpretation of the contamination (e.g. speciation, spatial and temporal changes) variability in sampling technique, and data modelling (deterministic versus probabilistic simulations). *Good* measurement strategy is an equilibrium between cost and data availability.
- The complexity and dynamic nature of soil systems and the soil system interacts with contaminants, taking into account: biodegradation, bioavailability, stationary transport and equilibrium soil phases and geology (including geological heterogeneity)
- Measurement techniques considering the relative value of established and innovative techniques, the relative value of quantitative versus semi quantitative techniques, detection limits, regulatory acceptance of techniques, the availability of standardised methodologies
- Application of the information collected,
 - taking into account how it will be used in the SCM,
 - variability in source data,

⁸ sediment, soil and (ground)water

- maximising the information value, for example: comparing the information value of many cheaper semi-quantitative techniques to a fewer expensive quantitative measurements, or considering if series of measurements in time might reveal useful information about processes going on in the site
- Dealing with uncertainties, for instance using deterministic versus probabilistic approaches to try and quantify uncertainties.

Pathway

- Identifying potential and actual pathways - use of the site affects the consideration of pathways
- Exposure and fate and transport of contaminants (principal pathways are usually: indoor air, plant uptake and contaminant –groundwater flow)
- Uncertainties, taking into account the characteristics of pathways (such as cracks in old basements), and the relationship between groundwater and surface water
- Country specific regulatory conditions (for example use of leaching tests)

Receptor

- Main receptors considered are typically: the human (considerations vary between adult or child), drinking water, eco-receptors, migration to groundwater and off site targets
- Considerations vary from country to country, for example in some countries there is a greater importance on ERA than in others, in others there may be a stronger focus on groundwater.

This presentation focused on two bottlenecks: exposure assessment: modelling versus measurements (particularly for indoor air) and ecotoxicity assessment.

There is a credibility issue for human exposure models, highlighted by the recent NICOLE comparison of a selection of models, which concluded that:

- There needs to be a better understanding of differences/better credibility of models
- Differences in model results can be orders of magnitude
- Using model defaults (versus site data case) can lead to large differences, for different pathways, especially true for indoor air ‘prediction’.

Given the problems with models one might ask the question when should one model, and when should one measure. Modelling is probably best applied to considering potential situations, and for screening. The model approach used should be a conservative one, which tends to “fail positive”. Measurements can then be used to make a final determination where there are elevated modelling results. Measurements are particularly important where preferential pathways are suspected such as cracks in basements, foundation walls. Soil gas measurements may be used, but they are subject to a high degree of variability.

Ecotoxicological findings are highly dependent on the measurement strategy, and a key consideration is bioavailability. Approaches to ecotoxicological work are country specific, as is their significance in site management planning overall. Ecotoxicological data tend to show a lot of variability.

The speaker concluded that progress is being made towards transparency and credibility in risk assessment, and that SCMs are a key tool in this regard, combining scientific knowledge and rational thinking. Exposure model comparison studies have highlighted a number of limitations, in particular that findings are sensitive to the type of model selected and the boundary conditions used in the model. Direct measurements can be used to supplement modelled data, but are themselves subject to variability. Models are improving, and this improvement requires rapid exchange of fundamental technical information used in developing models, and about measurements. There is a need for harmonisation of the technical basis on which models are derived, such as datasets.

Regarding ecotoxicology, the speaker concluded that it can be hard to define what an adverse effect for ecology is. If the risk of an adverse effect is detected, is not yet clear how this should be managed.

How uncertainty in radioactive waste disposal safety cases is treated and how this can be applied to contaminated land sites, *Hamdi El-Ghonemy, BNFL, UK*

Uncertainty is a key aspect of developing conceptual models. Uncertainty needs to be considered because sources may be poorly understood and subsequently the pollutants of concern will not be identified, which may lead to poor design of a site investigation. Uncertainty may lead to misrepresentation of scenarios in the conceptual model. Stakeholders need to have evidence that uncertainty was identified and understood.

In the nuclear industry a safety case must be made for facilities. A safety case is carried out at nuclear sites (disposal sites and power plants) for planning, operation and closure phases. This safety case is similar in some ways to a contaminated land risk assessment, but differs in the following ways: there is a greater level of detail and longer timescales are considered. As for contaminated land assessments, conceptual models are a key tool in decision making. However, information used to compile a conceptual model will always be incomplete and might be conflicting. The processes occurring may be poorly understood, and assumptions will have been made in developing the conceptual model. These are all significant causes of uncertainty.

There is a systematic approach in the nuclear industry for dealing with uncertainty in environmental assessments in safety cases. This approach involves the development of a conceptual model in a systematic framework using FEPs and interaction matrices. Risk assessment uses a conceptual model of source-pathway-receptors relationships. The conceptual model can be extended to include a list of *features, events and processes* (FEPs) that influence the risk assessment. FEPs were initially developed in the US in the 1980's for radioactive waste disposal planning. The technique is intended as a logical process that demonstrates that all factors have been considered and to capture decisions made during the assessment. The FEP process consists of the following steps:

- Division of the site into components (features)
- Identification of events and processes that control the interaction between these features using matrices (*interaction matrices*).
- Development of a site-specific list of features, events and processes.

Interaction matrices are used to identify the interactions of greatest relevance to risk assessment. Interactions are identified at varying levels of detail according to complexity (e.g. levels 1 and 2 etc) – see Figure 9. Key interactions are then reviewed to establish how to best represent them using modelling tools

Figure 9 Example Interaction Matrices

Level 1				Level 2						
		A	B	C			A	B	C	
1	Source				1	Buildings				
		Geosphere				2		Buried waste		
			Biosphere				3			Site (other sources)

An example safety case is that for the Drigg low level waste disposal site in the North West of England. Drigg is the UK's principal site for the disposal of low level radioactive waste (LLW). Disposals commenced in 1959 into earth trenches. The trench system was operated until 1995 and is

now covered with an interim cap. The Drigg site includes seven trenches and one vault. Waste includes: soil, redundant equipment, wood, paper, and scrap metal.

The purpose of the safety case was to determine the long-term safety performance of the disposal system. It involved a radiological safety assessment to evaluate impacts to receptors and to aid in decision making. Factors that were taken into account for scenario development included climate change and future human actions. At Drigg 225 FEPs were identified for the biosphere, 232 for the geosphere and 948 for the *near-field*⁹. The importance of each FEP to the overall assessment was considered. FEPs were sorted according to how they could be evaluated using assessment software and algorithms,

The conceptual model included a number of uncertainties, for example:

- Scenario uncertainty: e.g. climate change and identification of alternative descriptions
- Conceptual model uncertainty: e.g. water balance; release of radionuclides from waste
- Parameter uncertainty: e.g. contaminant transport parameters - need to justify the best estimate for groundwater flow and transport parameters

An auditable approach to considering and making judgements was used. This consisted of using forms to record conceptual model uncertainties and the assumptions and judgements made about them. Parameter input forms were used as a means of recording supporting information on the parameters used in the calculations and modelling.

