CL:AIRE and English Partnerships
Land Remediation Technologies Workshop
The New Connaught Rooms, London
8 December 2005

Programme

09.30	Registration and coffee
10.00	Welcome: Jane Forshaw, Chief Executive, CL:AIRE
10.10	English Partnerships and Brownfield Strategy: Prof. Paul Syms, Director, Brownfield Team, English Partnerships
10.20	NLUD Results Overview: Tony Swindells, English Partnerships
10.30	Insurance – A Key to Unlocking Brownfield Sites, David Brierley, Bridge Insurance Brokers
10.45	Regulatory Overview: Bob Harris, Environment Agency
11.00	Remediation Technology Overview: Mike Summersgill, SEnSe Associates
11.15	Tea/ Coffee break
11.30	Bioremediation, John Rees, CELTIC
12.00	Permeable Reactive Barrier, Prof. Paul Younger, Newcastle University
12.30	Thermal Desorption, Guy Pomphrey, DEC NV
13.00	Lunch
14.00	Air Sparging / Soil Vapour Extraction, Adrian Shields, Komex
14.30	Soil Washing, Guy Pomphrey, DEC NV
15.00	Stabilisation / Solidification, Dr. Brian Bone, Environment Agency
15.30	Cluster Project, David Edwards, CL:AIRE
15.45	Round up
16.00	Close

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Printed in Great Britain by Leycol Printers, London

Biographical Note

Jane Forshaw

Jane Forshaw is the Chief Executive for CL:AIRE. She joins the team having been the Chief Executive at Urban Mines, another environmental charity for over 4 years.

In terms of her academic background she completed her Environmental Health Degree with a First Class Honours from Salford University, and then held a number of different positions employed by Birmingham City Council over a period of ten years. She first worked as an Environmental Health Officer and was then promoted to be Head of the Sustainability Team. She also became the personal advisor to the Chief Executive on sustainability issues. She was also on the Government's working group which published the National Sustainability Indicators Report.

She has led teams on a number of regeneration projects and is an accomplished networker. She sits on FIRSTFARADAYs Advisory Group and the English Partnerships Coalfields Project Board. She is currently the Chair of the Government’s Soil Guideline Value Taskforce.

Jane holds three diplomas in Waste Management, Health and Safety and Management Development, and is a member of the Chartered Institute of Environmental Health and The Institute of Waste Management. She is currently a LEAD Fellow, an international programme which creates Leaders for Environment and Development.

Land Remediation Technologies Workshop

8th December 2005

Jane Forshaw, CL:AIRE

Contaminated Land: Applications In Real Environments

CL:AIRE

Why are we bothering?

- Sustainable solutions
- Availability of land - being a finite resource on a small island
- Legislative drivers EU and UK, for instance Landfill Directive, Groundwater regulations and Environmental Protection Act
- National Policy drivers – National Brownfield Strategy
- Upcoming legislation eg Water Framework Directive 2015, Soil Framework Directive

Contaminated Land: Applications In Real Environments

CL:AIRE

The Scale of the Challenge

- Environment Agency Report – Indicators for Contaminated Land 2005
- 292,000 hectares potentially contaminated land on 333,000 sites in England and Wales
- Of which 57,000 hectares might be contaminated on 30,000 sites
- 5-20% of these might require intervention under Part IIA because of unacceptable harm
- This means 5,000 – 20,000 sites in England and Wales requiring regulatory intervention
- 3,500 km river at risk from mine water and 18,000 km² of aquifer at risk

Contaminated Land: Applications In Real Environments

CL:AIRE

CL:AIRE - The Organisation

- Established in 1999
- Public/private partnership
- Environmental charity
- Encourage demonstration of remediation research and technologies
- Our Vision

To eliminate the problem of contaminated land

Our Role

- Our role is to improve the uptake of alternatives to dig and dump
- To raise the standard of the scientific understanding of remediation techniques by providing independent verification
- To raise the expectations of site owners and remediators
- To be a constructive partner to policy makers and opinion formers

Contaminated Land: Applications In Real Environments

Member Organisations

Contaminated Land: Applications In Real Environments

The Alternative Becomes Viable

- Treatment costs per tonne below that of hazardous landfill
- Haulage costs are being quoted at £1.50/tonne for every 20 miles
- Techniques being used for pre-treatment to reduce hazards
- Soil washing and on site biological treatments beating landfill prices, especially when transport costs are considered

Contaminated Land: Applications In Real Environments

CL:AIRE

Some of our Achievements

- With £1.3 m of our core funding we have levered in £14.6m of other project funding
- We have completed or have ongoing 33 projects with over 70 partners
- Our database has over 4,500 registered organisations and individuals

Contaminated Land: Applications In Real Environments

CL:AIRE

Benefits of working with CL:AIRE

- Added value of Technology and Research Group
- Project evaluation
- Independent verification
- Global dissemination

Contaminated Land: Applications In Real Environments

CL:AIRE

Technology Demonstration Projects

- Low temperature thermal desorption (2)
- Soil washing (3)
- Permeable reactive barrier (4)
- Bioreactor
- Wetlands
- Static biopile (2)
- Aerated biopile
- Solidification/stabilisation (2)
- Air sparging
- Ex situ Soil Vapour Extraction
- Accelerated Natural Attenuation using HRC

Contaminated Land: Applications In Real Environments

CL:AIRE

Other CL:AIRE Projects

- CLUSTER
- European projects
  EURODEMO (http://www.eurodemo.info/) and
  EUGRIS (http://www.eugris.info/)
- WRAP - Market study

Contaminated Land: Applications In Real Environments

CL:AIRE

Opportunities for compost use in brownfield sites in the UK

Research aims and objectives

- Assessing the potential for compost use in regeneration and remediation of brownfield sites in the UK
- Quantify current use of compost already used in land regeneration and land remediation
- Identify barriers limiting compost use in land regeneration projects
- Identify potential sites in each region where compost could be specified for use in regeneration/remediation

Contaminated Land: Applications In Real Environments

CL:AIRE

Project outputs

- Understand development procedures and role of regional stakeholders in brownfield site regeneration.
- Determine relevant stages of development at which compost can be specified.
- Quantify market opportunity for compost in regeneration & remediation.
- Regional mapping of potential sites for compost, including priority sites.
- Identify synergies between WRAP and region's for future working.

Contaminated Land: Applications In Real Environments

CL:AIRE

How we can help you

- Signpost your queries
- Provide information and reports
- Assistance in finding the right partners
- Linkages to academics to help with research possibilities

Join our database – it's free!

Contaminated Land: Applications In Real Environments

CL:AIRE

Summary

Contact details for CL:AIRE:

Website: www.claire.co.uk

Email: enquiries@claire.co.uk

Tel: 020 7340 0470

Contaminated Land: Applications In Real Environments

CL:AIRE

Today we want to :-

- Examine the policy framework
- Showcase best practice across a range of technologies
- Provide you with a stimulating learning experience
- Leave you confident that you know where to go for guidance

Contaminated Land: Applications In Real Environments

CL:AIRE

Biographical Note

Paul Syms

Paul Syms is Director of the National Brownfield Team at English Partnerships. He leads a joint EP / Office of the Deputy Prime Minister team, charged with developing and delivering a comprehensive brownfield strategy for England. Prior to taking up his post in Autumn 2004 he was Professor of Urban Land Use at Sheffield Hallam University. Paul has more than 35 years property related practical experience, mostly as a development surveyor. He has acted for many internationally known development companies, for local authorities and other landowners, advising on the specialist aspects of re-using previously developed land.

He is a Fellow of the Royal Institution of Chartered Surveyors, a member of the boards of the Institution's Environment and Planning and Development faculties. His academic qualifications include MPhil (Economic Geography) from the University of Manchester and PhD in the development and valuation of contaminated land from Sheffield Hallam University. He represented the surveying profession on the working party set up under the auspices of the Urban Task Force to consider implementation of its recommendation on standardised Land ConditionStatements. He has undertaken research for the Office of the Deputy Prime Minister into the transferability of lessons from the enterprise zones and, for ODPM and Inland Revenue, into the initial impacts of the Urban White Paper Fiscal Measures.

His publications include several books and major research reports. His books include Contaminated Land: the practice and economics of redevelopment (1997), Land, development and Design (2002) and Previously Developed Land: industrial activities and contamination (2004).

Biographical Note

Tony Swindells

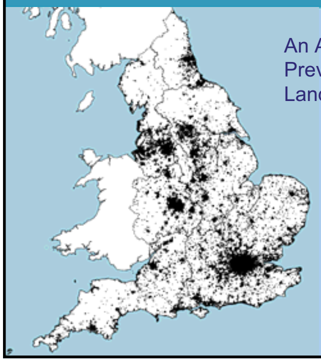
Tony is a Chartered Surveyor who has been working for English Partnerships for 9 years. He is currently the Project Manager of the National Land Use Database (NLUD).

NLUD – The Key to the Success of the NBFS

CL:AIRE 8 December 2005

Tony Swindells
Project Manager - NLUD

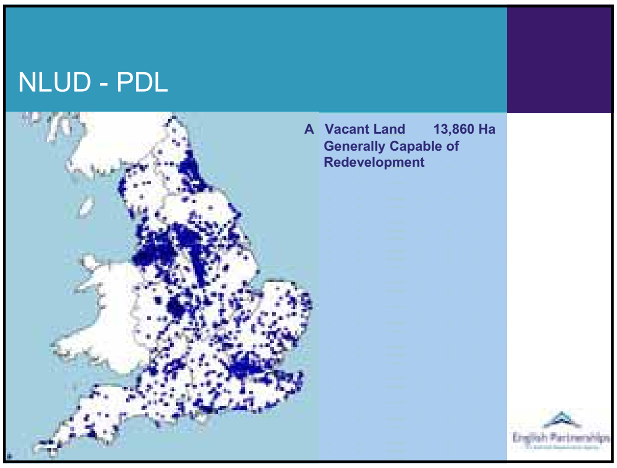
NLUD - PDL

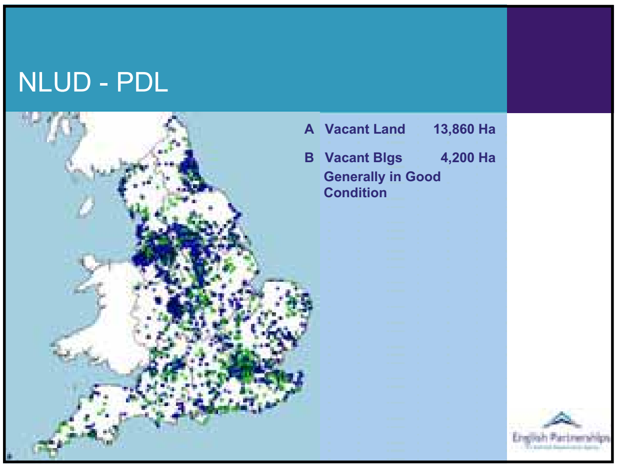


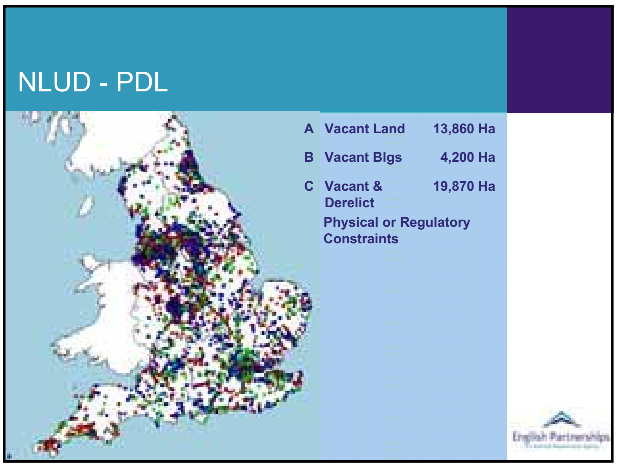
An Annual Survey of all Previously Developed Land in England

NLUD - PDL

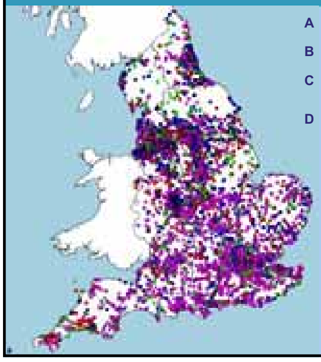
Previously developed land
is that which is or was
occupied by a permanent structure
and
associated fixed surface infrastructure
in both
urban and rural settings


NLUD - PDL
A Vacant Land 13,860 Ha
Generally Capable of Redevelopment


NLUD - PDL
A Vacant Land 13,860 Ha
B Vacant Blgs 4,200 Ha
Generally in Good Condition


NLUD - PDL
A Vacant Land 13,860 Ha
B Vacant Blgs 4,200 Ha
C Vacant & Derelict 19,870 Ha
Physical or Regulatory Constraints

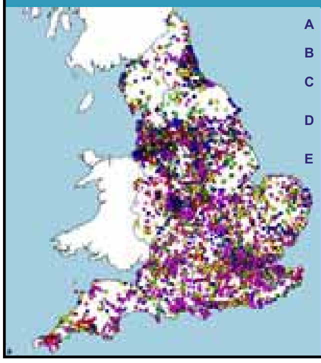
NLUD - PDL



A	Vacant Land	13,860 Ha
B	Vacant Blgs	4,200 Ha
C	Vacant & Derelict	19,870 Ha
D	Still in Use with planning	18,120 Ha

May be Under Utilised or Not Achieving Full Potential

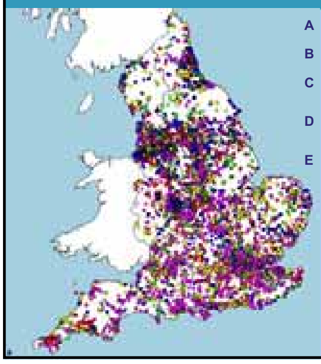
NLUD - PDL



A	Vacant Land	13,860 Ha
B	Vacant Blgs	4,200 Ha
C	Vacant & Derelict	19,870 Ha
D	Still in Use with planning	18,120 Ha
E	Still in Use with Potential	8,070 Ha

But no Planning Permission for Development

NLUD - PDL



A	Vacant Land	13,860 Ha
B	Vacant Blgs	4,200 Ha
C	Vacant & Derelict	19,870 Ha
D	Still in Use with planning	18,120 Ha
E	Still in Use with Potential	8,070 Ha
	Total	64,130 Ha

NLUD - PDL A Few Misconceptions

- **All sites are suitable for housing**
- **All sites are suitable for hard end re-development**
- **All sites are ready for re-development**
- **Sites are surplus to owner's requirements**

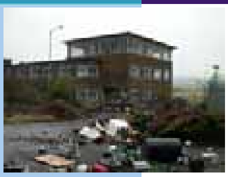
NLUD - PDL & NBFS

The report 'Towards a National Brownfield Strategy', published in September 2003, identified a number of issues including:

- **The problem of 'hardcore' land – vacant or derelict since 1993 or earlier; (Now referred to as 'Long-term Dereliction)**

Long Term Vacancy & Dereliction

	Medium term (93 -98)	Long term (Pre1993)
No of sites	4,570	2,063
Total hectares	8,460	16,768
Avg. size	1.85	8.13



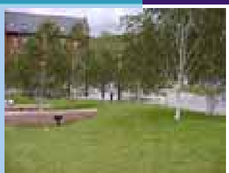
NLUD - PDL & NBFS

The report 'Towards a National Brownfield Strategy', published in September 2003, identified a number of issues including:

- **The problem of 'hardcore' land – vacant or derelict since 1993 or earlier;**
- **That not all Previously Developed Land is suitable for Hard End Redevelopment;**

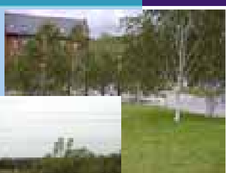
Soft End Uses

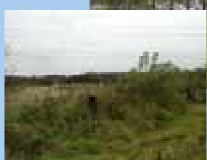
Open Space



Soft End Uses

Open Space
Sites with No Planning





Equates to One Third of all Previously Developed Land

NLUD - PDL & NBFS

The report 'Towards a National Brownfield Strategy', published in September 2003, identified a number of issues including:

- **The problem of 'hardcore' land – vacant or derelict since 1993 or earlier;**
- **That not all Previously Developed Land is suitable for Hard End Redevelopment;**
- **An emerging shortfall in the supply of PDL 'suited for development'.**

Emerging Shortfall

Emerging Shortfall

Provision will be made in Local Plans for an additional 50,200 dwellings between 1996 and 2011.

