Inaugural Sustainability Meeting

18th June 2007

Law Society, Chancery Lane, London

SuRF

SUSTAINABLE REMEDIATION FORUM UK

CL:AIRE

CONTAMINATED LAND: APPLICATIONS IN REAL ENVIRONMENTS

www.claire.co.uk/projectsandsites/surfuk

INAUGURAL SUSTAINABILITY MEETING

AGENDA

18 June 2007

9:30 – 10:00 Refreshments

10:00 – 10:30 Introductions and welcome
Who is present, their objectives for the day, overview of the day by the Chair.

10:30 – 10:45 The context
How can remediation take its own account of climate impact – Jane Forshaw

10:45 - 11:30 Our success criteria
Small group work to agree two /three success criteria for judging sustainability in remediation with a plenary to share, compare and prioritise to agree four or five.

11:30 – 11:45 Refreshments

11:45 – 13:00 Presentations of examples of developing good practice

- Regulator Perspective – Brian Bone, Environment Agency
- European Perspective - Innovation, Policy and Costs for Remediation - Hans Vanduijne, TNO
- Industry Perspective, National Grid's Sustainability Calculator – Frank Evans, National Grid
- US Perspective, US SURF & Duponts sustainability estimation tool – David Ellis, Dupont
- USEPA Pilot Trials – Deborah Goldblum, USEPA
- R & D Sustainability Accounting Tool – Philippa Scott, Shell & Stuart Arch, WorleyParsons Komex

13:00 – 13:45 Lunch

13:45 – 14:10 Risks and Opportunities 'walk'

14:10 - 15:00 How do we organise for success?
Further group work to explore what is required to achieve the success criteria – what needs to be done, who needs to do it and by when

15:00 – 15:15 Refreshments

15:15 – 16:00 Final plenary
Whole group to consider overarching

16:00 – 16:30 Next steps and close

CL:AIRE
CONTAMINATED LAND: APPLICATIONS IN REAL ENVIRONMENTS

Environment Agency

Sustainable remediation - a regulator's perspective

Brian Bone - Principal Scientist (Remediation)

Two words - first word

- Sustainable
  - Context?
  - For/to whom?
  - How to measure - generic or specific?
  - Timescale?
  - Learning process - monitoring?

Second word

- Remediation
  - Technology
    - Generic indicators
    - Performance,carbon, energy, waste/resource
  - Strategy?
    - Indicators?
    - Carbon, energy, waste/resource
  - Timescale (durability)

Decision support

- Current/previous initiatives (knowledge & tools)
  - SUBR:IM
  - SNOWMAN
  - EURODEMO
  - Others
- Scale/detail required
  - Single small site
  - Major industrial complex
  - Urban river basin

Environment Agency

My perception of needs

- Multi-level (tiered)
  - Data sheet to expert system
- Key indicators
  - One Planet Living
  - Directives (water & soil frameworks)
  - Waste/resource streams (incl. emissions)
  - Cost benefit
  - Timescale
  - People
- Feedback loop