For contaminated land assessment, the benefits of following this approach are that it creates a systematic methodology for documenting assumptions and simplifications during conceptual model development. This in turn creates a robust and transparent conceptual model, with a clear audit trail for its development, assisting in the selection of modelling tools and dealing with uncertainty.

The difficulties of this approach for contaminated land assessment are the level of detail required, which depends on the complexity of the site but could be excessive for contaminated land risk assessment work; and the resources required in terms of cost and time. These resources may not be justified, given the time constraints imposed on most contaminated land risk assessments work.

Modelling critical pathways or measuring them: the plant transfer pathway, *Christa Cornelis / Johan Bierkens, Vito, Belgium*

There are a range of pathways by which contaminants can impact human health. The usual pathways considered are:

- Ingestion of soil and dust
- Dermal absorption from soil and dust
- Inhalation of soil and dust
- Inhalation of vapours
- Ingestion of water
- Dermal absorption from water
- Intake of vegetables
- Intake of meat, dairy products, eggs.

The last two of this list are linked to plant transfer pathway as illustrated in Figure 10.

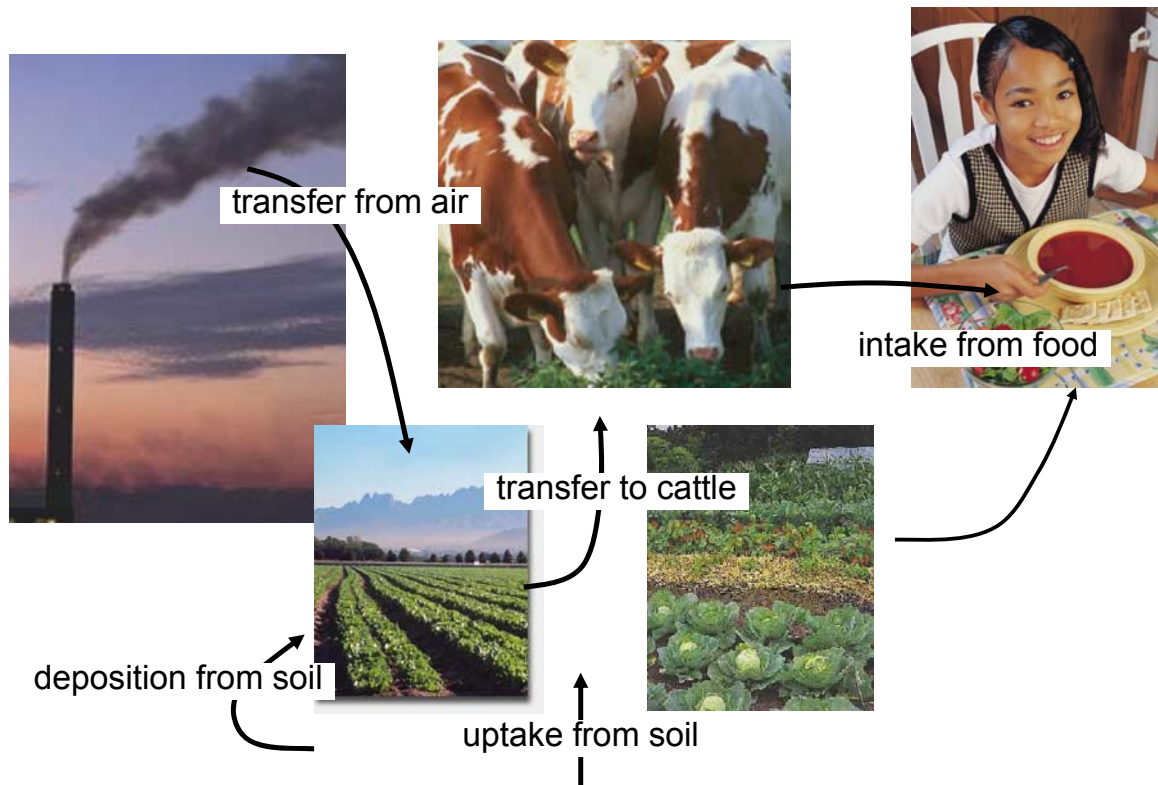
The tools used to investigate pathways can be categorised in tiers:

1. General models
2. Models using site specific measurements
3. Direct measurements.

⁹ the engineered barrier system

At Tier 1 tools are thought to be conservative, and also cheaper but less accurate. At Tier 3 the tools are more accurate, less conservative, but more expensive.

Figure 10 The Plant Transfer Pathway



A number of questions need to be considered when assessing transfer pathways:

- Do the models provide accurate predictions, and if so, under which conditions?
- When should models be used?
- Can model predictions be refined?
- If measurements are needed, what should be measured and how?
- How accurate are the measurements?
- How the data be used?
- What is the uncertainty, variability of the data?

This presentation offered some guidance on these questions.

The underpinning factors affecting accuracy of these models are the origin of the datasets they are based on, and how these datasets and assumptions compare with real sites. For example three exposure models use the following algorithm for estimating plant uptake:

$$C_{\text{plant}} = \text{BCF} * C_{\text{soil}}$$

Where C is concentration, and BCF is a concentration factor, which may vary for different parts of the plant, typically considered is a BCF for leafy parts and a BCF for roots.

This algorithm does not take into account the speciation of the contamination in the soil, nor the impact of soil properties or differences between different plant species. The transparency of existing models could be improved to make clear the assumptions and datasets upon which they rely. It is clearly important, when using contemporary generalised models, to compare boundary conditions of model data with site-specific conditions before relying on modelled outcomes.

When compared with actual field observations of cadmium uptake across a range of species (from information in the scientific literature) the model captures in part the gradient of change between soil concentration and plant uptake, but may under-estimate cadmium uptake, and it does not deal with the variability of field data. An investigation was carried out looking at the uptake of cadmium by grass on several contaminated sites. This indicated that the model tended to over-predict cadmium uptake for *grass* on those test sites. Looking at a range of vegetables and reports of plant uptake in the literature it is clear that the generalised algorithm fairly consistently over-estimates uptake for some species and under-estimates for others.

The general conclusions that can be drawn from this are that plant uptake algorithms used in current models are very general, and it is also not always protective, which is at odds with the need for conservatism in Tier 1 risk assessment. Possible improvements to models might be to use models that incorporate influencing factors such as plant species, soil characteristics, food consumption data. Ideally, a site-specific dataset should be used. Given that plants vary in their uptake of contaminants, it may be better to make use of an average food “package” in models consisting of a series of uptakes related to different dietary components, weighted for an average diet. This does imply the need for some fundamental research to widen the pool of plants for which good data about soil-plant relationships and contaminant uptake exist. There is a large amount of data on plant transfer available for (metals). There is a need for better use of this information in models and manuals for risk assessment.

In practical risk assessment work site specific information may indicate higher plant uptake of metals than generic models. In this situation it is prudent to measure actual uptake if at all possible, and/or to look for “better” transfer data in the scientific literature to apply in the site specific model.