District	Plan	P.A.	Land	On PDL
Bath & NE Somerset	6,200	413	12Ha	7Ha
Bristol	13,000	867	25Ha	15Ha
N Somerset	14,900	933	27Ha	16Ha
S Gloucestershire	16,100	1,073	31Ha	19Ha
Total	50,200	3,286	95Ha	47Ha

Source: Joint Strategic Planning & Transportation Unit

Emerging Shortfall

Provision will be made in Local Plans for an additional 50,200 dwellings between 1996 and 2011.
PDL Allocated/Planning for Housing

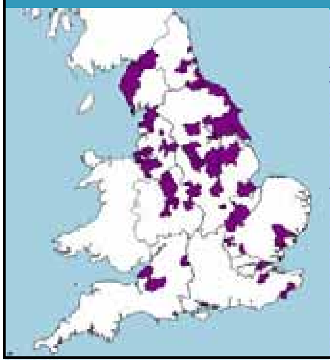
District	Vacant	EHC	Density
Bath & NE Somerset	2.33	92	40
Bristol	18.44	860	47
N Somerset	61.65	1,864	30
S Gloucestershire	0.44	4	9
Total	82.86	2,820	34

Source: National Land Use Database

Questions?

- **Vacancy & Dereliction**

Vacancy & Dereliction



Local Authorities where Vacant and/or Derelict Land is 2% or more of Urban Area

Questions?

- Vacancy & Dereliction
- **Planning**

Planning

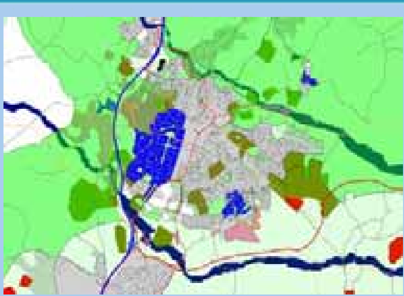
NLUD – PDL
No Planning
>15,000 Ha

Questions?

- Vacancy & Dereliction
- Planning
- **Regulatory Constraints**

Regulatory Constraints

Regulatory Constraints



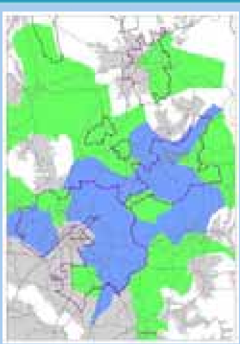
Green Belt
Flood Plains
SSSI's
Landfill Sites
Conservation Areas
Nature Reserves
Archaeological Sites

Questions?

- Vacancy & Dereliction
- Planning
- Regulatory Constraints
- **Socio Economic Constraints**

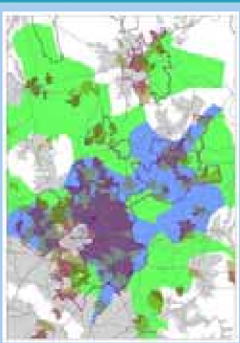
Socio Economic

Socio Economic



Land Values
House Prices

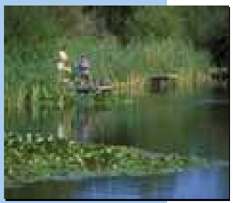
Socio Economic



Land Values
House Prices
Deprivation

In conclusion…

- Brownfield regeneration - an opportunity that must be seized
- Confront industrial blight for the sake of future generations
- NLUD The Cornerstone of Information
- The Tool for Monitoring and Evaluation



www.englishpartnerships.co.uk

Biographical Note

David Brierley

David Brierley heads the Environmental Risks Unit at Bridge Insurance Brokers Ltd., which is acknowledged to be the only leading environmental insurance specialist outside London. Its coverage programmes have actively facilitated property and corporate transactions which would otherwise have failed due to environmental issues. Bridge has assisted a range of clients from RDAs and plcs to small developers on projects from international portfolio disposals to individual site transactions.

Insurance – a key to unlocking brownfield sites

David Brierley MA (Oxon) Environmental Risks Manager

BRIDGE INSURANCE BROKERS LTD.

The National Brownfield Strategy

- A macrocosm of the single site
- The same risks apply
- How can insurance address these?
- A positive impact on the sites' future

The Risks

- Practicalities - S.I. Procedures
  - Landfill Directive
- Popular misconceptions
- Planners' and funders' concerns
- Residual risks and legal changes
- Will the completed site sell?


BRIDGE
Environmental Insurance
• How it works
- Standard cover
- Negotiable policy conditions
- Plugs gaps in existing insurance arrangements
- Comfort for planners and funders
• Case study - an unlocked site


BRIDGE
The Future
• Complementing practical RM
• Confidence for end purchasers
• Local Authority opportunities
• Preserving the “green”

Biographical Note

Bob Harris

Bob Harris has spent 33 years in the UK water and environment sectors within government agencies at local, regional and national levels. He was involved in the early days of waste disposal sites regulation and helped with the development of guidance and policies in relation to groundwater management and associated urban and rural land use. He built and headed up the Environment Agency's National Groundwater & Contaminated Land Centre for 5 years before becoming Head of Ecosystems Science in the Agency. He leads the Agency's Integrated Catchment Science Programme that provides the scientific underpinning for policies and regulation, relating to the Water Framework Directive and ultimately Integrated River Basin and Coastal Management. Bob is active internationally in collaborative projects and policy/science networks, such as the contaminated land ERA-Net, SNOWMAN, and is a visiting Professor in Catchment Science at Sheffield University.

Environment Agency

A Regulatory Perspective on Contaminated Land

Bob Harris
Environment Agency

creating a better place

Environment Agency

Reflections on where we've come from

- contaminated land becoming visible on the environmental agenda in late 70's/early 80s;
- Increasing attempts to use planning controls during redevelopment for environmental benefit;
- From early 1990's - development of risk-based approaches to setting:
  - site-specific groundwater qality goals;
  - generic soil guideline values for human health

Environment Agency

Reflections on where we are now

- Overarching risk-based approach incorporated in legislation: S-P-R paradigm introduced;many CLEA guideline values, Model Procedures and Planning Policy Statement 23 published;
- The process of dealing with (ground)water pollution assessment and remediation is now well founded in UK. We have:
  - a sound generic and site-specific risk-based approach with tools: vulnerability maps and protection zones;guideline value setting methodologies and models;
- An approach for Ecological Risk Assessment has been consulted on;However…

Reflections on where we are now

- Risk-based approaches reqire well trained: regulators, consultancy/advisory community and informed problem-holders;still some way to go;
- Generic guidance in itself is not enough if site-specific judgements to be made;
- Split regulatory role;split in legislative drivers:
  - Part IIA;Planning;Waste legislation;groundwater regulations etc.

Reflections on where we are going

- Water Framework Directive a reality
  - urban sources of pollution to groundwater and river systems will be increasingly brought into focus;
  - mining heritage (water and spoil) will also be a major factor.
- Soil Protection (Framework) Directive on the cards:
  - c.700,000 contaminated land sites in Europe that need attention. Will this be a prescriptive or a truly framework Directive? Much to influence...
- Brownfield land redevelopment the major focus?

Part IIA Regime (E&W)

- So far...313 Determinations of Contaminated Land (11 in Wales); of these,
  - 22 are Special Site designations (2 in Wales)
  - 132 inspections of potential Special Sites (8 in Wales)
  - 100+ relate to individual houses within housing estates
- So far....34 Remediation Statements, Notices or Declarations issued by LAs and further 11 (all Statements) by the EA.

Human and Ecological Health risk assessment

- CLEA the main pillar of generic guideline values;On-going SGV programme;Cabinet Office Task Force.
- Various tools developed/being developed for assessing site-specific risks.Trade off between cost of more information and higher acceptable values for individual sites.
- Issues of uncertainty over bioaccessibility make assessments complex.

Regulatory Hurdles

- Plethora of environmental legislation in last 10 years, not well joined together.
- Compatibility issues of risk-based culture of cont land versus risk-averse culture of waste regulation.
- Remediation Licensing Task Force looking at Brownfield redevelopment issues;
- Mobile Plant Licensing process being streamlined.
- Guidance also being reviewed to help explain the regulatory position on when soils are waste

Water Framework Directive

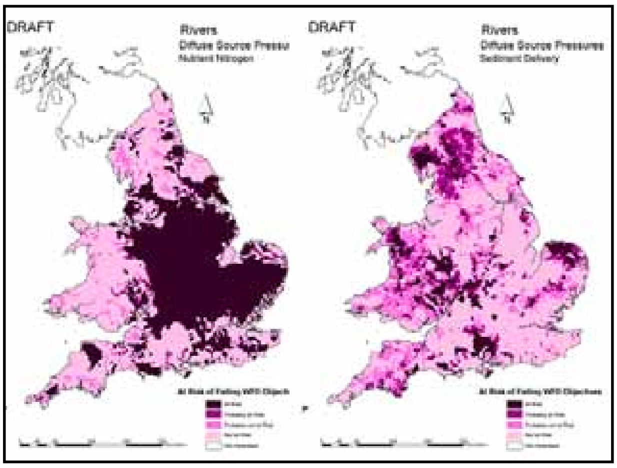
- This new EU Directive uses the measure of good aqatic ecosystems as a surrogate indicator of a clean & healthy environment;
- EU Member States have to assess and report on the status of (groundwater and surface) water bodies and manage through River Basin Plans to deliver good status;
- It will bring diffuse source pollution sharply into focus.

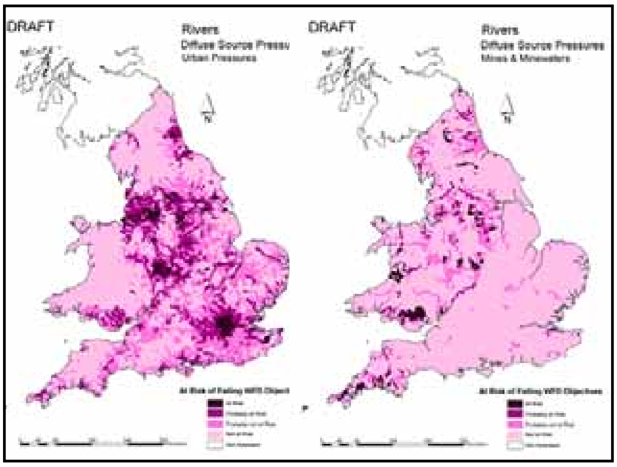
Environment Agency

The Major Problems

- Agricultural diffuse pollution..from nitrate, phosphate & pesticides;
- Acid drainage from historical mining activity;
- Megasites - i.e. large scale urban pollution;
- A (very) few specific point sources.
- The current situation in England & Wales...

creating a better place



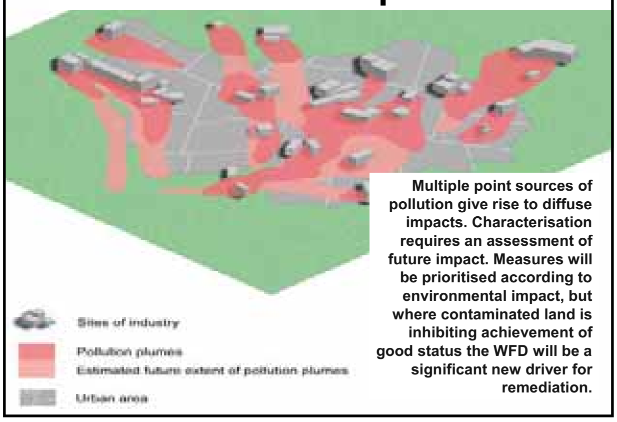


The Scale of the “Problem”
- we still don’t know

Environment Agency

- Con. land traditionally a problem of human health, or water pollution, **at the local scale**;
- Many sites, but what are the **real** problems?
- Estimates of the extent of land “affected by contamination” in England & Wales have varied from: 50,000 to 300,000 ha, relating to c. 100,000 sites.
- Of the latter, between 5,000 to 20,000 **may** be considered to be “problem” sites, (i.e. need action to ensure they don’t pose an unacceptable risk to human health - or the environment.)
- 25 years on and the problem still not qantified.

Urban diffuse pollution



Multiple point sources of pollution give rise to diffuse impacts. Characterisation requires an assessment of future impact. Measures will be prioritised according to environmental impact, but where contaminated land is inhibiting achievement of good status the WFD will be a significant new driver for remediation.

WFD and Integrated Catchment Management

Environment Agency

- Improvements to **aquatic** (eco)systems can only be realised by **managing land use** and/or remediating historical pollution. We have:
  - **Characterised river basin catchments** and now have to:
  - **Manage “pressures”** within them so as to:
  - **Reduce “impacts”** on ecosystems considered in a whole river basin context within a “Programme of Measures”.
  - **Achieve good status** by 2015, but a cyclical process

Managing River Basins

A more holistic approach is needed to understand better how river basins work, and the key geochemical fluxes & pollutant linkages which influence aqatic ecosystems. This should underpin…

a risk-based land management approach to **all** activities within a spatial land-use planning framework.

It reqires closer working within and between scientific disciplines and more integrated programmes. It will also reqire underpinning with sound science....