Environment Agency

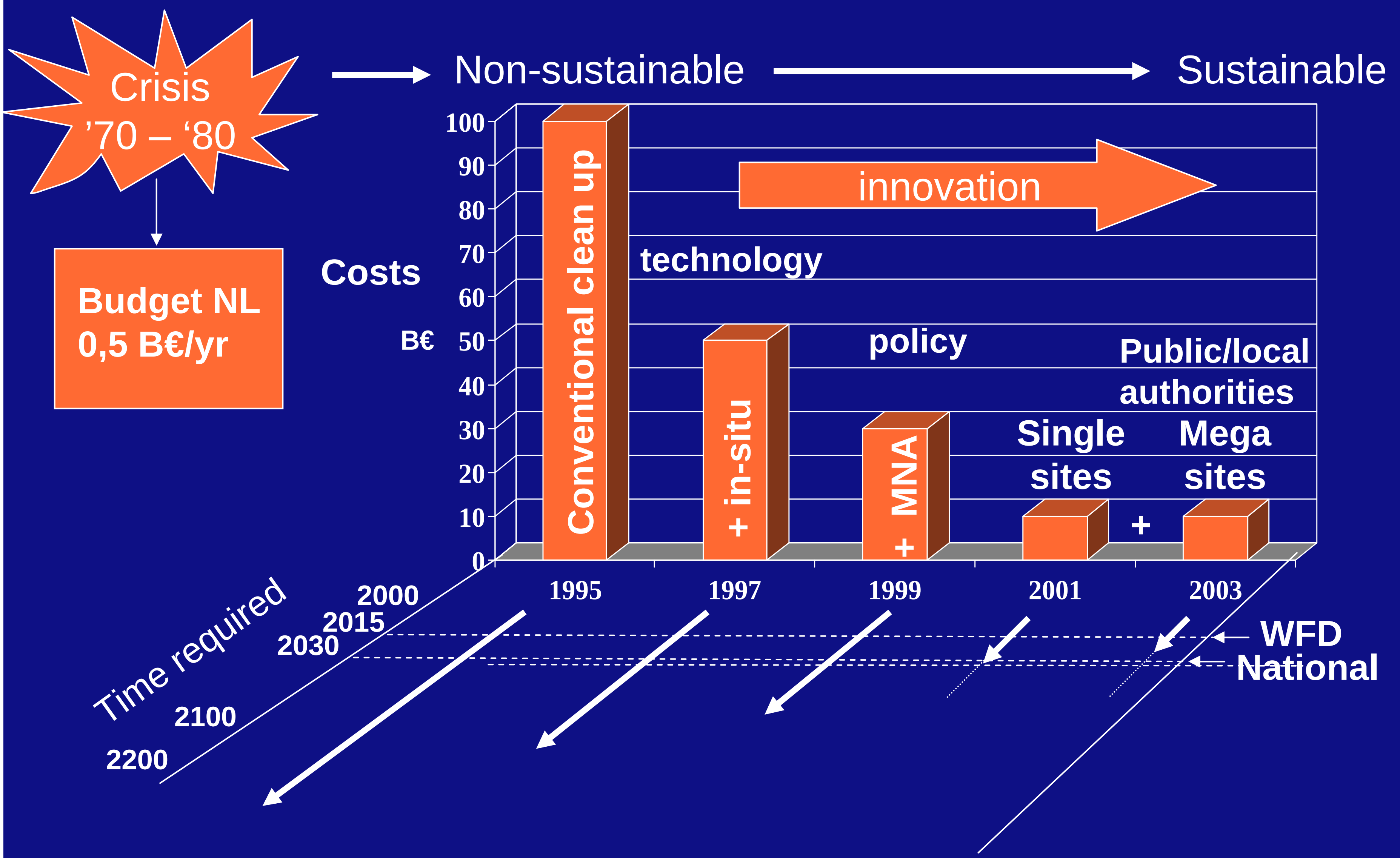
Innovation, policy and costs for soil remediation