The usefulness of measurements of plant uptake is dependent on three issues:

- Does the measurement truly represent what needs to be known? For example, the source of metals in the above ground portion of plants can be from deposition from the atmosphere, or uptake from the soil. The relative contribution of these sources varies from metal to metal, as, obviously, do the opportunities for risk management.
- Do available analytical methods (always) allow reliable measurements? For example, some measurements show extremely variable data, with differences evident between different analytical practitioners, such as PAH concentration in leaves.
- How can the measurements be made and used? It is important to consider the objective of the measurement: is it representative of food consumption – taking into account the complexities of food chains¹⁰; is it representative of the area of exposure.

The key conclusion is that measurements are essentially *estimates*, and their consideration requires awareness of the accuracy of analytical methods used, the representivity of results, and that the uptake data obtained truly reflects all sources.

Ecological Risk Assessment – the UK approach *Danielle Ashton, Environment Agency, UK*

As part of our responsibility for protecting the environment from pollutants, the Environment Agency (England and Wales) and eight partners in industry are working together to trial a tiered ecological risk assessment framework. The framework will be used by experienced risk assessors to measure harm, or the likelihood of harm occurring, to terrestrial wildlife following exposure to soil contamination.

There are business and science drivers for the establishment of an ERA framework in the UK. Under Part IIA Environmental Protection Act 1990 contaminated land must be managed, and the costs of this

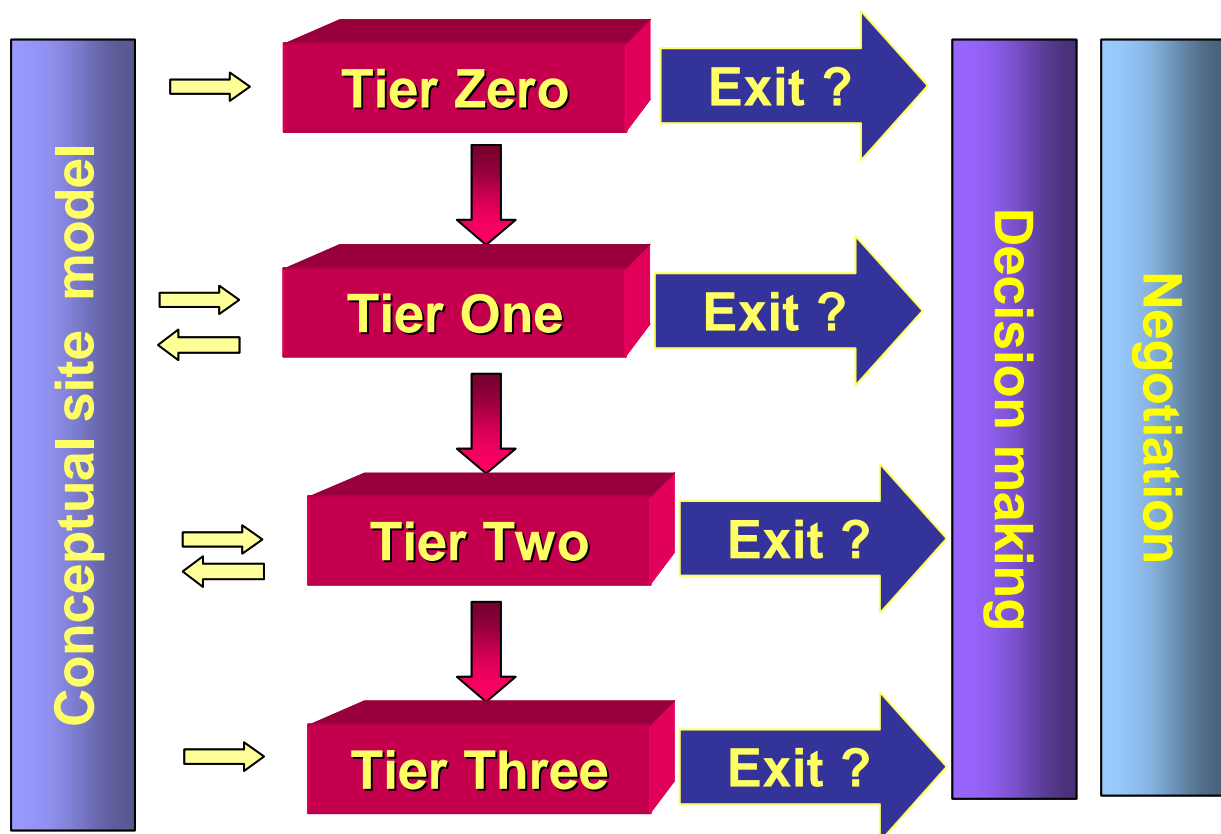
¹⁰ E.g. uptake via cattle

management are met in the first instance by the contaminated land owner. In addition, where land is redeveloped, then planning controls may trigger contaminated land risk assessment and management. Under Part IIA *contaminated land is any land which appears. 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.* Harm encompasses ecological impacts: *an irreversible adverse change, or in some other substantial adverse change in the functioning of the ecological system within any part of the location.* For operational purposes, the definition in the Regulations has been translated: *significant harm is when growth, reproduction, or mortality are adversely affected, such that the survival of the population/community/species is threatened.* However, under Part IIA the range of specified ecological receptors is quite restricted to a range of areas designated as protected because of their scientific or natural interest.

The scientific drivers for the UK development of an ERA were that nothing appropriate was available and that a specific system was needed to service Part IIA. However the approach developed is intended to also address wider applications, including the Habitats Directive and risk assessment for radioactive soil contaminants.

The ERA framework being developed is a tiered approach, illustrated in Figure 11, based on the use of a conceptual site model, and use of weight of evidence and triad approaches. The framework has undergone public consultation and is currently being road-tested in collaboration with our industrial partners.

Figure 11 Features of the Environment Agency Ecological Risk Assessment Framework



Problem formulation and the development of a conceptual site model (CSM) are integral to the initial screening process. The CSM identifies the potential pollutant linkages between contaminants (source), pathways and receptors. Tiers 1 and 2 involve the collection of chemical data of contaminants in soil,

and biological effects data, respectively. Chemical data are compared with soil screening values¹¹ (SSVs) and, if exceeded, may prompt further risk assessment. We have followed the European Commission Technical Guidance Document approach to deriving predicted no effect concentrations (PNECs) - the basis of SSVs - for the soil compartment. New methods recently discussed at a European level may provide a better understanding of modifying soil and biological factors to more accurately assess risk and subsequently derive more appropriate screening values. The Agency proposes a process for modifying field concentrations (PEC) using such methods – for example, normalising the soil organic carbon content of field soils to generate more realistic screening assessments.

The framework includes a tool-box of biological techniques in support of Tiers 2 and 3. These include a range of micro-organism, soil invertebrates and plant tests – see Table 4. These encompass different endpoints (lethal, sub-lethal - growth, reproduction) and different trophic levels (micro-organisms, plants, invertebrates). Tier 3 utilises the data from lower tiers to predict population, community and/or ecosystem level effects (e.g. likelihood of extinction) of soil contamination.

The scheme uses a weight of evidence approach to determine if harm is occurring. The framework has defined entry and, importantly, exits at each tier so all tiers of the framework are only used when a decision cannot be made at a lower tier regarding the potential risk of the site.