Managing the Impacts through a Risk-based approach

Remedial strategies must be developed in accordance with the understanding and the risks - i.e. on a site or catchment specific basis;

Stakeholders need to work in partnership in developing appropriate remediation options; **this becomes more necessary as the scale increases**;

Sustainable/durable, cost-effective, least disruptive, knowledge-based solutions are best;

In-situ passive techniqes - e.g. Monitored Natural Attenuation (MNA) and Permeable Reactive Barriers (PRBs) - have an (the most?) important role.

Resumé

Need to understand the importance of contaminated land in affecting aqatic ecosystem and human health at the catchment scale;

Need to focus more on where major improvements - diffuse pollution at the regional/landscape scale - can be delivered;

New driver for remediation - widespread impact on ecosystem as opposed to a value being exceeded;

Need for better interaction between contaminated land and waste communities- both in terms of risk/knowledge based approaches and technology transfer.

Biographical Note

Mike Summersgill

Mike is a civil engineer with 30 years experience in construction, covering water, soils and environmental work. He has worked for Yorkshire Water, major Consultants (Halcrow & Atkins), site investigation companies (Weeks & GSG), and a land remediation Contractor, VHE Technology. Currently, Mike operates his consultancy, SEnSe Associates, and a Site Investigation company (LCE) in Kent. He is a member of the CL:AIRE advisory panel on land remediation technology issues.

Mike has also undertaken a review of European land remediation costs for the PURE project, and was the founding chairman of the European NICOLE Network's Service Providers Group in 2000/01. He continues to keep in touch with European activities.

Mike has also been involved in the research and licensing of UK soil remediation, the support documentation behind the SiLC register, and the Single Regeneration Permit.

A chartered civil engineer, Mike also represents CIWEM (Chartered Institute of Water and Environmental Management) on several technical panels, and has Masters degrees in Soil Mechanics and Business Administration (not together!).

In the past 15 years, project involvements included Wheal Jane minewater wetlands, Sarajevo water supply reinforcement, Greenwich JLE station box, Fulham gasworks bio-remediation, Strood riverside regeneration, Woolwich Arsenal soil washing. And soil stabilisation, groundwater treatment and bioremediation at several gasworks sites.

UK Remediation Technologies

A Cost/Availability Overview
EP/CL:AIRE Seminar – 8th Dec 2005

Presentation by:
Mike Summersgill, C.Env, FCIWEM, MICE, SiLC
Managing Partner, SEnSe Assocs, Maidstone
Tel: 07779-367412. Email: senseass@btinternet.com

2005 Treatment Concepts

- Landfill as a last-resource option
- Sustainability Principles apply?
- Pre-Treatment or Modification
- UK well behind northern Europe.
- ExSitu/InSitu - Biological, Physical, Chemical, Thermal, 'Natural'.
- 36 Technologies in Europe - PURE

Europe Market – Conclusions

- Legislative Variability, e.g.'Waste'
- Commercial Variability - maturity
- Expertise Variability – UK/NL insitu
- Landfill Price 'marker' many places
- Data was published Oct 2005 at CONSOIL. Also in BrownBriefing Technology Supplement Nov '05.

UK 1996/9 – EA Research

Technical Report P401

- Baseline Technology Usage
- 40 Organisations: public/privat
- 367 Sites; 70% < 5ha
- 16% Insitu, 5% ExSitu
- Landfill & Encapsulation/Cover
- DVE (31),Bio (11), SVE,Wash

UK 2001 - FirstFaraday

Pre-CLEA; 28 owners, 72 sites

- Similar results re. Civils use
- 60% Landfill, 25% Capping
- Pump & Treat 30%; Insitu 7%
- No exsitu Wash or exBio ??
- No DVE, but SVE Flush Phyto
- Cost not the 1st/2nd factor…

UK 2000/04 – ExSitu Bio.

Student Research in Vacation /BB

- 20 Specialist UK Contractors
- 17 Responses with 5 year data
- Market increasing at 25% pa
- Prices returning to 2000 level

- Detailed Study by CL:AIRE of larger marketplace – due at Xmas.

Technologies Applicable

- BIOLOGICAL InSitu/ExSitu
- PHYSICAL Geot + ExSitu
- CHEMICAL InSitu + Stabilise
- THERMAL Novel In/ExSitu
- 'NATURAL' InSitu; default!

- OR a Combination of some…

BIOLOGICAL Methods

- Landfarming
- Treatment Beds
- Windrow/Composting
- Aerated Biopiles
- Process Bio-reactors
- inSitu Oxidation/Reduction

PHYSICAL Methods

- Crushing/Sorting/Separation
- Covers and Barriers
- Soil Washing
- Water/Vapour Pump&Treat
- Air Sparging/SVE
- Hydrofracturing
- Electro-remediation

CHEMICAL Methods

- Oxidation/Reduction/Hydrolysis
- Insitu Chemical Injection
- Stabilisation/Solidification
- Vitrification/Immobilisation
- Permeable Reactive Barriers
- Water treatment/adjustment

THERMAL Methods

- Incineration
- Vitrification
- Thermal Desorption
- Ground Heating
- Steam Injection

NATURAL Methods

- Degradation (by do-nothing)
- Monitored Attenuation
- Enhanced Attenuation
- Phyto-Remediation
- Fungal Innoculation

  …latest research…
- SonoChemistry/Lightning

How to Choose Which Type

- Geotechnology – soil type
- Chemistry – contam type
- Geochemistry – reactions
- Hydrogeology – flow field
- Hydrogeochemistry – insitu
- GeoEnviroBioChemicoPhysical Confusion!! – ask a Consultant? Or more probably a Contractor

then.. Which Contractor?

- No definitive Trade Body
- Many specialist SMEs
- Few published Case Studies
- Sometimes several Options
- Does QA/MCERTS guarantee
- Ask a SiLC? Look at EUGRIS

Market Prices in mid-2005

- HAZ - £60 to £100+ /ton
- Non-HAZ - £20 to £40 /tonne
- Stabilised N/R Cells – new
- Technologies £30-50 /tonne
- Pays to treat then Landfill…
- 'Period of Uncertainty' ensues

THE very NEAR FUTURE

- European Waste Definition!!
- Mobile Treatment Licence
- Soil Hospitals – CLUSTER
- …meanwhile…
- Brownfld >70%; ODPM happy
- Landfill Tax Exemption goes?, …but does Corporation Tax 'benefit' work instead - Barker

Biographical Note

John Rees

John is Managing Director of CELTIC Technologies Ltd which was established in 1992 as a design & construct remediation company with a focus for the on site treatment of contaminated land. After graduating in Fermentation technology and microbiology from London University in 1975 he joined the DoE Landfill Research Programme at Harwell and worked in conjunction with the BGS and the WRC on the landfill characterization programme, and on understanding the fate of landfill leachates in the subsurface & groundwater. His work focused on understanding microbial processes in landfills and in the deep subsurface. He took a secondment to the USEPA Kerr Laboratory in 1983 and undertook anaerobic microbial research work into the degradation of petroleum hydrocarbons in subsurface sediments. He was a founding director of Biotechnica/Biotreatment in 1984 in which time on site biotreatment of gasworks wastes was applied for the first time at Blackburn and Doncaster Gasworks. After a period working as a specialist consultant, CELTIC was established in 1992.

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Design and Construct Remediation Contractor

Soil Bioremediation – Principles & Application

EP Training: CL:AIRE 2005

Dr John F Rees

www.celtic-ltd.com

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Contents

- Bioremediation in Practice – What is it?
- How it Works
- How Long does it Take?
- Why Use it – and When not to Use it
- Case Study – Bioremediation at Dewsbury Gasworks 2005

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Bioremediation What is it?

- Bioremediation as applied to materials from the subsurface comprises the use of microbes to convert contaminants to less harmful products.
- A destructive treatment technology effecting contaminant mass reduction.
- Hugely *POWERFUL* process (i) breadth of application (ii) intensity of application.
- Microbes comprise naturally occurring fungi & bacteria.
- Natural inocula generally facilitate initiation of treatment.
- Engineering, Optimising & Controlling a Natural Process
- The growth of microbes in an engineered environment consuming & destroying contaminants in the process.

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What is it - Background

- Pre 1970s Agricultural research had limited awareness of soil microbiology. Focused on topsoil and 1st 300mm.
- 1970s Microbes ubiquitous in deep soils/groundwater
- DoE Landfill Research Programme: (i) Natural Attenuation in the subsurface (ii) Greensand /Chalk/Sherwood Sandstone (iii) Aerobic & Anaerobic Processes (iii) methane optimisation.
- 1983- Anaerobic degradation of Petroleum Hydrocarbons
- 1985 - Bioremediation of Blackburn Gasworks – 1st UK
- 1992 - In situ air sparging / bioremediation of diesel spill in shallow aquifer -1st UK
- 1994- Total anaerobic bioremediation of Cl solvent in aquifer - Canadian

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Bioremediation – How it works I

- Microbes are only 20% of the solution
- A process which can be well controlled and costed for programme and contractual issues.
- Process comprises 2 Phases: Phase 1: Initiation and intensification of biotreatment process. Phase 2: Process maintenance, monitoring & closure.
- Site area required between 2m2/m3 and 0.7m2/m3
- Variations on a theme:
  - Phase 1: Agricultural rotorvator; Traymaster; Straddle Compost Turner; Mechanical Excavator; Allu Bucket.
  - Phase 2: As above plus Static biopiles to 2m with induced aeration; Static "en croute" with VE.
  - In situ applications run in parallel with construction programme.

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Bioremediation – How it works II

- Critical selection & minimisation of materials to be treated
- Pretreatment/screening for oversize > 100mm
- Optimize starting concentration 5,000 to 50,000mg/kg
- Ensure contaminant availability & even distribution
- Get the ingredients right for microbial growth
- Process monitoring ensures control & validation.
- Monitoring for: water; temperature; contaminant removal; changing variance; statistically valid data sets.

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Bioremediation – How it works III

- *The Bioremediation process will treat:*

(i) a very wide range of Total Petroleum Hydrocarbons
(ii) concentrated hydrocarbon waste sludges (150,000mg/kg)
(iii) BTEX
(iv) PAHs full USEPA range 2 ring to 6 ring
(v) Phenols
(vi) Chlorinated solvents & explosives eg RDX Nitro compounds

- *Difficult Materials for treatment:*

(i) Ammonia
(ii) Cyanides
(iii) PCBs

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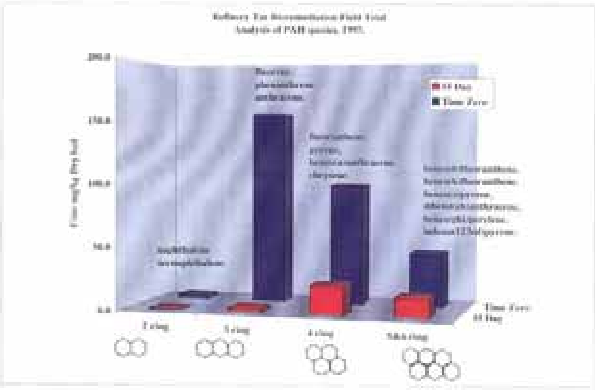

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EX SITU BIOREMEDIATION OF SOILS & SLUDGES

- Biological treatment of oily and tarry sludges including land application
- Above ground Processed Biopile Systems for wastes and contaminated soils
- Biological treatment of contaminated vapours
- Chemical treatment
- Treatability studies & feasibility field trials for contaminated soils, canal sediments, lagoon sludges & wastes

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Bioremediation – How it works IV

- Metals and anions are important and especially:
  Iron; Manganese; Sulphate and Nitrate under anaerobic conditiond.
- Inhibitors to the process are:
  Poor bioavailability of the contaminant (eg tar ball); poor oxygen diffusion; poor mixing of treatment system; poor design of treatment mix.

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How Long does it Take?

- In biopile treatment time typically 3-10 weeks

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Why Use it ?

- When NOT to use it
- Cost Benefit

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CELTIC Clariant, Cadishead – Barrier V's Bioremediation

Why Use it ?

- A Risk Based Approach
- Cost benefit analysis
- Programme
- Integrated with a suite of other on site treatment technologies

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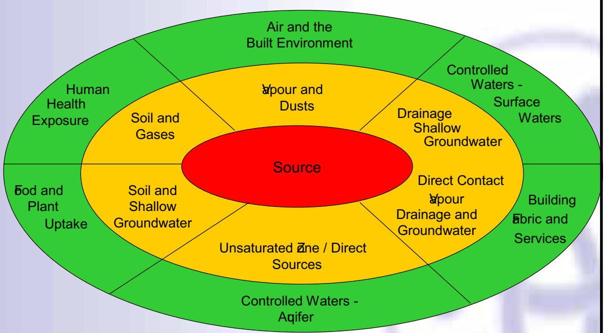
Foundations of Design – Source – Pathway - Receptor



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Why Use it ?

- Integrated with a suite of other on site treatment technologies

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CELTIC's IN HOUSE TECHNOLOGIES

Technology	Examples
Chemical Stabilisation with *EvoCem*™ **Source Reduction**	(i) Inorganic stabilisation, St. Helens. (ii) Spent oxide stabilisation. (iii) Hydrocarbon stabilisation, Caerphilly.
Turnkey Solutions	(i) Ogilvie Homes, Stirling, Scotland. (ii) Building demolition and tank pulls for Wilcon Homes, London. (iii) Merck, East London. (iv) Cadishead Railhead for Clariant and Peel Holdings, Manchester. (v) Sludge pit remediation for BP, Llandarcy, South Wales.
In-Situ Dual Phase or Multiphase Vacuum Extraction (HVE) **Source Reduction**	(i) Hydrocarbon waste landfill for Shell. (ii) Keighley Gasworks remediation for SPH, Yorkshire. (iii) Cadishead Railhead site for Clariant, Manchester. (iv) Hydrocarbon contamination for Carillion, West Midlands. (v) Hydrocarbon contamination for Mowlem, Salisbury. (vi) Toluene treatment for ASDA Properties, Woking.
Soil Vapour Extraction (SVE) **Source Reduction**	(i) NGT sites, Yorkshire. (ii) Benzene and cumene contamination for BP, Grangemouth. (iii) Styrene contamination for BP, South Wales. (iv) Pinner Gasworks for SPH. (v) Hydrocarbon contamination for Kuwait Petroleum, Handsworth.
LNAPL Recovery (Floating Product) **Source Reduction**	(i) Fuel contamination for BAA, Heathrow. (ii) Hydrocarbon site for Shell, North West England. (iii) Hydrocarbon treatment for BP, South Wales.
DNAPL Treatment **Source Reduction**	(i) Chlorinated solvent contamination for WSP, New Malden. (ii) Creosote treatment for SPH, Musselburgh. (iii) Coal Tar contamination for SPH, Keighley Gasworks, Yorkshire.
Pump and Treat **Source Reduction** **Pathway Interception**	(i) Contamination on a Nuclear site for BNFL. (ii) Chemical contamination for Walters, South Wales. (iii) Shallow groundwater treatment on most sites with excavations and on-site treatment.