TNO | Knowledge for business

Research centre on soil and water quality management

Meeting at CL:AIRE, 18th June 2007

Innovation, policy and costs for remediation

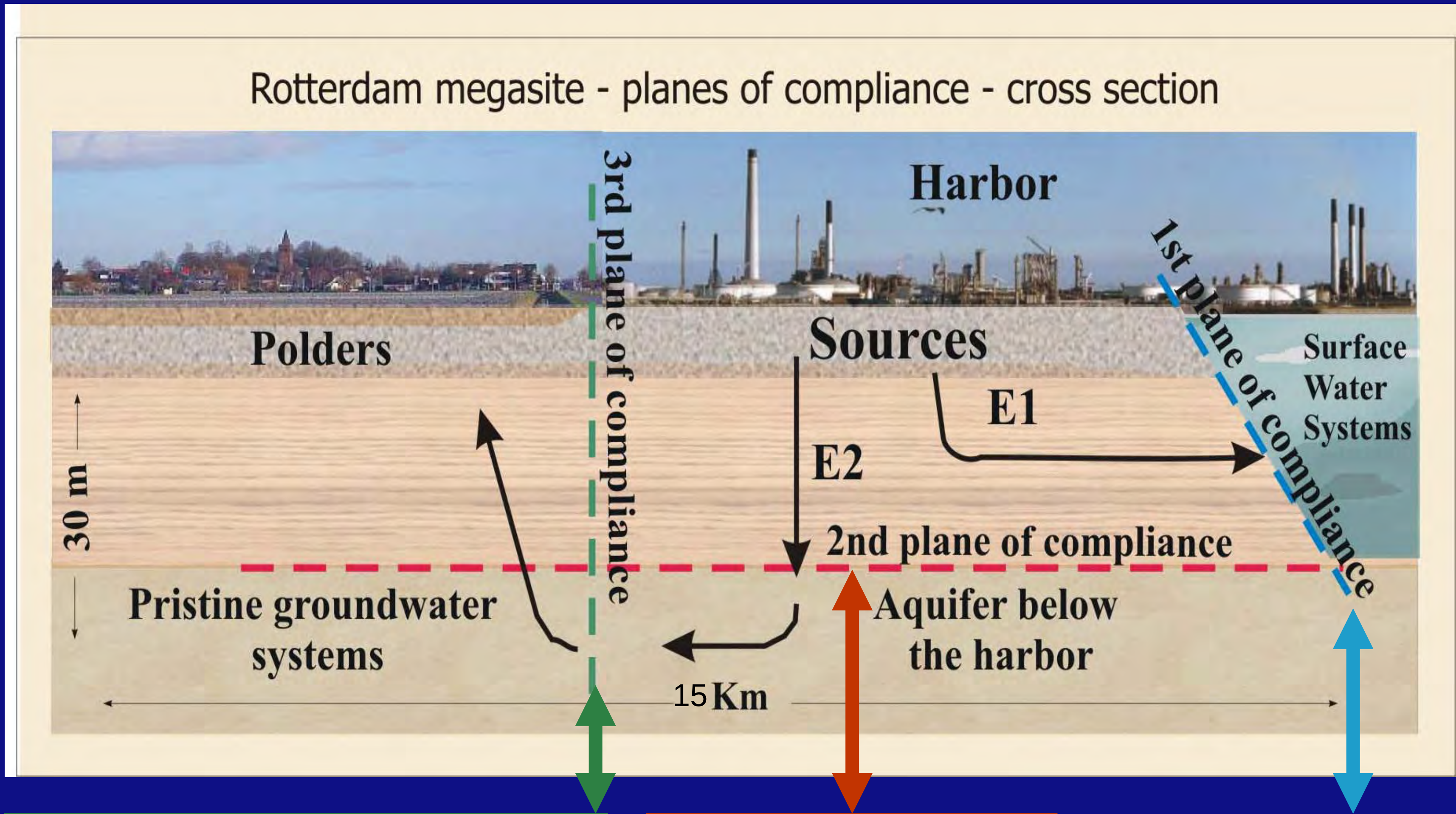


Innovation

- Technology
  - Use “natural” cost-effective technologies:
    - MNA
    - in situ biotechnology
  - Split in source and plume management
  - Coherent remediation concept approach

- Policy
  - 1987: normative legislation
  - 2006: risk-based ”system-oriented” legislation added (stable end-situation, groundwater plume management in line with GWD)
  - Near future: integrated remediation and management programmes:
    - Megasites (Kempen, Rotterdam Harbour, …………)
    - Clusterized approaches (dry cleaning sector, metal industry, etc…)

Result regional risk assessment Rotterdam Harbour



Possible Significant Effects on GWQ; time frame, 2020-2060. Contribution NA??

Significant Effects on GWQ; time frame, 2005-2040

No significant Effects on SWQ

Lack of confidence in-situ remediation technologies

- Relatively small; site remediation is still too a large extend based on use of non-sustainable and too expensive technologies
- Local authorities and (small) company site owners feel uncertain about in situ and MNA technology
- Service providers do not always contribute to take these feelings away
- To break the chain, a new innovation programme is initiated: “On the job learn-and-experience programme for local authorities and site owners with respect to sustainable site remediation”.
- Holland In-situ Program (HIP):
  - 24 pilots using In Situ Technologies and MNA
  - Support on working processes (interactions between site owner-consultant-contractor-local authority-regulating authority)

Why Holland In-situ Program (HIP)?

Growing attention in (sub-)urban brownfields to:

- Provide building space in a densely populated area
- 600.000 contaminated sites, 90% in urban environment

- Ministry of Environment adjusted its policy for the soil remediation plan until 2030
  - Adopting risk based approach: only the “immediate risk” sites to be remediated
  - Risk driven clean-up plan:
    - 15.000 high priority risk sites, in 10 years
    - 60.000 risk carrying sites, in 30 years
  - Shallow contamination needs to be remediated;
    - Targets made flexible (land use, costs and risks)
    - Industrial sector oriented programs
    - From 900 to 2000 sites/yr remediated

HIP setting

Bottlenecks applying in-situ techniques

- In-situ techniques not fully matured
- In-situ techniques insufficiently demonstrated in back yard
- No standardized approach to remediate common situations

- Mind set of competent authority/regulators lacks confidence in in-situ techniques:
  - “Outcome uncertain and risks difficult to manage”
  - Insufficient flexibility to deal with risks and uncertainties
  - Processes (authorisations etc.) with soil remediation too complex (many stakeholders, red tape)
  - Lack of knowledge and experience at daily practice level

What is HIP?

- Duration 3 years, 24 in-situ pilots, 5 pilots have started
- 10 contracting firms with financial contribution
- Biological-, physical-, and chemical technologies and combinations
- Development of standardized in-situ technologies for situations with a high occurence (a high repetition factor, low costs, good market position)

Towards standardized reliable and accepted in-situ technologies: the “Holland In Situ Demo” project (HIP).