The Agency sees important benefits from the adoption of the proposed ERA approach. A tiered risk assessment approach provides transparency with defined exit points and a clear decision making process. The approach is flexible and integrates generic and site specific assessments, utilising current thinking on screening values, and has potential applicability within in other UK regulatory regimes.

Table 4 Proposed Biological Tests

Standardised	Non-standardised
Earthworm acute toxicity test	earthworm reproduction test
Collembola survival	collembola reproduction test
Germination and shoot growth - monocotyledon	collembola population increase test
Germination and shoot growth - dicotyledon	bait lamina to measure invertebrate feeding
Nitrogen mineralisation	earthworm lysosomal membrane stability
Microtox TM luminescence bacterial sensor	expression measurement of selected genes (e.g. metallothionein)

Translation of biological tests to risk assessment *Samantha Fishwick, Environment Agency, UK*

The statutory guidance accompanying the Part IIA legislation defines significant harm (i.e. a level of harm that triggers a need for risk management) both in terms of function and structure:

- Function: *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;*
- Structure: *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.*

These definitions need to be translated by the Agency into operational terms, which in turn can be used to derive quantitative criteria for biological and ecological findings. The operational translation adopted by the Agency is that harm (adverse change) is when growth, reproduction, or mortality are adversely affected, such that the survival of the population/ community/ species is threatened. In

¹¹ Concentrations of contaminants in soil which, if exceeded, may prompt further risk assessment

terms of ecological risk assessment, a significant possibility of an adverse change is when the indicators of significant harm differ from reference or control values at an agreed statistical confidence level. The need to disentangle effects due to contamination from those arising from natural variation is central to ecological risk assessment.

The Agency proposes the following quantitative criteria for operational purposes:

- For bioassays
 - when the mean value of a parameter measured in the test samples differs at the 95% confidence interval from the control sample (in the presence of contamination) there is an 'effect'. Consideration must then be given to the cause of the effect.
- For ecological surveys
 - if the measured parameter falls outside the 95% confidence interval of a range expected from natural variation (temporal) or variability (spatial), there is an 'effect'.

This approach is consistent with the Agency approach to human health risk assessment. The key steps in analysing biological test data are to use statistical techniques (e.g. analysis of variance) to analyse results for significant *within* site differences. In parallel the biological data for the site are compared with an external reference (e.g. laboratory control soil). If differences between site soils and references/controls are significant it is then important to consider if observed effects might be explicable by other causes. A weight of evidence approach is used to assess if harm is occurring. This depends on considering the various strands (lines) of evidence including correlations with site chemistry and ecological information. Each line of evidence is considered to determine whether it is: consistent or inconsistent with exceedance of a threshold, or ambiguous. Then all the available evidence is examined on an overall basis to assess the likelihood of a threshold being exceeded. If the evidence is consistent, then the weight of evidence is clear, if not then expert judgement is required.

This translates to the following decision criteria for the risk assessment:

- There are no significant effects ==> EXIT the process
- There are significant within site differences
 - correlated with chemistry
 - not explicable by other causes
 - results are not contradictory
 - confirmed by other ecological dataEffects are ecologically significant==> HARM is occurring
- There are significant differences between the site and the external reference
 - correlated with chemistry
 - not explicable by other causes
 - results are not contradictory
 - confirmed by other ecological dataEffects are ecologically significant ==>HARM is occurring

The presenter then applied this approach to a case study site in the UK, a primary cadmium, lead and zinc smelter in south-west of England which operated between 1920 and 2002. Its operation has resulted in aerial deposition of metals up to 15 km downwind of the smelter. Soil within 200m of the smelter is 10% metal content (dry wt). The surrounding area is managed pasture or semi-natural woodland.

Tier zero assessment indicated the possibility of a significant pollutant linkages, for example:

- Source: potential soil contamination by metals
- Pathways (and intermediate receptors) plants, soil invertebrates, herbivores
- Receptor: insectivorous birds.

Tier 1 screening found that most significant surface contamination seen at locations equivalent to 1, 1.5, 3.2 km from the smelter. However, exceedance of draft soil screening values (SSVs) were seen at all locations for at least one of the following contaminants: arsenic, lead, copper, nickel and zinc. The rural reference soil was below draft SSVs for all contaminants. This indicated progression to a Tier 2 assessment.

Tier 2 assessment used a suite of biological tests (findings are summarised in Table 5. In addition surveys of soil fauna indicated that the most heavily affected groups are detritivores; earthworms, molluscs, millipedes, woodlice and springtails. The Tier 2 finding was that harm is occurring (and at a distance of up to 3.2 km from the smelter – *Patch 3*). There are significant within site differences and differences between the site and the external reference, correlated with chemistry, not explicable by other causes, which are consistent and confirmed by other ecological data. Tier 3 assessment was not required

Table 5 Case Study Biological Test Data (“patches” refer to locations)

Biological test	Patch 5	Patch 4	Patch 3	Patch 2	Patch 1
Microtox™	●	●	●	●	●
Nitrogen mineralisation	●	●	●	●	●
Earthworm adult survival	●	●	●	●	●
Earthworm reproduction	●	●	●	●	●
Collembola survival and reproduction	●	●	●	●	●
Bait lamina	●	●	●	●	●
Plant growth - monocotyledon	●	●	●	●	●
Plant growth - dicotyledon	●	●	●	●	●
Earthworm lysosomal membrane stability	●	●	●	●	●
Genetic biomarker - metallothionein	●	●	●	●	●

● Significant ● Ambiguous ● Not significant

In its ongoing R&D work the Agency is working in partnership with a number of UK industries to test the proposed ERA framework, considering eight scenarios with a variety of pollutant linkages to further test the ERA framework, in particular considering criteria for “harm”, soil screening values, biological methods and ecological methods.

The TRIAD approach – organic pollutants in soil, what are the risks and perspectives? *Sytze Keuning, Bioclear and Tim Grotenhuis, Environmental technology Wageningen University, NL*

Owing to the enormous amount of polluted areas that need to be remediated, the demand for site specific risk and technology assessment in order to prioritise remediation work is increasing. Conventionally during risk and technology assessment for soil and sediment, chemical analyses are used in a model, to calculate potential ecological risks and to determine the possibilities for remediation. The bioavailability of contaminants and combined toxicology of the pollutants is not

taken into account, which suggests a sound based selection of remediation options is missing. A solution to this problem is to combine the TRIAD with consideration of bioavailability. This approach achieves assessment of ecological risks and assessment of remediation options in a holistic way, considering environmental chemistry, toxicology and ecology and bioavailability. Bio-availability of the pollutants is important for both risk assessment and technology selection and implementation.