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CELTIC's IN HOUSE TECHNOLOGIES (continued)

Technology	Examples
In-situ Bioventing **Source Reduction**	(i) Pinner Gasworks for SPH, Greater London. (ii) Styrene contamination for BP, South Wales. (iii-) National Power site in Liverpool. (iv) Hydrocarbon contamination for Kuwait Petroleum, Handsworth. (v) National Grid Transco sites, Yorkshire
Ex-situ Bioremediation **Source Reduction**	(i) GUV site for Taylor Woodrow, London. (ii) Treatment of refinery sludge for BP, Llandarcy. (iii) Railhead contamination for Clariant, Manchester. (iv) Treatment of soils for Barrats, Southampton. (v) Hydrocarbon terminal for BP, Oxford. (vi) Power station site for National Power, Pembroke. (vii) Power Station for Scottish and Southern Energy, Lerwick, Orkney. (viii) Benzene and cumene contamination for BP, Grangemouth.
Concentrated Waste Treatment **Source Reduction**	(i) Gasworks tar lagoons for Derby CC and EMDA, Derbyshire. (ii) Hydrocarbon contaminated site for BP, Pumpherston, Scotland.
Monitored Natural Attenuation (MNA) **Receptor Protection** **Pathway Interception**	(i) Chlorine solvent landfill, Flitwick. (ii) 30 gasworks for SPH. (iii) Hydrocarbon terminal for BP, Oxford. (iv) National Grid substations, Yorkshire. (v) NGT, Oldbury.
Cover Systems **Pathway Interception**	(i) Cover and interceptor system for Walters, Castlegate. (ii) Colliery and coking works for WDA, Coed Ely. (iii) Stabilisation cover, St Helens.
Lateral Containment **Source Reduction**	(i) LNAPL intercepting hanging wall for Clariant, Manchester. (ii) Piled barrier for Clariant, West Midlands. (iii) Bentonite barrier for Mowlem, Salisbury.
Pre-treatment and Off-site Disposal **Source Reduction**	(i) Mercury contaminated material for BP, South Wales. (ii) Colliery and coking works waste for WDA, Coed Ely. (iii) Gasworks waste for SPH. (iv) London Green Development site. (v) Chlorinated solvent contamination for Merck, East London.

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Case Study Ex`Situ Bioremediation at Dewsbury Gasworks

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PROJECT OVERVIEW

- Client – Clugston /PPG Developments
- Remediation for Industrial Development
- Site – Former Gas Holder Station
- Objectives – Treat 7,146 m3 hydrocarbon contaminated made ground materials to Site Target Values (TPH 2,000 mg/kg, PAH 1,000 mg/kg) for re-use as Engineered Fill
- Remediation Costs £20-£30/m3
- Contract Start – July 2005

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PROGRAMME OF WORKS

- Total Programme Duration of 28 weeks
- Programme split into 2 work phases, each comprising 3 weeks biopile construction, 10 weeks treatment
- Phase 1 Treatable Volume – 2,800 m3
- Phase 2 Treatable Volume – 4,346 m3
- Machinery utilised; Traymaster and Fleece Cover Roller
- Nutrient Additions
  - Soil Conditioner Compost
  - Proprietary Fertilizer

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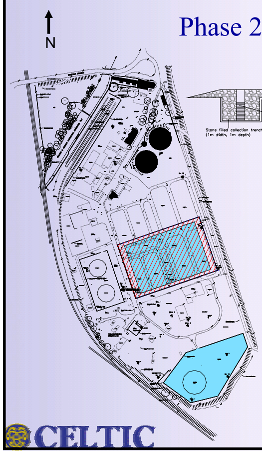
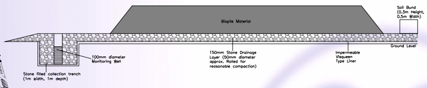
Phase 2 Treatment Area





EA Agreed Requirements:

- Compacted (rolled) area of 10,450 m2
- Area to have 1 in 350 gradient towards trench
- Entire Area to have 300 gauge Visqueen Liner
- Visqueen overlain with 150mm hardcore (6F2)
- Three sides of area to have clay soil bund
- One end to have shallow gravel filled collection trench with monitoring sump
- Monthly sampling regime of captured surface waters for key determinands

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Treatment Area Preparation

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Challenges

PHASE 1 WORKS

- Cohesive material with high number of 'tar balls'
- High Conc of TPH (36, 876 mg/kg C24-C40) and PAH (9,000 mg/kg) in stockpiled material
- Considerable EA Interest in ensuring containment of all surface water run-off

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Construction of Biopile

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Biopile Construction

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Clayey treatment matrix

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Tar Ball

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Dewsbury: Adding Soil Conditioner inoculum

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Dewsbury: Phase 1 treatment Area

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Biopiles with Stockpiled materials

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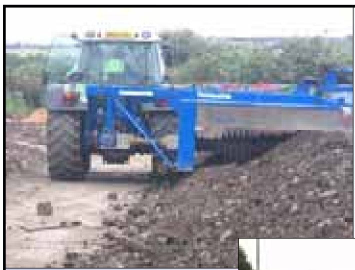

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Monitoring Validation
&

Project Closure

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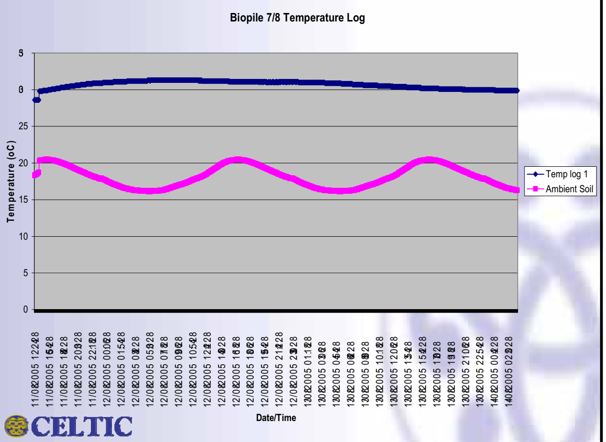

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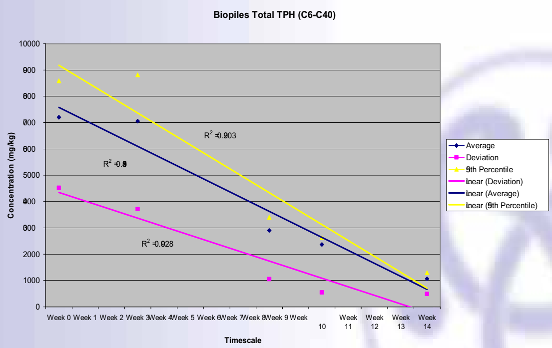

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Lessons Learnt

- Intensive monitoring of biopile temperatures and moisture content during initial 3 weeks of treatment to enhance/monitor optimum degradation
- Turning of biopile base material during weeks 4-6 to allow traymaster treatment of entire biopile
- Varying loading rates of admixtures based on treatment material characteristics
- Cost contingencies in place for longer than anticipated treatment times

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Biographical Note

Professor Paul Younger

Paul Younger is a hydrogeologist and mining environmental engineer with more than 20 years' experience in groundwater engineering, particularly in the remediation of polluted mine waters. He has personally designed some seven full-scale mine water remediation systems, two of them in Wales. Paul has also played a leading role in other mine water management projects in the coalfields and metallic orefields of Wales. Currently HSBC Professor of Environmental Technologies at the University of Newcastle, Paul has published more than 150 papers in the international literature and has acted as principal author / lead editor of 5 books. In addition to his academic duties, he sits on the Boards of Directors of three companies engaged in the environmental consulting, construction dewatering and ground-source heat technology markets. He has coordinated three of the European Commission's most prominent mine water R&D programmes. He currently serves as the principal European representative on the Global Alliance of acid rock drainage abatement organizations, convened by the International Network for Acid Prevention (INAP), a collaborative organization formed by the world's largest mining houses.

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Permeable reactive barriers (PRBs) for the treatment of polluted leachates and groundwaters

Brief overview and example application to coal mine spoil leachate in the UK

Paul L Younger C.Geol. C.Eng.

HSBC professor of Environmental Technologies
Hydrogeochemical Engineering Research and Outreach (HERO)
Institute for Research on Environment & Sustainability
University of Newcastle, UK

Contacts: paul.younger@ncl.ac.uk

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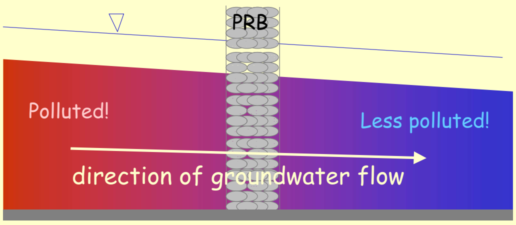
Permeable reactive barriers

The basic concept:



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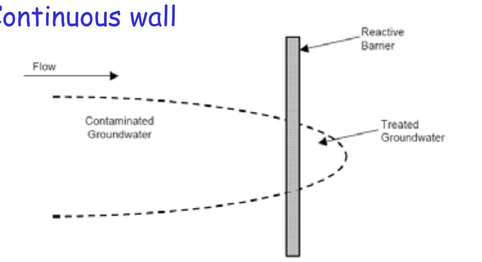
PRB layout variants (plan views)

- Continuous wall



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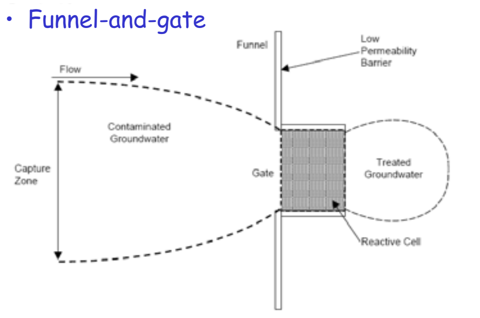
PRB layout variants (plan views – cont.)

- Funnel-and-gate



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Essential ingredients of a PRB

- The substrate:
  - More permeable than surrounding ground
  - Reactive with respect to pollutant(s) of interest
  - Shouldn't release worse pollutants!
- The reactive zone (substrate receptacle):
  - A simple trench (cut and fill) best option
  - Overlapping boreholes (like continuous bored pile wall)
  - Discrete reactant chamber in shaft

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Substrates

- Zero-valent iron (i.e. small fragments of scrap iron) produces highly reducing environment, capable of destroying many organic contaminants
- Sorbents
- Microbial metabolites: case study
- (NB: patents may apply to some or all of these, depending on application)

Passively treating acidic mine leachates: favourable geochemical proceses

- Obvious *inorganic process*: calcite dissolution

  $CaCO_{3(s)} + 2H^+_{(aq)} \leftrightarrow Ca^{2+}_{(aq)} + CO_{2(g)} + H_2O_{(l)}$
- Implemented "stand-alone" in limestone drains etc: limited applicability due to armouring of clasts with hydroxides
- Key *biogeochemical process*: bacterial sulphate reduction (BSR)

  $M^{2+} + SO_4^{2-} + 2CH_2O \leftrightarrow MS + 2H_2O + 2CO_2$

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Suitable substrates …

- Ideal physical properties:
  - permeable enough to permit ready flow of water through pores ($K \geq \sim 1$ m/d)
  - 'handleable' and safe under reasonable loads
- Desired reactive properties:
  - alkaline and promoting anoxia (Eh << 0 mV)
  - not prone to releasing viruses etc
  - suitable carbon source for sulphate-reducing bacteria

Favoured by coarse grain size

Favoured by fine grain size

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Examples: organic fractions of successful reactive substrates


Horse manure and straw, Quaking Houses wetland


Composted municipal waste, Quaking Houses

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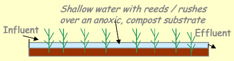
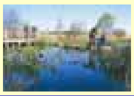
Harnessing BSR - passive system configurations

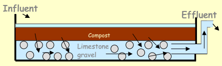
Compost wetlands (mainly surface flow)





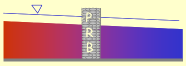
Example: Quaking Houses

Reducing & Alkalinity Producing Systems (RAPS)



Example: Pelenna (South Wales)

Permeable Reactive Barriers (PRBs)



THIS STUDY!

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Shilbottle, Northumberland

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Shilbottle Colliery (Grange Pit)

1926 - 1982

Cooperative Wholesale Society's Grange Pit Shafts at commencement of coaling in 1926

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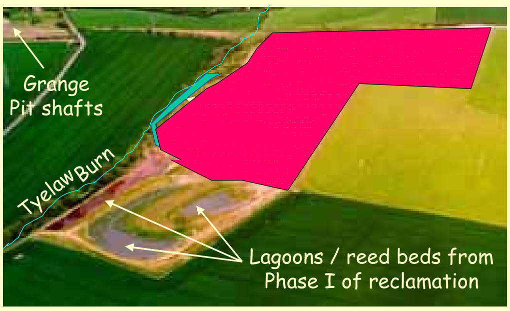
Shilbottle Brass Heap



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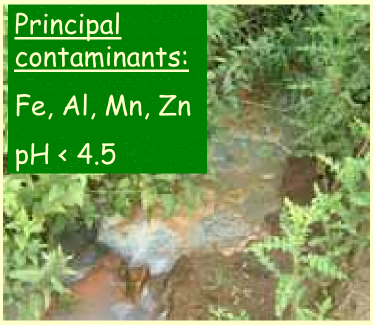
Contamination of the Tyelaw Burn



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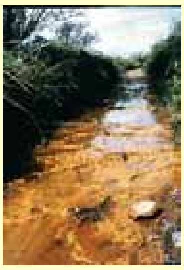
Surface leachate seepages



Brass Heap Leachates

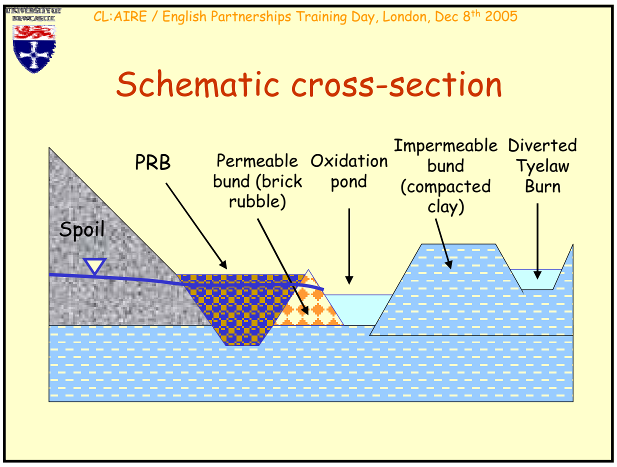
	BH 6	BH 5	BH 4	BH 3	BH 2	BH 1	GW 11	GW 10	GW 9
pH	4.47	3.64	4.00	4.08	4.17	6.32	3.29	3.55	4.17
Acidity (mg/l $CaCO_3$)	742	2048	2557	2908	6342	78	1360	2534	3322
Fe (mg/l)	92	200	405	599	1136	26	278	452	688
Mn (mg/l)	68	108	180	205	299	22	165	181	238
Al (mg/l)	86	267	270	263	678	1.2	97	249	298
SO_4^{2-} (mg/l)	8701	8162	8230	10167	15318	3745	6334	9288	11176

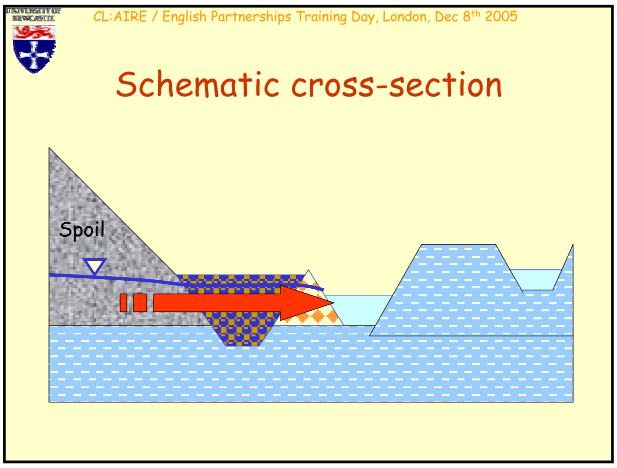
Challenges …

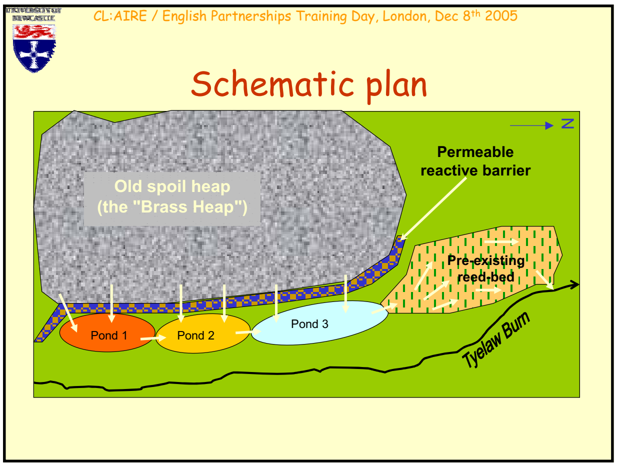
- Extremely polluted spoil leachate – worst yet found in UK
- 65% of leachate entering Tyelaw Burn diffusely through riparian scrub zone
- Very little driving head available on site
- Close proximity to Tyelaw Burn
- Desirability of harmonising remedial actions with previous site reclamation

Design Concept

- Divert Tyelaw Burn to give space for passive treatment system installation
- Install permeable reactive barrier (PRB) to catch all groundwater leaving spoil
- Collect groundwater leaving PRB in oxidation ponds, which drain then into existing reed bed


CL:AIRE / English Partnerships Training Day, London, Dec 8th 2005
Schematic cross-section
PRB
Permeable bund (brick rubble)
Oxidation pond
Impermeable bund (compacted clay)
Diverted Tyelaw Burn
Spoil


CL:AIRE / English Partnerships Training Day, London, Dec 8th 2005
Schematic cross-section
Spoil


CL:AIRE / English Partnerships Training Day, London, Dec 8th 2005
Schematic plan
N
Permeable reactive barrier
Old spoil heap (the "Brass Heap")
Pre-existing reed-bed
Pond 1
Pond 2
Pond 3
Tyelaw Burn

Construction phase
(note installation of "built-in" multi-level piezos in foreground)

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PRB and ponds after first six months

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Seepage face from PRB

Outflow from ponds to wetland

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Reedbed

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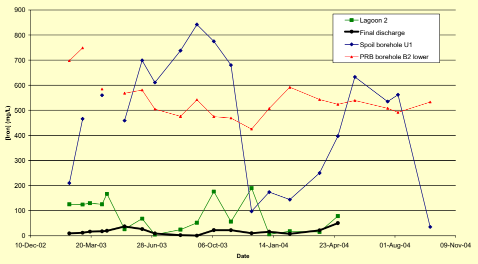
Early performance: "Honeymoon Period"

- Raw leachate:
- pH = 4.0
- Alkalinity = 0
- Total Fe = 500 mg/l
- Total Al = 250 mg/l

- Effluent PRB (pond 3):
- pH = 7.2
- Alkalinity = 136 mg/l as $CaCO_3$
- Total Fe = 3.8 mg/l
- Total Al = 0.3 mg/l

First 2 years performance - Total Fe



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Comments on Fe removal

- Removal of Fe is extremely impressive
- Decrease is from > 800 mg/l in the raw water down to only 10 mg/l at the final outfall to the Tyelaw Burn
- About 50% of Fe removal is as sulphides within PRB, and rest as hydroxides / hydrosysulphates in ponds (25%), and reedbed (25%)
- Compared with the situation before installation of the PRB and ponds, this equates to a net reduction of 98% in release of Fe to the Tyelaw Burn!
- The Burn is now stainless throughout its length

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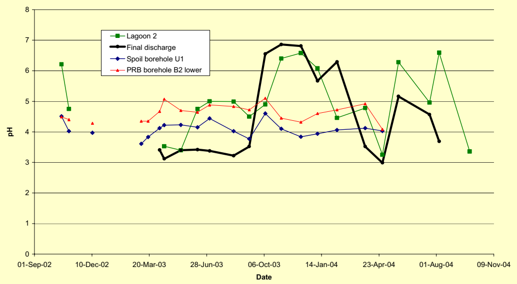
First 2 years performance - pH



Comments on pH changes

- pH rises from 4 to 6 in the PRB
- Given extreme mineral acidity of this water, insufficient alkalinity can be added to completely neutralise the mineral acidity within the PRB itself
- However, this temporary increase in pH speeds up the subsequent precipitation of metals as hydroxides and hydroxysulphates in ponds and reedbed (occurs thousands of times faster at pH 6 than at 4)
- However, as this occurs, the alkalinity provided by the PRB is consumed and pH drops once more
- The irony is that both pH and total acidity decrease in tandem!

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Comments on SO_4 removal

- Shilbottle system is performing better in SO_4 removal than analogous RAPS / compost wetlands elsewhere in the UK and the USA
- The PRB removes about 30% of the sulphate (by reductive precipitation of metal sulphides), while the lagoons and reed-bed together remove a further 20% or so (as hydroxy-sulphate precipitates)
- Final effluent has about half the sulphate content of the raw water; an example of partial 'biodesalination'

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Concluding remarks

- With a capital cost of around €100K, this remediation system represents extremely good value for money
- Operational costs are minimal, and three years after construction only minor further adaptations are envisaged
- Detailed groundwater flow and geochemical modelling is now underway
- Detailed microbiological characterisation is now in advanced stages

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R&D Funding and dissemination

- Shilbottle site has been adopted as CL:AIRE Technology Demonstration Project 13
- Shilbottle is a part of CL:AIRE's 'CoSTaR' national facility for mine site remediation research
- Two PhD studies underway
- EPSRC/BBSRC LINK Biorem 4 project 'ASURE' (£920K) commenced Q1 2003 - involves Scottish Coal, Rio Tinto and IMC Ltd
- CoSTaR ARI funding: EU 6th Framework Programme "Access to Research Infrastructures", commencing May 1st 2004 – please come and do some science in the sunny north-east of England! Contact: costar@ncl.ac.uk

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Guidance on PRB applications

- CL:AIRE TDP1 (Cookstown, NI)
- CL:AIRE TDP13 (Shilbottle) – due early 2006
- Environment Agency 'Guidance on use of permeable reactive barriers for remediating contaminated groundwater' (2002) – free pdf download from EA web-site

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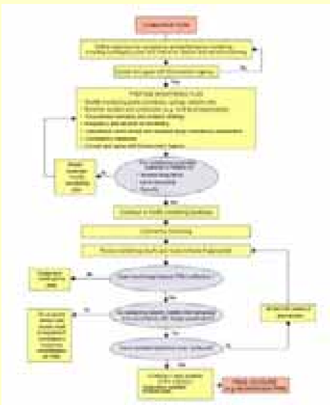
From EA guidance document

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Season's greetings

Biographical Note

Guy Pomphrey

Guy Pomphrey, a Chartered Civil Engineer, is the UK and Ireland Manager of DEC NV - one of Europe's leading Environmental Contractors. The company is specialised in the handling and treatment of contaminated soil and sediments using numerous techniques either on site or at fixed treatment facilities.

For the last 5 years Guy has been establishing the company on the rapidly changing UK and Irish markets. In 2003 DEC completed the remediation of Sir John Rogerson's Quay Gasworks in Dublin which involved the export and treatment of nearly 400,000t of soil using both soil washing and thermal desorption. More recently the company has completed a number of soil washing contracts on former gasworks sites in the UK as well as numerous environmental dredging projects.

CL:AIRE

ENGLISH PARTNERSHIPS

TRAINING DAY

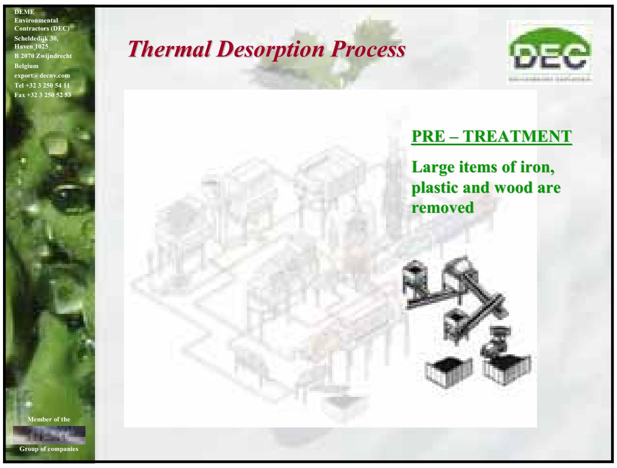
LONDON 8/12/2005

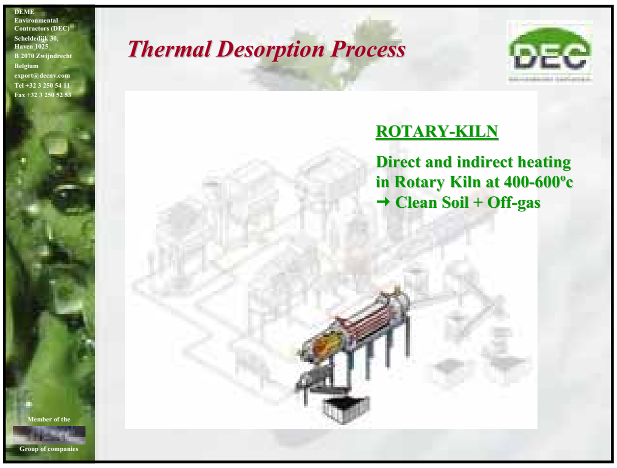
THERMAL DESORPTION

Thermal Desorption Introduction

- Treats soil contaminated with organics
- Will not remove metals, except Hg
- Rotary Kiln at 400-600ºc → Clean Soil + Off-gas
- Off-gas treated in afterburner at 850-1050ºc
- Additional filters/scrubbers as necessary
- Clean gas - CO_2, O_2 and H_2O emitted from stack
- Cleaned soil can be reused – maintains structure

Thermal Desorption Process


DEME
Environmental
Contractors (DEC)
Scheldedijk 30,
Haven 1025
B 2070 Zwijndrecht
Belgium
export@decnv.com
Tel +32 3 250 54 11
Fax +32 3 250 52 53
Thermal Desorption Process
DEC
PRE – TREATMENT
Large items of iron, plastic and wood are removed
Member of the
Group of companies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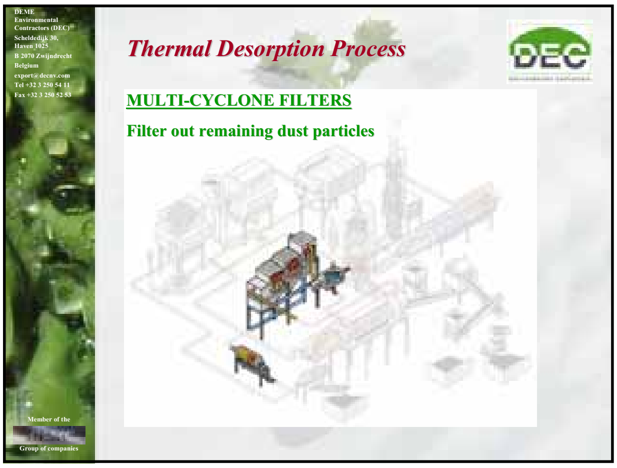
Thermal Desorption Process
DEC
ROTARY-KILN
Direct and indirect heating in Rotary Kiln at 400-600ºc
→ Clean Soil + Off-gas
Member of the
Group of companies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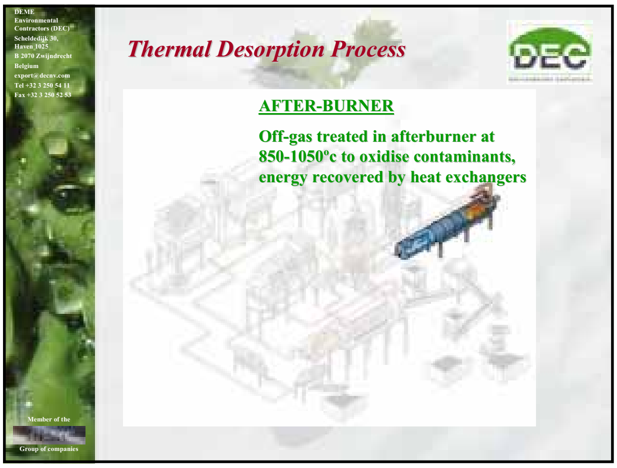
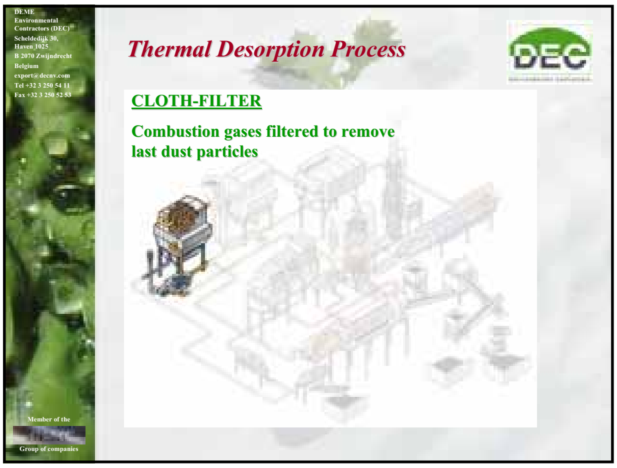
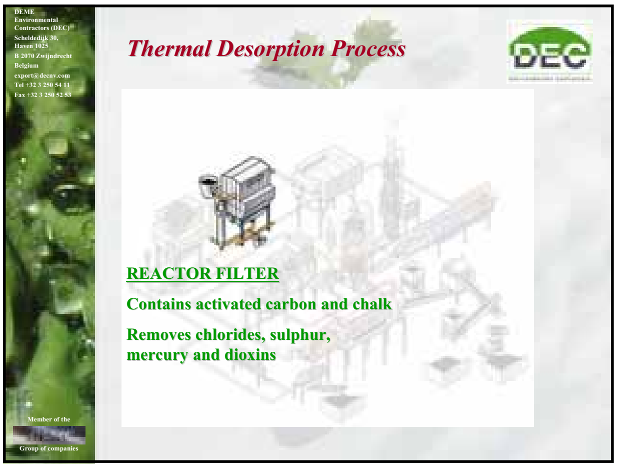
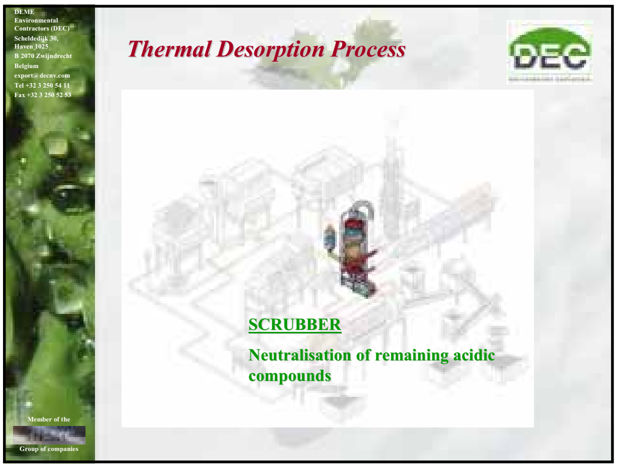
Thermal Desorption Process
DEC
MULTI-CYCLONE FILTERS
Filter out remaining dust particles
Member of the
Group of companies