The TRIAD approach, in simple terms, is an integrated consideration of site chemistry toxicology and ecology, with the risk effect being a combination of these three features. Bioavailability is an estimate of the uptake of contaminants by organisms, this is linked both to possible toxic effects and to the likelihood of biodegradation (e.g. in a soil treatment). Hence bioavailability measurements may be predictive of both toxic effects and performance of bioremediation. This combined approach can be used for the assessment of actual ecological risks and ecological functioning of both soils and sediments. Chemical analyses of soil or sediment, and chemical analyses of organisms, are combined with bioassays and ecological analyses at the site. To improve the risk and technology assessment the chemical analyses can be extended with analyses on bio-availability of organic pollutants. Several measurement techniques for bio-availability have been developed, such as: persulphate oxidation to determine PAH availability, and solid phase extraction to determine the bioavailability of hydrophobic organic compounds (HOC).

Bioclear and Wageningen University have used the TRIAD approach combined with availability measurements to assess the ecological risks and possibilities for remediation and management. Two example sites are:

- A riverbank impacted by contaminated sediment from conventional dredging (PAH, mineral oil and heavy metals). The riverbank abuts a tidal river, whose banks are uncovered during low tide. The riverbank has a high conservation value because of its reed-bed vegetation. Testwork included: chemical analyses, PAH bioavailability measurements, degradation tests for PAH and mineral oil and TRIAD measurements. The findings were that available fractions PAH were lower in dry zone and top layer of tidal zone, indicating natural degradation of PAH. This was confirmed by degradation tests. severe ecological effects were found in the wet and tidal zones. Ecological effects were less in the dry zone. Earthworm and nematode populations were normal for reed vegetation. Hence a relationship was shown between available fraction, biological degradation and ecological effects. The remediation options indicated were dredging for the wet and tidal zone and natural attenuation for the dry zone.
- Land reclaimed with polluted harbour sludge (heavy metals and HOC). The site near Rotterdam was forested as part of a remediation approach. The 42 ha forest is used as a recreation area, however, further remediation will be needed when the area is redeveloped. At present no risks to human health or groundwater are indicated. Highly bioavailable fractions of HOCs were found (> 50 % of totals). However no negative effects on plants and bacteria were detected. Negative impacts on earthworms at high available concentrations were found, and high concentrations of contaminants were found to have accumulated in earthworms, indicating potential for biomagnification of contaminants in food chains. This was seen as the principal potential risk, so any remediation or redevelopment must be focused on achieving a reduction of bioaccumulation in the food chain. Remediation using conventional a cover layer and excavation approach would be extremely expensive (€ 30 – 175 million). The contaminants were not naturally biodegraded. However, the ERA indicated that redevelopment could be customised to prevent bioaccumulation of contaminants by soil dwelling organisms (at an estimated cost of € 1 million) for built locations by carefully selecting areas where building would take place. Fr the remainder of the site, denser forest and less meadowland would prevent birds feeding on contaminated earthworms.

Based on the results of the risk and technology assessment, for both sites a redevelopment plan has been made based on specific integrated management. The combined approach of bioavailability measurement and TRIAD was thus shown to be a powerful tool for risk and technology assessment.

As shown in the examples, it is possible to assess the most optimal remediation or management option for the polluted location once bioavailability and ecological risks are known. Several options are possible for the remediation of the sources of organic pollutions, like natural attenuation and stimulated biodegradation. The routes of exposure of a pollutant to a receptor can be dealt with by cover systems or by specific integrated management measurements like green redevelopment. These approaches can result in a dramatic cost-reduction in the remediation of polluted sites.

Toward common references for risk assessment of contaminated sites in Europe, *Claudio Carlon, EC DG JRC Ispra, Italy*

The need for European common technical references is a major recommendation contained in the European Thematic Strategy for Soil Protection expressed by the Working Group on “Contamination and land management”. This is also the general feeling of the scientists who met in Ispra on February 2005 in a workshop on needs for risk assessment harmonization in Europe, jointly organized by the JRC and DG-ENV of the European Commission.

Although some differences can be related to country –specific geographical, social and cultural, as well as regulatory conditions, the cooperation among Member States on many methodological elements and data bases would be feasible and beneficial in terms of the following goals:

- Achieving greater consistency and comparability of results;
- Enhancing the general scientific quality of national technical guidance;
- Enhancing, or restoring, the confidence of regulators in risk assessment;
- Avoiding competition impairments for companies due to remediation obligations as well as large discrepancies in human health and environmental protection throughout EU countries;
- Avoiding duplicating and facilitating synergism in related research;
- Better focusing EU research to fill gaps and enhance weak aspects of risk assessment;
- Improving the risk assessment practice by providing a most robust support in terms of guidelines, tools and databases.

With regards to the type of common references, it is necessary to investigate the technical building blocks of risk assessment and their application, to define the status of development, the priority need for more robust or widely agreed methodologies, and the scientific basis for differences. In so doing, human health and ecological risk assessment might show different scenarios.

While many European countries have grown and consolidated the application of risk assessment to protect human health and for setting environmental quality criteria of soil, only a few have adopted methodologies of ecological risk assessment (ERA). In particular, the application of ERA at site specific scale (SSERA) is still seldom included in the decisional process of contaminated land management. It is not clear in which circumstances SS-ERA should be applied, what type of results are expected, and how they can be fed into the decisional process on remediation and risk mitigation measures. Although the scientific community has delivered some operational methodologies and assessment tools for SS-ERA, they are mainly affected by the lack of an accepted general framework, of testing activity and supporting databases.

In the context of ERA, the development of common European references is not only necessary to support a soil common policy, but also the opportunity to provide an impulse to the development of experimental approaches into operational procedures. It would ensure the comparability of results and improve the operational value of available assessment tools; it would promote the development of European joint databases (e.g. ecotoxicological, bioassay); it would enrich the pool of case studies and enforce the recognition of ERA within the stakeholder arena.

Priorities and suitable means for the development of common references were investigated at technical and scientific level by circulating a questionnaire to more than 35 scientists throughout Europe. The outcomes showed a general favour towards harmonisation, in increasing order for site specific risk assessment, screening risk assessment and the decisional framework. Various degree of harmonisation were indicated for different scientific building blocks of risk assessment. A special interest was expressed for the development of common databases, e.g. human toxicology, ecotoxicology, human exposure, chemico-physical properties of chemicals, etc. The tool box concept, i.e. the possibility of selection out of a set of multiple tools after the assessment of suitable conditions for applications, was preferred for exposure modelling. Common references for human health risk assessment were given higher priority than those for ERA. The reasons might be related to the fact that ERA is less supported by public concern than human health risk and, at present, is rarely invoked in the management of local contamination.

The results of the questionnaire were further analysed and discussed during a meeting in Ispra in February 2005, which was attended by more than 30 scientists from most of Europe. The proceedings of the workshop are available on the web on http://viso.ei.jrc.it/contaminated_lands/. A detailed list of technical elements suitable for common references was produced for human health risk assessment, while more general recommendations were provided on ecological risk assessment.