Thermal Desorption Process
DEC
AFTER-BURNER
Off-gas treated in afterburner at 850-1050°c to oxidise contaminants, energy recovered by heat exchangers
Member of the
Group of companies


Thermal Desorption Process
DEC
CLOTH-FILTER
Combustion gases filtered to remove last dust particles
Member of the
Group of companies


Thermal Desorption Process
DEC
REACTOR FILTER
Contains activated carbon and chalk
Removes chlorides, sulphur, mercury and dioxins
Member of the
Group of companies


Thermal Desorption Process
DEC
ACTIVATED CARBON FILTER
See reactor filter


Thermal Desorption Process
DEC
SCRUBBER
Neutralisation of remaining acidic compounds


Thermal Desorption Process
DEC
STACK
Clean gas - CO2, O2 and H2O emitted from stack
Continuous monitoring

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Thermal Desorption Process

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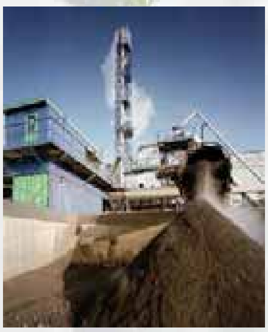
Thermal Desorption



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Thermal Desorption

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Thermal Desorption

Which contaminants are important to determine feasibility and price ?

- ❖Dry matter content
- ❖Organic matter content
- ❖Particle size distribution (% lutum and stones)
- ❖Calorific value
- ❖PAH's, mineral oil, BTEX
- ❖Total cyanides
- ❖Heavy metals including Hg
- ❖EOX
- ❖Total sulphur and sulphates

Thermal Desorption

Air emission limit values

European air emission limit values for the incineration of waste 2000/76/EC

Continuous monitoring for :

- ❖CO
- ❖SO_2
- ❖NO_X
- ❖C_xH_X
- ❖O_2

Thermal Desorption

Air emission limit values

European air emission limit values for the incineration of waste 2000/76/EC

Periodic monitoring for :

- ❖Heavy metals including Hg
- ❖Dioxines and furans
- ❖Cyanides
- ❖HCl, HF
- ❖TOC
- ❖Dust

Thermal Desorption

Air emission limit values

European air emission limit values for the incineration of waste 2000/76/EC

Continuous registration of :

- ❖Temperature in drum
- ❖Temperature in after burner
- ❖O_2 content in after burner
- ❖Temperature and pressure drop at bag house
- ❖Underpressure in installation

Thermal Desorption

Advantages & drawbachs

Advantages

- ❖Fast
- ❖Can handle all organic contaminants
- ❖Can handle all types of soils
- ❖Complete destruction of contaminants
- ❖Can be applied on-site

Drawbacks

- ❖ Limitations in case of heavy metals
- ❖Permit

Thermal Desorption

Cost drivers

Water content : 15 %

❖Energy (2300 to 3000 KJ/ton soil)	10 €/t
❖Labor & maintenance	12 €/t
❖Chemicals	3 €/t
❖Loader	3 €/t
❖Water handling	1 €/t
❖Disposal residue	2 €/t
❖Depreciation & Financing	15 €/t
	46 €/t

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Thermal Desorption

DEC

Case study

Avenue Coking Works

TFS (Transfrontier Shipment)

250 tons of soil / sludge from tar lagoons / waste tip

1 day trial in March 2004, different mixtures

Trial executed to determine :

⇒ Removal efficiencies for contaminants in soils

⇒ Necessary air treatment steps

⇒ Consumables : gas, caustic, activated carbon

⇒ Possible throughput

Thermal Desorption

DEC

Thermal Desorption

DEC

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Removal efficiencies soil loop

Concentration (mg/kg)	Input	Output	Efficiency
Dm in %	68,6	90,5	
Cyanide	1800	17	99,06%
BTEX	600	0,26	99,96%
Benzene	130	0,19	99,85%
Toluene	190	0,07	99,96%
Phenol	760		
PAH (10 VROM)	10000	32	99,68%
Naphtalene	7000	2,6	99,96%
Benzo(a)pyrene	120	2,1	98,25%
EOX	9,2	0,1	98,91%
THP (C10-C40)	8400	80	99,05%

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Thermal Desorption

Conclusions for gas loop

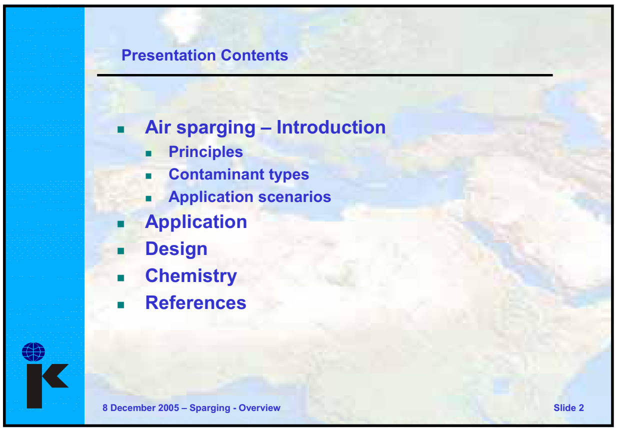
- ❖High capacity after burner
- ❖Wet alhaline scrubber for SO_2 removal
- ❖DENOX for NO_x removal
- ❖Activated carbon for Hg removal

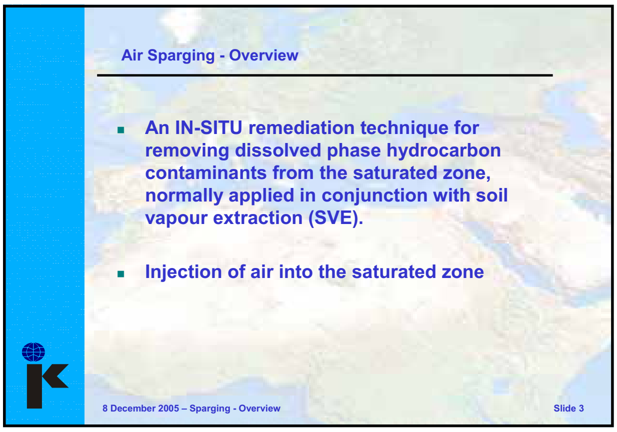
Biographical Note

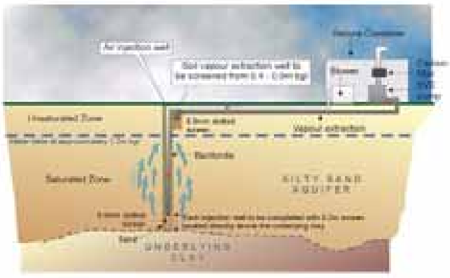
Adrian Shields

Following several years in the oil industry, Adrian joined Komex in 1996 and has spent the last 10 years undertaking a range of environmental projects for clients. His current focus is remediation design and implementation, with particular interest in in-situ techniques. Adrian is currently Office Director for Komex's Bristol office.


Air Sparging – An Overview
Adrian Shields
Technical
Director
Komex Europe
KOMEX
ENVIRONMENT AND WATER RESOURCES


Presentation Contents
Air sparging – Introduction
Principles
Contaminant types
Application scenarios
Application
Design
Chemistry
References
8 December 2005 – Sparging - Overview
Slide 2


Air Sparging - Overview
An IN-SITU remediation technique for removing dissolved phase hydrocarbon contaminants from the saturated zone, normally applied in conjunction with soil vapour extraction (SVE).
Injection of air into the saturated zone
8 December 2005 – Sparging - Overview
Slide 3



Air Sparging - Overview

- **TWO mass removal mechanisms operating:**
  - **Promotes volatilisation**
  - **Enhances aerobic biodegradation**

8 December 2005 – Sparging - Overview   Slide 5

Air Sparging - Mechanisms

- **Volatilisation**
  - **Mass transfer of contaminants from the aqueous phase to the vapour phase.**
    - **Governed by Henry's Law**

8 December 2005 – Sparging - Overview   Slide 6

Air Sparging - Mechanisms

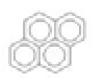
- **Biodegradation**
  - injection of air into the subsurface causing dissolved oxygen concentrations in the groundwater to rise. This can lead to aerobic bioactivity, allowing naturally occurring microorganisms in the soil to respire.

8 December 2005 – Sparging - Overview — Slide 7

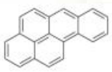
Air Sparging - Mechanisms

- **Biodegradation**

Benzene



Pyrene



Benzo(a)pyrene

Easily biodegradable

↓

Not easily biodegradable

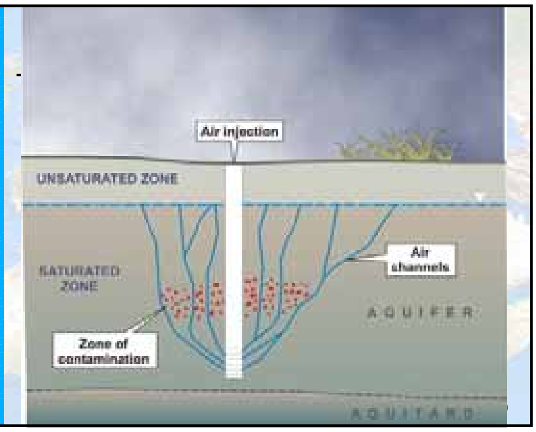
8 December 2005 – Sparging - Overview — Slide 8

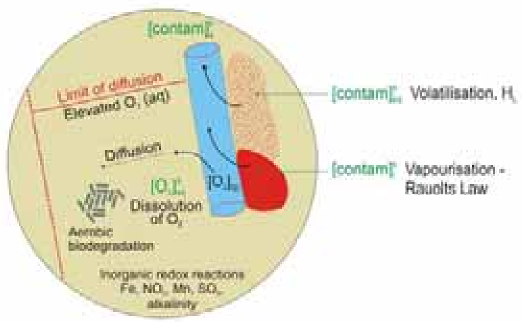
Air Sparging – Suitable contaminants - HYDROCARBONS

Contaminant	Aqueous Solubility (mgL^{-1})	Vapour Pressure (atm)	Henry's Constant (atm m^3 mol^{-1})	stripability	biodegradability
Benzene	1750	0.13	5.6×10^{-3}	High	High
Toluene	535	0.04	6.7×10^{-3}	High	High
Ethylbenzene	152	0.01	6.4×10^{-3}	High	High
Xylenes (mixed)	198	0.01	7.0×10^{-3}	High	High
Trichloroethene	1100	0.08	9.1×10^{-3}	High	High
Vinyl chloride	2670	3.50	8.2×10^{-2}	Medium	Medium
MTBE (methyl-tert butyl ether)	54300	0.26	1.8×10^{-2}	Medium	Medium
Naphthalene	32	3×10^{-4}	1.15×10^{-3}	Medium	Medium
Benzo(a)pyrene	0.001	7×10^{-12}	1.55×10^{-6}	low	Low

Numeric data from Montgomery 1997

8 December 2005 – Sparging - Overview — Slide 9





8 December 2005 – Sparging - Overview Slide 11

Air Sparging – Subsurface Properties

- **Requirements**
  - **Need to maximise the air-water contact area**
    - **This will enhance both volatilisation and biodegradation mechanisms**

8 December 2005 – Sparging - Overview Slide 12

Air Sparging – Theory and Application

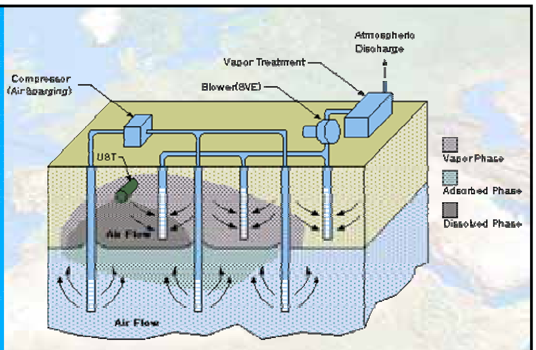
- Suitable ground conditions:
  - Unconfined aquifer
  - Works best with granular matrices (down to very fine sands).
  - Homogeneous media (to get even air distribution)
  - Where access is restricted (eg under live plant, buildings, structures)
  - NOT suitable for low permeability soils (eg clays)
  - NOT suitable in highly heterogeneous soils (eg some made ground)

8 December 2005 – Sparging - Overview   Slide 13

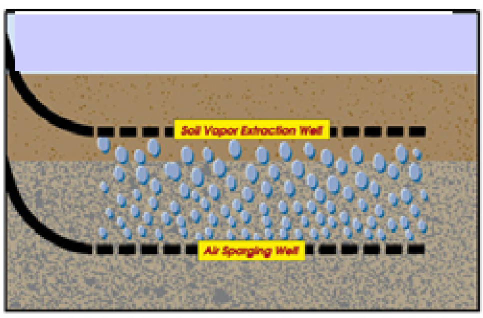
Air Sparging – Theory and Application

- System Design (General)

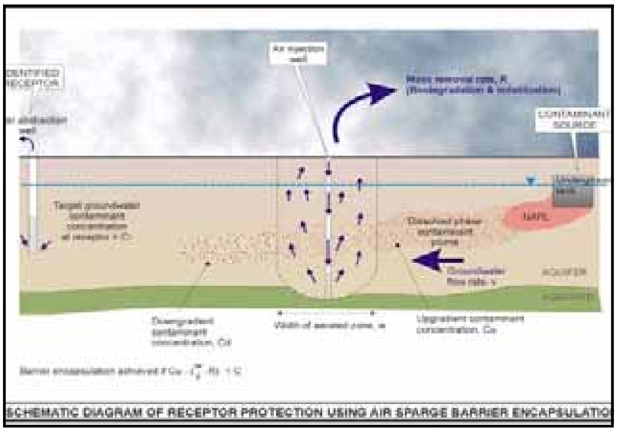
8 December 2005 – Sparging - Overview   Slide 16



8 December 2005 – Sparging - Overview   Slide 17



8 December 2005 – Sparging - Overview   Slide 18


Air injection well
CONTAMINANT SOURCE
NAPL
AQUIFER
Width of aerated zone, w
Upgradient contaminant concentration, Co
SCHEMATIC DIAGRAM OF RECEPTOR PROTECTION USING AIR SPARGE BARRIER ENCAPSULATIO

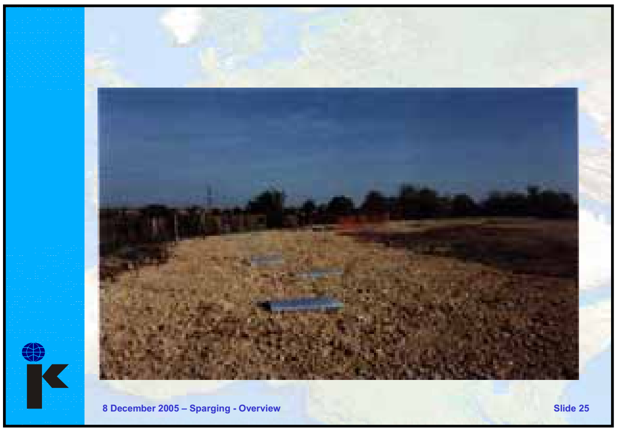

8 December 2005 – Sparging - Overview
Slide 20


8 December 2005 – Sparging - Overview
Slide 21

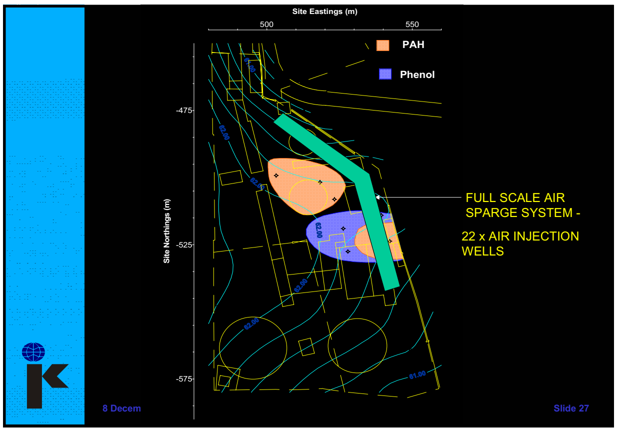

8 December 2005 – Sparging - Overview
Slide 22


8 December 2005 – Sparging - Overview
Slide 23


8 December 2005 – Sparging - Overview
Slide 24


8 December 2005 – Sparging - Overview
Slide 25


8 December 2005 – Sparging - Overview
Slide 26

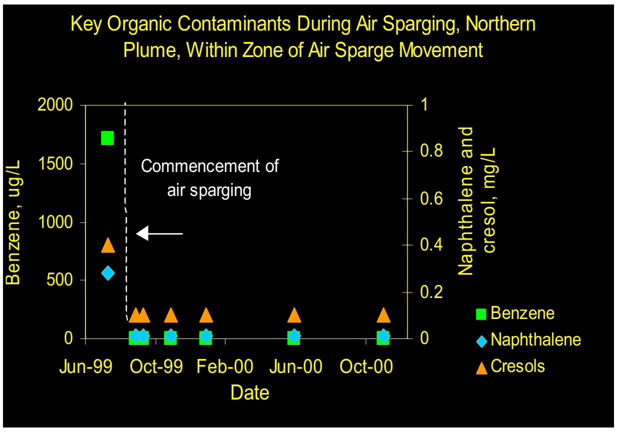

Site Eastings (m)
500
550
PAH
Phenol
-475
-525
-575
Site Northings (m)
FULL SCALE AIR SPARGE SYSTEM -
22 x AIR INJECTION WELLS
8 Decem
Slide 27

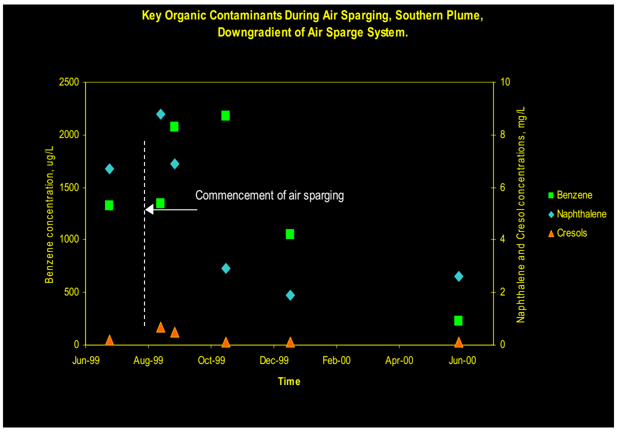
Air Sparging – Timescales

In common with most in-situ techniques…

- **Not instantaneous**
  - If dealing mainly with volatile contaminants (eg benzene), may take months
  - If dealing with biodegradable but less volatile contaminats (eg naphthalene), may take months to years

8 December 2005 – Sparging - Overview   Slide 28





Air Sparging – Chemistry considerations

- Air sparging may promote oxidation of inorganic species (any oxidation technique will do this)
  - Eg oxidation of iron and manganese
  - Potentially leading to precipitates
  - Same process as acid mine drainage – AMD

$$Fe^{2+}_{(aq)} + H_2O_{(l)} + 0.5O_{2(aq)} = \underset{\text{precipitate}}{Fe^{III}O(OH)_{(s)}} + H^+_{(aq)}$$

- Sparging tends to suffer less from inorganic fouling than more passive oxidation techniques

8 December 2005 – Sparging - Overview — Slide 31

When doe Air Sparging win?

- 2 mass removal mechanisms – can be very efficient across a wide range of organic contaminants
- No special chemicals, therefore O&M costs tend to be low
- Hence once installed, ongoing costs need only cover monitoring and maintenance
- Footprint of surface equipment is small – can be applied around existing buildings and infrastructure
- No excavation / disposal
- Covered under Mobile Plant Licensing
- Simple to install, not much to go wrong

8 December 2005 – Sparging - Overview — Slide 32

Air Sparging – Guidance

- EA (UK) website – limited resource
- www.clu-in.org
- USEPA website – major resource
  - http://www.epa.gov/swerust1/cat/asrefbib.asc
- CL:AIRE TDP9 Air Sparge Curtain
  - http://www.claire.co.uk

Bibliography:

Freeze & Cherry (1979) Groundwater. *Prentice Hall, New Jersey USA*

Wiedemeier et al (1999) Natural Attenuation of Fuels and Chlorinated Solvents in the Subsurface. *John Wiley & Sons, New York, USA*

Chappelle (2001). Ground-Water Microbiology and Geochemistry. *John Wiley & Sons, New York, USA*

8 December 2005 – Sparging - Overview — Slide 33


Air Sparging
Thank you
8 December 2005 – Sparging - Overview
Slide 34

Biographical Note

Guy Pomphrey

Guy Pomphrey, a Chartered Civil Engineer, is the UK and Ireland Manager of DEC NV - one of Europe's leading Environmental Contractors. The company is specialised in the handling and treatment of contaminated soil and sediments using numerous techniques either on site or at fixed treatment facilities.

For the last 5 years Guy has been establishing the company on the rapidly changing UK and Irish markets. In 2003 DEC completed the remediation of Sir John Rogerson's Quay Gasworks in Dublin which involved the export and treatment of nearly 400,000t of soil using both soil washing and thermal desorption. More recently the company has completed a number of soil washing contracts on former gasworks sites in the UK as well as numerous environmental dredging projects.

CL:AIRE

ENGLISH PARTNERSHIPS

TRAINING DAY

LONDON 8/12/2005

SOIL WASHING

What is Soil Washing ?

- Physico-chemical soil washing is a wet extraction process for separating contaminants (essentially bound to the clay-fraction) from the potentially recoverable sand- and gravel-fraction.
- Pollutants in the input material are separated and transferred from the sand and gravel fractions to a filter-cake residue; thereby facilitating the recovery of granular materials suitable for re-use on-site.

What is Soil Washing ?

- Minimizes the volume of contaminated material needing to be landfilled.
- Essentially, processes encompasses a series of separation techniques, based on the principles of :
  - ✓ Separation based on particle size.
  - ✓ Separation based on density.
  - ✓ Separation based on ferromagnetic properties.
  - ✓ Separation based on adsorption behaviour.
  - ✓ Separation based on dissolution.

Soil Washing

Soil Washing Techniques

- ❖ Wet-Screening
- ❖ Hydrocyclones
- ❖ Upstream Classification
- ❖ Spiral-Separators – media shape separator
- ❖ Gravel-washing
- ❖ Counter-current classifiers
- ❖ Attrition Scrubbing
- ❖ Flotation Tanks
- ❖ Settling Tank
- ❖ Belt-press
- ❖ Water Treatment

Soil Washing Techniques

Wet-Screening

- ❖ Encompasses two differently sized screens on top of each other which vibrate; water jets are positioned on both decks to provide washing and to promote disturbance of the material. This stage aims to separate the sand/silt/clay fractions from the gravels. Larger gravels (>4mm) pass through the upper-deck cleaning stage, whilst within the lower-deck the smaller gravel (2-4mm) is washed/separated. Both leave this stage together.

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Hydrocylones

- Density separation technique
- Separates sand (underflow) from the fine-fraction (overflow, including water)
- Through control of the vacuum of the hydrocyclone the "cut-off" point can be altered to increase for example the amount of sand and water exiting with the fine-fraction in the overflow. This for example would decrease the wetness of the sand output, whilst also increasing the quality of the filter-cake. It must be noted, excessive sand will result in flocculation destabilization.

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Soil Washing

Froth-Flotation Tanks

❖ Flotation systems separate hydrophobic particulates from hydrophilic particulates by passing fine air bubbles up through a solid-liquid mixture. The fine bubbles attach to and lift or float the hydrophobic particles up where they are collected.

Scrubbing-Attrition Tanks

❖ Promotes additional attrition of the gravels assisting the removal of contaminants.

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Soil Washing

Up-Stream Classification

❖ Exploits the density of material to separate them, through a injection of water from the base causing lighter material to rise and leave as overflow (i.e. organics) whilst heavy material falling to bottom and exiting via outlet at base (i.e. sand).

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Gravel-Washing
Several Different types of gravel-washer
(1) Rotating Cylinder Drum
(2) "Sword-Washer"
DEC


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Soil Washing
DEC
Settling - Tank


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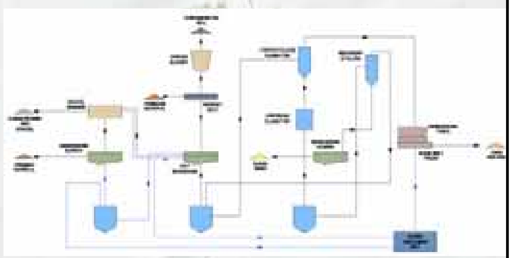
Filter Belt-Press

Mobile Soil Washing Plant

Former Gasworks, High Wycombe, UK
April-August 2005
Treatment of 6500 m^3 of material

Former Gasworks, Carlisle, UK
August – October 2005
Treatment of 5500 m^3 of material

Current Set-Up of Mobile Installation



Feasibility Tests

- For each material to treat DEC carries out laboratory-scaled feasibility tests on representative samples. From these tests the removal efficiencies for the various contaminants are determined, together with the amount of recoverable and residue fractions.
- In general lab tests are sufficient to determine the operational parameters of the required soil washing process, allowing the ease with which the material may be separated to be determined along with the correct polymer type, set-up and dosage to be ascertained.

Soil Washing

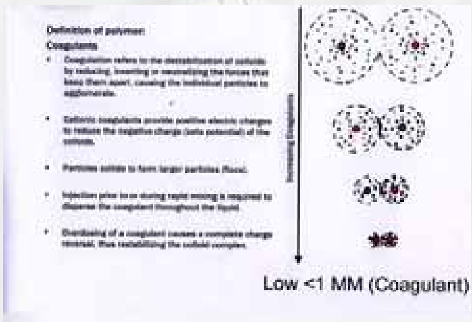
Aspects to consider when assessing the treatability of a material:

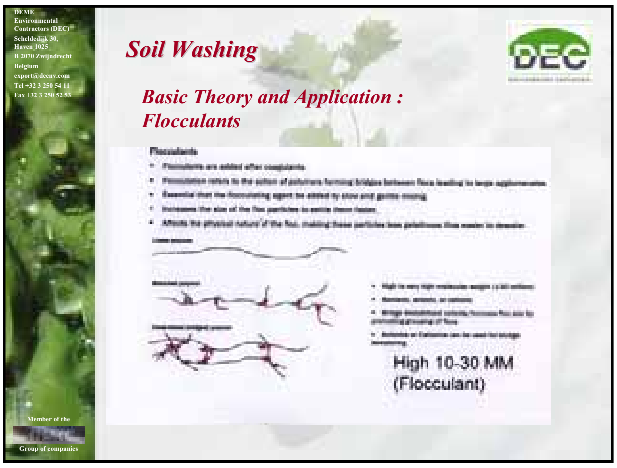
- Ease with which the fractions may be separated
- Contribution of fine-fraction and organics/waste foreign material (plastics, scrap metal etc.)
- Extent of tar/oil content
- Recoverable quantities – economically viable?
- Polymerization: flocculation/settling rate/overall strength for pressing.
- Contaminant Efficiencies and Separation with Fractions

Soil Washing

Soil Washing

Basic Theory and Application : Coagulants




Soil Washing
Basic Theory and Application :
Flocculants
High 10-30 MM
(Flocculant)