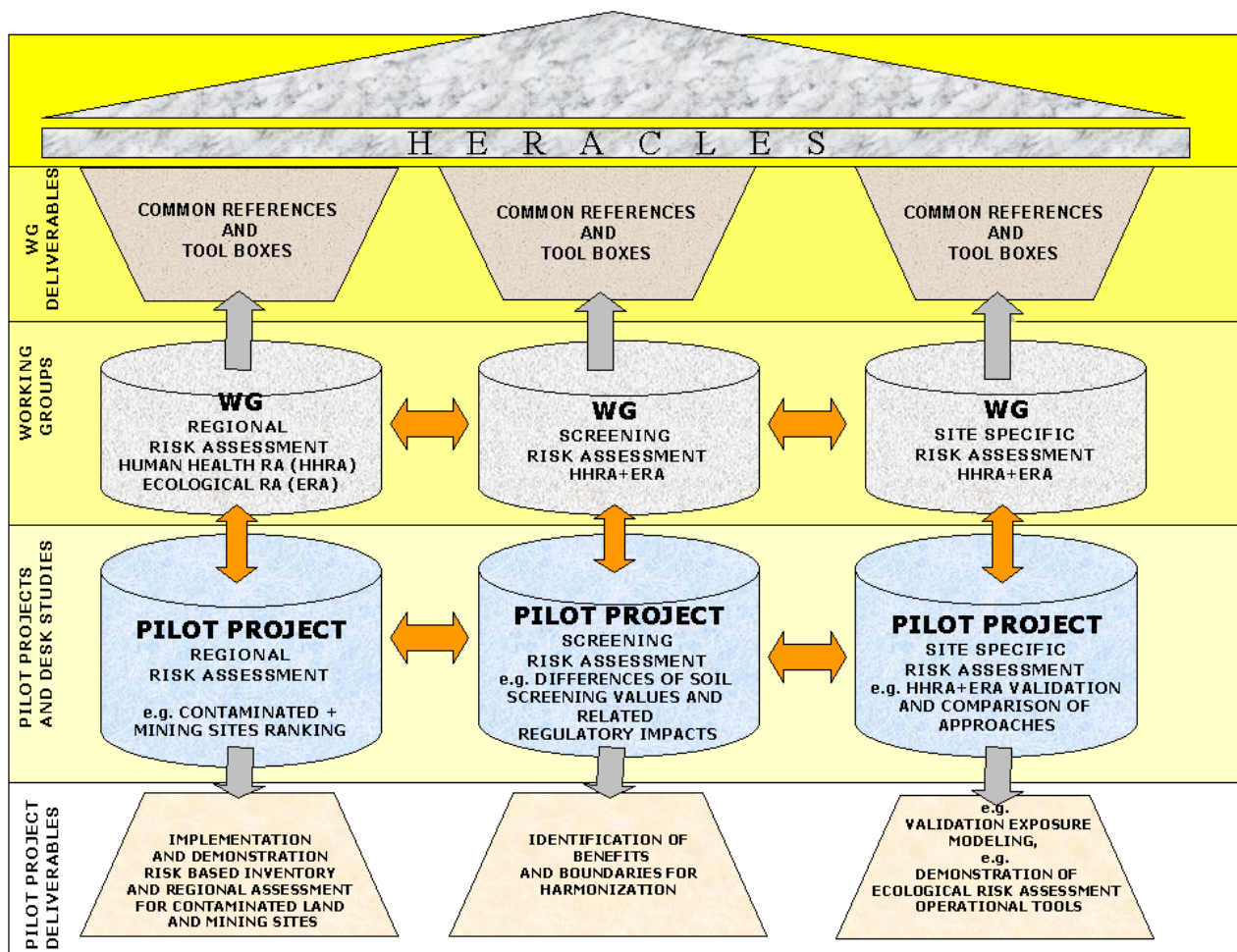
It was the general feeling that all tiers of ERA, and SS-ERA in particular, could benefit of some kind of European harmonisation. Moreover, there was consensus on the need of a general framework providing, e.g., a decision tree on when entering and ending an ERA, suggestions/recommendations of ecological factors and receptors to be considered in different land use classes. The TRIAD approach was identified as one useful way of organising ERA, but it was considered not feasible for all sites. With regards to the ecotoxicity aspects, the development of a good European database on ecotoxicity data was recommended. Moreover, it was suggested to organise the bioassays in a toolbox including recommended conditions for applicability. Another aspect of interest was the relation between ERA and human health risk assessment. In fact, the two approaches have many scientific building blocks in common which should be developed in more synergy than present. At the end, the participants to the meeting recommended the development of a general framework for a joint effort of JRC and other European Institutes for the continuation of the harmonisation process.

For the scope of supporting the development of common references of risk assessment for contaminated land in Europe the JRC, in collaboration with several other European research institutes, launched a long term research framework, named HERACLES, Human and Ecological Risk Assessment for Contaminated Land in European Member States. The HERACLES framework is summarised in Figure 12.

HERACLES addresses three levels of risk assessment, Relative Risk Assessment, Screening Risk Assessment, Site Specific Risk Assessment, encompassing both human health and ecological risk assessment. It intends to activate a dynamic process by keeping track of the development of risk assessment methodologies and providing operational references for contaminated land. For this scope, HERACLES combines two parallel activities: (1) working groups' discussion and (2) research and pilot projects.

It is an open framework, since all European research institutes with relevant interest and expertise in the specific field are invited to participate and contribute. While the Joint Research Centre will ensure the coordination of the HERACLES network and will be responsible of the achievement of some specific tasks, the success of the overall HERACLES initiative will be mainly based on the voluntary participation of other European research institutes.

Figure 12 Outline of the HERACLES Framework



The EU Waste Directive & the connection between soil and waste Geert Cuperus, Tauw, NL

Many of the current developments within the European Commission (EC) have a relationship with soil management. The emerging Soil Strategy deals with protection of soil, but soil issues are touched upon also in other policy areas, in particular, waste policy. The EC has defined its approach on all environmental issues in the Sixth Environmental Action Program (6EAP). The 6EAP identifies the main environmental issues the EC will concern itself with, and specifies the specific topics for which *Thematic Strategies* should be developed, currently including: *soil, sustainable use of natural resources, and waste prevention and recycling*. The EC is seeking consistency between these strategies. It is also considering a Thematic Strategy on the *Urban Environment*.

The Soil Strategy focuses on issues such as the prevention of soil contamination, soil biodiversity, salinisation and erosion. It is expected that the EC will propose its Soil Strategy in November 2005. It will include a framework Directive on soil. A specific issue within the Soil Strategy is the relation between soil and compost. Use of compost illustrates the dependency between several policy areas.

- From a viewpoint of waste management in the Waste Strategy
- Compost is also viewed as a possible sink for carbon. Through sequestration of carbon the emission of CO₂ is reduced, hence compost has a link to the climate change policy.
- Owing to its organic content, compost is also relevant to the Soil Strategy.

The Thematic Strategy on the Sustainable Use of Natural Resources deals with the impact of the extraction and use of resources. The approach of this Strategy is not yet as well developed as that for the other strategies. Two Working Groups have elaborated the issues to be addressed by the strategy and the approach strategy development will take. Soil will be considered in this thematic strategy as it is an important natural resource. Excavated, contaminated soil and clean soil after treatment will also be considered as potential “secondary” resource, which may replace primary resources.

In the Thematic Strategy on the Prevention and Recycling of Waste, the EC has in a general way described all kinds of possible measures to support prevention and recycling of waste. This document invites stakeholders to give their view on proper approaches and therefore a stakeholder consultation process has been launched. Via several meetings and through questionnaires, the EC has consulted stakeholders on such issues as how to approach waste management, the role of landfill taxes and the definition of waste. In September 2005 the Commission will launch its Strategy, based on all information it has gathered.

Approaches to standards for soil and soil treatment within the EU will change significantly, once the Thematic Strategies have been adopted. An example may be the treatment of contaminated soil. The Commission has proposed to draft BAT (Best Available Techniques) for the treatment of non-hazardous waste. Similar drafting is currently underway for hazardous waste. These documents will impose requirements on the treatment of waste, ranging from acceptance criteria up to measures to prevent emissions.

Another discussion taking place is whether or how soil will be influenced by horizontal approaches for standards for construction products. These standards will prescribe leaching methods and specific parameters which are to be tested. Soil will need to be considered as a construction material.

The Waste Strategy is of importance for soil management as excavated soil is regarded a waste. Furthermore, contaminated but still unexcavated soil is also regarded as waste. The EC has indicated that it will provide for a clause in the Waste Framework Directive, which makes it possible to use environmental criteria to decide if a substance is a waste or not. These criteria are still to be defined. A study will be launched to identify those waste streams which suffer from the fact that they are still considered a waste. New criteria will be developed for these waste streams.

It is not possible to draft criteria for all kinds of waste substances. Substances such as by-products or materials that derive from all kinds of activities (think for instance of roof tiles during demolition) are hard to define in such a way. Therefore, as an alternative, the EC may propose a set of guidelines which should help Member States to decide if a substance is a waste or not. These guidelines should then be deduced from clauses of the European Court of Justice on cases concerning the waste/non-waste discussion.

The Waste Framework Directive lays down the principles for waste management in Member States. It provides for definitions (on waste, disposal, recovery etc.) and describes general requirements, for instance: Member States must draw up waste management plans, they should provide for a network of disposal facilities, a system of permits and registration of waste must in place etc. As the development of the Waste Strategy proceeded, it became clear that a revision of the Waste Framework Directive was inevitable. The discussions on revisions focus on the following issues:

- Waste definition
- Definition of disposal, recovery and re-use
- Exclusions from the Framework Directive
- An approach based on life cycle thinking.

Definitions on disposal and recovery are of importance for instance when a waste material is exported: e.g. does the treatment abroad constitute a recovery operation or a disposal operation? The EC has asked stakeholders to give their opinions on the consequences of the Van der Walle case, in particular whether unexcavated contaminated soil should be maintained in the scope of the Waste Framework

Directive, or should a special regime be developed for its management, for instance under the Soil Thematic Strategy?

The Waste Framework Directive is rather clear in what constitutes a waste. Any material being discarded or is considered to be a waste. So far, this also includes soil which is excavated due to remediation activities, but also (non-contaminated) soil excavated due to construction activities. As it seems now, this situation will not change after the revision of the Directive. A waste material can however cease to be a waste. In several Member States materials such as clean secondary fuels and aggregates are not considered a waste anymore. Main arguments are: these materials do substitute a primary material and they do not pose an additional effect to the environment.

It is foreseen that after the revision, for some materials (environmental) criteria will be set in order to distinguish between waste and non-waste. This may be the case for certain materials which after treatment are made fit for re-use.

Soil may then cease to be a waste, within the concept recently described by the EC, when a set of criteria is agreed on. Considering soils as waste has significant negative impacts. If such criteria are not set for (treated) soil, owners of soil are dependant on national interpretation of the waste definition. Possible guidelines from the EC could be helpful to Member States in deciding when a material is a waste or not. All "soil- stakeholders" should in that case be eager to get involved in the drafting of these guidelines.

3 Discussion Session

A number of presentations identified topics for further research and development, or issues that NICOLE should take an interest in. Four syndicate groups were convened to discuss and list ecological risk assessment issues felt to be of importance for future NICOLE activities. The syndicate groups each focused on the same three themes

- Legislation/regulation;
- Data needs; and
- Modelling/assessment methods

The result of the group discussions were listings of ranked/prioritised issues/questions that were presented in a following plenary session. This concluded with a series of actions and issues prioritised by the participants.

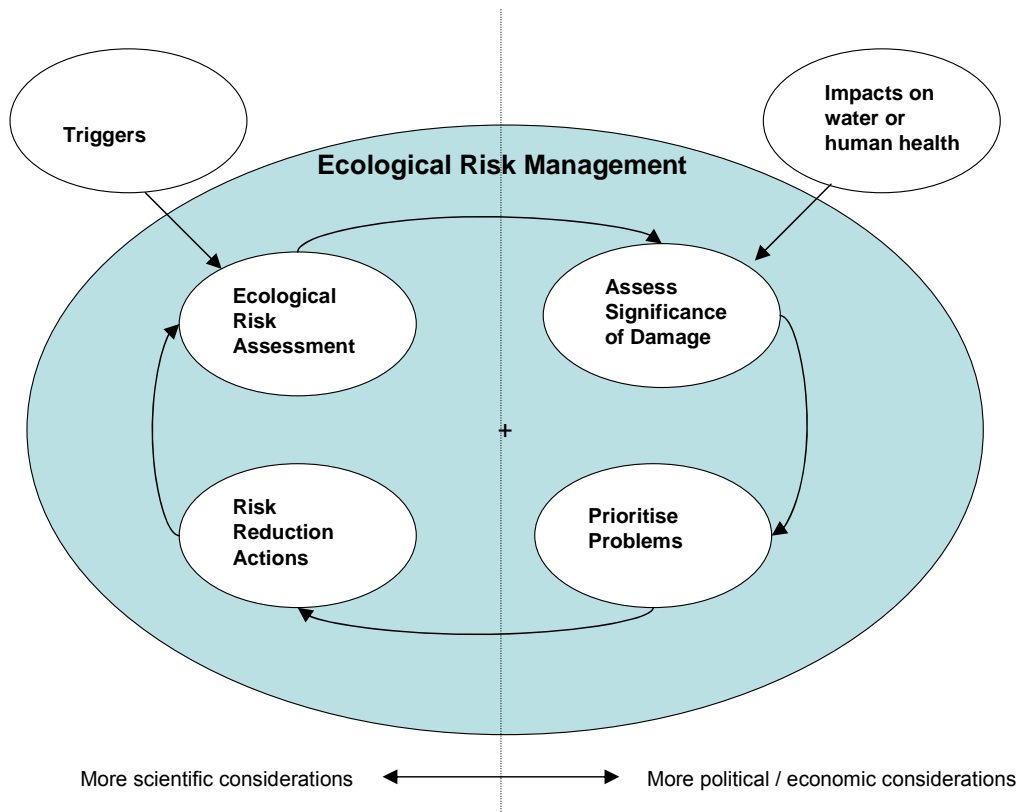
Overall Synthesis of Opinions and Ideas Expressed by the Workshop Participants, Bertil Grundfelt, KemaktaKonsult AB, Sweden

Legislation/regulation

1. It is important to identify and clearly define which receptors (individuals, species, eco systems) need to be protected and to what level of ambition.
2. Industry needs to be given a better understanding of what might trigger ecological risk assessment. Measurements of ecological harm need to be better defined, and should be understood in a holistic way with other impacts, for example on human health or groundwater.
3. An industrial site is normally defined as an industrial site in the municipal planning process. Therefore, it is not clear to many NICOLE members where the responsibilities of industry for ecological risk management lie, for example should industry's concern be limited to its own site perimeters, or if not, how far is it reasonable for off site impacts to be considered.