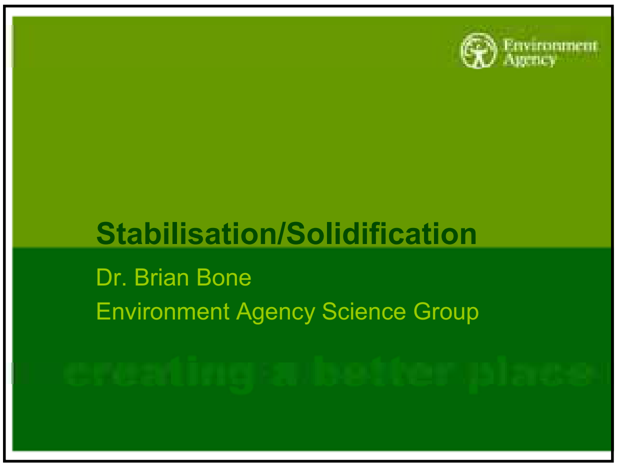

Soil Washing
Polymers

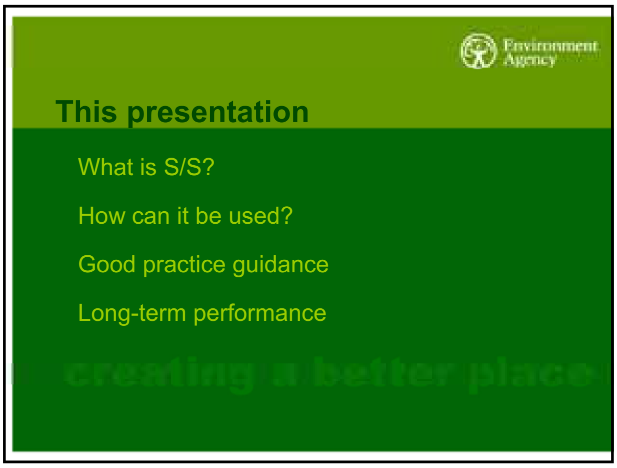

Case Studies: Treatable Materials
A
B

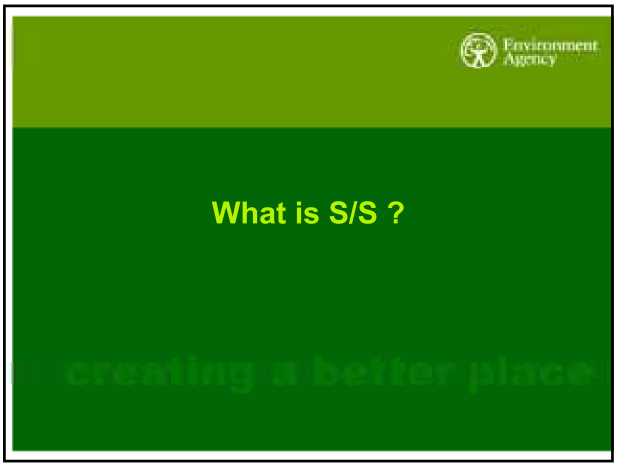
Biographical Note

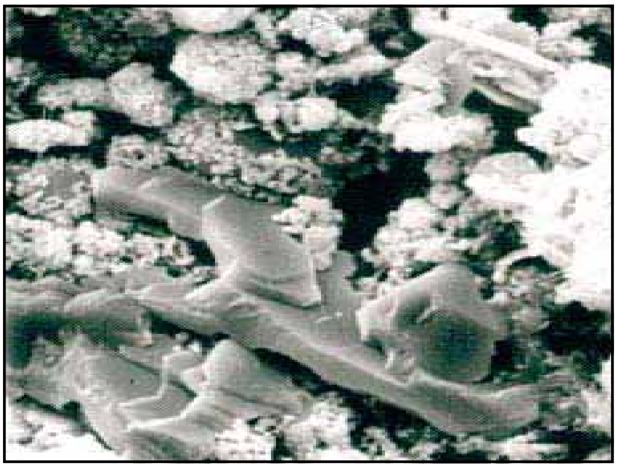
Dr Brian Bone

Brian worked for the British Geological Survey as a geotechnical geologist between 1989 and 1991. In 1991, he joined Warwickshire County Council as landfill gas control engineer and waste regulator before joining the Environment Agency in 1996. He worked as an Area waste technical specialist and led a team with responsibility for providing technical advice on landfill, contaminated land and special waste until 2000. Brian is now a Principal Scientist in the Environment Agency Science Group and leads a small team that specialises in land contamination site investigation and remediation research. His current focus includes permeable reactive barriers and stabilisation/solidification technologies, with a growing interest in the application of nanotechnology to remediation.


Environment Agency
Stabilisation/Solidification
Dr. Brian Bone
Environment Agency Science Group
creating a better place


Environment Agency
This presentation
What is S/S?
How can it be used?
Good practice guidance
Long-term performance
creating a better place


Environment Agency
What is S/S ?
creating a better place



Environment Agency

Type of contaminants

- Heavy metals
- Radioactive materials
- Asbestos
- Inorganic corrosives
- Inorganic cyanides
- TPH
- PAH
- PCB
- Dioxins/furans
- Halogenated HC
- Phenols

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Environment Agency

Application of S/S ….

creating a better place

Pros and cons

Pros	Cons

Pros

- Quick
- Footprint
- Flexible
- Difficult contaminants
- Geotechnical

Cons

- No destruction or removal
- Volume increase
- Use of natural resources
- Long-term performance

creating a better place

Environment Agency

Good practice guidance ….

creating a better place

Environment Agency

Need for guidance

- Established technology elsewhere, but relatively poor uptake in UK
- High profile failure in 1980s-90s
- Uncertainty over long-term performance

Confidence in S/S technologies

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Environment Agency

Good practice guidance

- Is S/S feasible?
- What binder should be used?
- How to apply?
- What construction issues?
- Sampling and testing needs?
- Long-term performance?

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Environment Agency

Where can you find it?

- Output from Codes and Standards for Stabilisation and Solidification Technologies initiative
- Comprehensive review of S/S science
- Available from Environment Agency publications catalogue

(About Us - Publications - follow links through to catalogue - search on stabilisation)

Environment Agency

Long-term performance ….

creating a better place

Environment Agency

Passify …

- UK/USA/France collaboration
- Performance of S/S treated soil and waste
- 5 contaminated land sites in USA
- 2 contaminated land sites in UK
- 1 re-use of treated dredgings in UK
- 2 landfilled treated wastes in France

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Environment Agency
And to conclude ….
creating a better place


Environment Agency
Treatability studies
Range of plant and equipment
Range of contaminants
Long-term performance
Monitoring and maintenance
creating a better place


Environment Agency
Any questions?
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creating a better place

Biographical Note

David Edwards

David is a Project Manager with more than 30 years of construction experience, more than 25 years of industrial reconstruction and recycling experience, and more than 20 years of international trading experience. He is a Corporate Member of the Institution of Civil Engineering Surveyors and a Member of the Association of Geotechnical and Geoenvironmental Specialists.

Currently, David is the International Project Director of CL:AIRE and a freelance consultant, specialising in innovative solutions to brownfield redevelopment problems.

CLUSTER

"What does CLUSTER mean?"

David Edwards, CL:AIRE

CL:AIRE/EP Workshop, London, December 8th 2005

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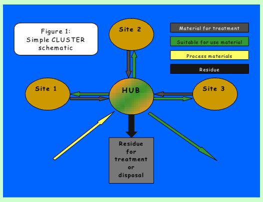
EU Sustainable Development Strategy 2005

Priorities –

- ***Energy use, generation, management***
- ***Non renewable resource consumption***
- ***Impacts of actions***



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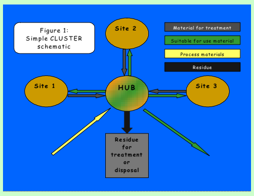
UK Waste Strategy principles 2000
(Waste Framework Directive Article 3)

- ***Self sufficiency***
  - *Waste should be treated within the region in which it is produced.*
- ***The waste hierarchy***
  - *Reduction*
  - *Re-use*
  - *Recycling, composting or energy production*
- ***The proximity principle***
  - *Waste should be managed as near as possible to its place of production, mainly because transporting waste has a significant environmental impact.*



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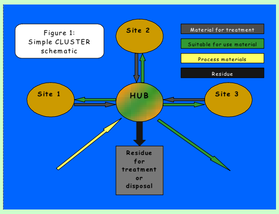
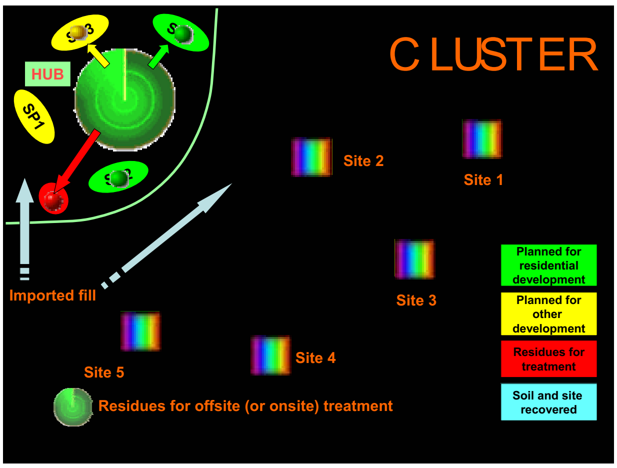
EU Environmental Technology Action Plan 2005

Three questions –
- ***Will it work?***
- ***Will we be able to afford it?***
- ***Will we be allowed to use it?***

?





CLUSTER

What is the potential of CLUSTER?

	EU Sustainable Development Strategy			UK Waste Strategy			Environmental Technologies Action Plan		
	Energy	Impact	Natural resources	Self sufficiency	Waste hierarchy	Proximity	Technical reliability	Economic efficiency	Regulatory Acceptability
Single (small) site	⌛	⌛	⌛	⌛	⌛	⌛	⌛	⌛	🗐
CLUSTER	🗐	🗐	🗐	🗐	🗐	🗐	🗐	🗐	?

CLUSTER would satisfy all priority aspects.

CLUSTER

Other projects – 1 – Glacier A.R.M

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Other projects – 1 – GLACIER A.R.M

Industrial waste as feedstock for cement manufacture									
	Energy	Impact	Natural resources	Self sufficiency	Waste hierarchy	Proximity	Technical reliability	Economic efficiency	Regulatory Acceptability
Portland cement	🗐	🗐	🗐	🗐	⌛	🗐	🗐	🗐	🗐

GLACIER is a disposal operation that makes cement.

Licensed as a disposal operation from waste source to cement kiln

CLUSTER

Other projects – 2 - MARS

CLUSTER

Other projects – 1 - MARS

Manufactured Aggregates for Reclamation Sites

	Energy	Impact	Natural resources	Self sufficiency	Waste hierarchy	Proximity	Technical reliability	Economic efficiency	Regulatory Acceptability
Lightweight aggregates to BS EN 772									

MARS relies on an industrially acceptable exemption.

Exemption 13.1
Waste Management
Licensing Regulations
1994

CLUSTER

When does waste become recovered & how?

	GLACIER A.R.M	MARS	CLUSTER
Source to process	Waste	Waste	Waste
Store pre-process	Waste	Waste	Waste
Execute process			Waste
Store post-process			Waste
Relocat	Waste	Waste	Waste
Store post-re	Waste	Exemption	Waste
Re-process into product	Waste	Exemption	Waste
Commercial utility	Cement	Blocks	*Fit for use soil*

Deposition in stockpile

Compaction at final location

Combustion & grinding

Is this efficient, is it economic,
Is it rational, is it sustainable?

CLUSTER

When might the waste be recovered?

Deposition in stockpile at block production plant

Fixed procedure

		MARS	CLUSTER
Source to process		Waste	Waste
Store pre-process	Waste	Exemption	Waste
Execute process	Waste	Exemption	Waste
Store post-process	Waste	Exemption	Waste
Relocat	Waste	Exemption	Waste
Store post-re	Waste	Exemption	Waste
Re-process into product	Waste	Exemption	Waste
Commercial utility	Cement	Blocks	*Fit for use soil*

Waste processed as part of the product manufacturing process

CLUSTER

A more efficient CLUSTER regime

Process soil to comply with defined quality criteria

	GLACIER A.R.M		CLUSTER
Source to process	Waste		Waste
Store pre-process	Waste		Waste
Execute process	Waste	Exemption	Waste
Store post-process	Waste	Exemption	*Fit for use soil*
Relocate	Waste	Exemption	*Fit for use soil*
Store post-relocation	Waste	Exemption	*Fit for use soil*
Re-process into product	Waste	Exemption	*Fit for use soil*
Commercial utility	Cement	Blocks	*Fit for use soil*

How can CLUSTER be managed to enable this step change?

CLUSTER

ODPM workshop - creative focus

Relevance of CLUSTER to National Brownfield Strategy	Jill Trendler
A real CLUSTER	Steve Wallace
The issues	Judith Lowe
Appropriate regulation	Ged Duckworth
Managing liabilities	David Brierley
Quality protocols	Murray Reid
Breakout 1 - Policy and regulatory solutions	Delegates
Breakout 2 - Technical and perception solutions	
Breakout 3 - Management and commercial solutions	

How should CLUSTER be enabled to satisfy all parties?

CLUSTER

WORKSHOP RESULTS Oct 2005

Breakout 1 - Policy and regulatory solutions Recommendations for CL:AIRE action	
1	Disseminate the outcome of Defra and EA work on the application of the definition of waste to management and treatment of soils and other materials
2	Contribute to the development of the Thematic Strategy for Waste Soil
3	Encourage the development of protocols for identification of substances for testing, sampling and analysis
4	Help to broker linkages and understanding of soil treatment requirements within the planning framework – particularly in regional planning for facilities but also at a site-specific level.

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WORKSHOP RESULTS Oct 2005

Breakout 2 – Technical and perception issues Recommendations for CL:AIRE action	
1	Develop specifications, process controls, checklists and QA for input data, building on the extensive work in similar areas already done by a number of organisations.
2	Contribute to the development of technical competencies for management and operation of a CLUSTER, eg by ensuring that relevant stakeholders respond to Defra's proposals for future development of the WAMITAB system
3	Encourage dissemination of work on perception of waste treatment facilities and on risk communication, including eg work in SUBRIM and case studies of good practice in regional minerals and waste planning.

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WORKSHOP RESULTS Oct 2005

Breakout3 – Management and commercial issues Recommendations for CL:AIRE action	
1	Support a specific CLUSTER project
2	Further develop and disseminate contractual models, particularly those that address multiple land use and multiple site owner scenarios
3	Host a further workshop to promote and continue development of CLUSTER solutions
4	Promote research into the environmental benefits of the CLUSTER approach, drawing on other approaches to assessing the sustainability of particular activities

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Next steps

1	**Technical meeting December 2005 to address the workshop recommendations and produce an Action Plan**
2	**Dissemination of the Action Plan to potential funders**
3	**Subject to funding, the Action Plan will be instigated.**
4	**Assembly of a CLUSTER of sites**
5	**Monitoring of CLUSTER performance – economic, social, environmental, including energy, impact and non-renewable resource use issues**