4. A number of NICOLE members are uncertain about the value of ecological risk assessment of individual sites in a wider urban environment.
5. Ecological risk assessment implies a need for management of ecological risks, in cases where significant risks are found. It is not clear how ecological harm and risks to human health and water can be compared. One of the syndicate groups suggested an initial framework for ecological risk management (shown in Figure 13).

Figure 13 Suggested Ecological Risk Management Framework



6. A Soil Framework Directive is being debated in conjunction with the Soil Thematic Strategy. Contaminated land risk assessment (ecological or not) will not be included in a Soil Framework Directive. “Harmonisation” has been discussed but this as something that EC will stimulate not regulate. NICOLE is engaged in these discussions, but some delegates felt that it should also take a view on the importance of considering ecological risks within the Soil Thematic Strategy.
7. Soil is a consideration in a wide range of EC policy initiatives. NICOLE should pursue the issue of integration and harmonisation of legislation
8. Participation in the HERACLES network was seen as an important opportunity for NICOLE to participate in and contribute to the technical and stakeholder debate on risk assessment across Europe.

Data needs

1. NICOLE should support the exchange of data and knowledge relating to ecological risk assessment.

2. A mechanism should be found to document experiences (e.g. case studies) with ecological risk assessment, in order to promote progress.
3. NICOLE sees a need for comprehensive access to harmonised and readily available ecological.
4. Significant gaps in technical data gaps were identified by a number of speakers. These may have a major impact on the reliability and credibility of models used in ecological risk assessment. ERA methodology would be more credible if gaps in technical data were comprehensively reviewed and action taken to “plug” those gaps at a European level.
5. ERA typically refers to background conditions. However, it is not entirely clear what kind of background conditions are a realistic baseline for ERA, since in many areas virgin conditions no longer exist, and may not be relevant to the current land use.

Modelling/assessment methods

1. Methods of ecological risk assessment should be holistic in approach rather than being based on a limited number of specific bioassays, which if they are representative of anything, may only represent segments of ecosystems. A useful tool to ensure a holistic approach is the use of a conceptual model.
2. Good quality guidance on approaches to ecological risk assessment is a vita; pre-requisite for industry. A tiered approach is preferred with clear exit points from the ERA process when a site can be seen as acceptable, without incurring unnecessary and wasteful expense.
3. Meeting delegates had mixed views about the current usefulness of harmonised modelling and risk assessment methods across the EU. The state of the knowledge about ecological risk assessment is still at an emergent level. So while methods harmonised across the EU are desirable for many NICOLE members, other felt that it may be premature to expect harmonisation. Some delegates felt that the current diversity of methods creates an opportunity to create more insight into effective approaches in the future.
4. Conversely, at an operational level, most delegates agreed that there is a need for a common approach to decision support systems.
5. Methods for ecological risk assessment should be cost effective.
6. The workshop discussed a wide variety of ecological risk assessment tools, whose basis and relevance to particular problems varies. There is a need for clear guidance on what to use and when. It was suggested that NICOLE could support a study to survey available ecological risk assessment approaches, guidance, models and datasets (the ERA “toolbox”).

The NICOLE Steering Group and Subgroups will discuss the workshop findings to agree next steps in the second half of 2005. Also expressed in the discussion was the need for NICOLE to continue its engagement in the consultation and debate about the Waste Framework Directive. This continues to be a major theme for NICOLE and will be the focus of a NICOLE Special Session at Consoil 2005.

4 Concluding Remarks

These conclusions have been drawn from the concluding session of the workshop and from comments invited from NICOLE Steering Group members, the meeting organisers and speakers in the weeks following the workshop.

There is clearly potential for industrial activities to impact on ecological processes, and in a number of cases major impacts have occurred over large areas. Ecosystems are the engine of the world's biosphere and we are dependent upon them for our survival. For example, soil ecosystems support the agricultural and horticultural use of land, the condition of the soil (including its physical properties), the ability of soil to buffer and degrade contaminants and the ability of soil to support bioremediation or natural attenuation for the management of risks to human health or water. However, it is only recently that ecological risk assessment has begun to become a more regular part of contaminated land management, which has primarily focused on risks to human health and water.

There are uncertainties in the role of ecological risk assessment, and also in its execution. A major question implied by ecological risk assessment is: can we do anything with its findings, i.e. how do we manage ecological risks.

The context of many contaminated sites is that they are in industrial or urban areas, both of which are already highly disturbed from an ecological point of view. Hence, if the implication of ecological risk assessment is that there is a problem arising from a contaminated site that needs to be put right, the next question is what is the end-point desired. Even if it could be determined what the original status of an ecosystem was, is it appropriate to expend resources (that could be used for environmental protection elsewhere) to restore an ecosystem that does not exist elsewhere in the site's local environment. One could further argue that it may perhaps be inappropriate to make a further set of artificial interventions into local ecosystems. Furthermore, it is not yet well understood what those interventions might be. Perhaps the answers will lie in preventing further deleterious impacts and supporting some kind of ecological natural attenuation and regeneration.

The idea of "ecological risk management" would seem to be a natural consequence of the use of ecological risk assessment, but has scarcely begun as a discipline. Most at the NICOLE workshop were anxious that any requirements for ecological risk management were proportional, taking into account the geographical and urban context of a site and ongoing land use. However, it should not be that ecological risk assessment will inevitably lead to an increase in contaminated land management costs. A few presentations showed that an intelligent approach to ecological risk management could enable site re-use at a lower than expected cost.

The execution of ecological risk assessment as a site investigation process is also at emerging level of knowledge. In countries which have, or are on the process of establishing, ERA frameworks; a number of common principals are already apparent, such as the use of a tiered approach and a "weight of evidence". Several presentations highlighted the role of the TRIAD approach (considering chemical analysis, ecotoxicity testing and ecological field work in parallel). A major problem in carrying out ecological risk assessment (and indeed human health assessment) is a paucity of technical data, and an inadequate consideration of existing information by some models. Delegates called for a better exchange of risk assessment know-how, and the creation of integrated datasets as a common basis for practioners across Europe. NICOLE could play a role in catalysing this development, for example by supporting a forum for the exchange of experiences about practical applications of ecological risk assessment (case studies), and supporting, in some way, an overarching review of available ecological risk assessment approaches, tools, models and datasets.

Ecological risk assessment is an important issue for NICOLE, which will seek to establish an overall technical viewpoint, with which to participate in the EC Soil Thematic Strategy and the HERACLES network.

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