Site Characteristics		Occurrence (% of total)
Contaminant type (C)	C.1 Chlorinated Hydrocarbons	45
	C.2 Aromatics/Oil/MTBE/Cyanide	45
	C.3 Other	10
Geo-hydrology (G)	G.1 Permeable (sandy)	45
	G.2 Layered, permeable and impermeable layers	45
	G.3 Other	10
Built Environment (B)	B.1 Urban	70
	B.2 Industrial	25
	B.3 Other	5

HIP Matrix

Pilot archetype Group 1 *2500 sites*	**Pilot archetype Group 2** *2500 sites*
C.1 Chlorinated Hydrocarbons **G.1** Permeable soil **B.1** Built Environment (urban)	**C.1** Chlorinated Hydrocarbons **G.2** Layered, permeable and impermeable layers **B.1** Built Environment (urban)
Pilot archetype Group 3 *5000 sites*	**Pilot archetype Group 4** *3500 sites*
C.2 Aromatics/Oil/MTBE/Cyanide **G.1** Permeable soil **B.1** Built Environment (urban)	**C.1** and/or **C.2** **G.1** and/or **C.2** **B.2** Built Environment (industrial)

“Combining bitter and sweet ”

- Trends:
  - Increased land ownership by project developers in new urban areas
  - From a public-oriented planning system to a integrated stakeholder-oriented system
  - Public-Private Partnership

- Approach:
  - Transferring money from commercially viable sites to marginally viable sites
  - Combine “Greenfield” with “Brownfield” development in compensating twinning projects



Industry Perspective: Sustainability Calculator

Monday 18 June 2007
UK Sustainability Meeting

Frank Evans
National Grid Property

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National Grid Perspective - Landowner

- Manages environmental risks associated with its gasworks portfolio (both surplus and operational land) and electricity-related sites.
- Historical use of sites
- Remediation programme sustained for 10 years
- Sale of surplus property and significant contribution to UK Brownfield regeneration
- High % materials re-use in remediation programme
- Leading user of remediation technologies
- Member organisation of SAGTA

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Surplus and Operational land: Differences

- Surplus land
  - Development potential
  - Effective transfer of liabilities
  - Closure with regulator prior to site sale
  - Concentrated and shorter remediation timescales
  - Land value is a factor
  - Developer confidence
  - Provision of warranties
  - Ex-situ remediation approaches
  - UK National Grid
- Operational land
  - Retained land-holding
  - Retention of associated liabilities
  - On-going regulator agreement
  - Longer remediation timescales
  - Land value less important
  - Plant and equipment remediation constraints
  - In-situ techniques
  - Both US & UK National Grid

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Remediation Options Appraisal

- Remediation Design process require Remediation Options Appraisal
- ROA required to justify 'internal approval' to spend statutory provision. Remediation option agreed by programme mgr.
- Expectation of regulator and part of CLR 11

- National Grid Approach
  - Site Characterisation inputs
  - Assessment of Site-specific Factors
  - Constraints and Development of Remediation Objectives
  - Preliminary assessment of remediation options
  - Detailed assessment of remediation options

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Example of Constraints Analysis

Project Timescales	e.g. Delivery by agreed sale date (note that this should be an iterative and 2-way consideration with the selection of remediation strategy influencing the agreement of a realistic sale date)
End-use	e.g. Residential across entire site Known zones for mixed residential/commercial Current use as operational compound
Operational issues	e.g. PRS overlies known tar tank sources Gas pipe crosses known tar tank sources (cost/benefit analysis of plant relocation may also require consideration)
Site factors	e.g. Area (vacant and operational), topography, access, vegetation, areas of hard-standing, Surrounding land-uses. Underlying strata type. Nature of contaminants
Relevant Stakeholders view	e.g. Client preference for source removal. Neighbouring properties in contact with SPH concerning cross-boundary issues. Regulator requirement for groundwater quality criteria. Planning restrictions on hours of operation
Cost	Minimise with reference to above factors
Sustainability	Maximise with reference to above factors

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Conceptual Example of ROA Output

	Viability	Sustainability			Cost
		C02	***Waste***	***Local***	
Landfill as hazardous	Yes	Road haulage to Teesport from site CO2 emissions for job = 2X kg	20%	Least. Shorter site works	£1.4M
Bioremediate to non-haz and dispose	Yes	Local disposal. C02=Xkg	20%	High-Medium. Long site works	£1.2M
Thermal desorption	Yes	CO2 emissions = 2X kg	90%	Highest/PR management. Long site works	£1.5M
Landfill tar tanks & S/S	No - Residential target prevent use	CO2 = 1.5X kg	80%	-	£1.2M
Bioremediate for re-use	No - Residential target prevent use	-	-	-	-
Soil washing	No -Soils too fine	-	-	-	-

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Remediation Impact Assessment Tool

- How do we measure ‘sustainability’ elements of a project?
- Spreadsheet-based tool that consultants can use to assess sustainability of different remediation options
- Worley Parsons Komex have been commissioned to development tool to aid consultant with ROA process

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Environmental Aspects

- ISO 14001 requires identification of aspects

- Local
    - Noise
    - Dust
    - Vibration
    - Odour

- Regional
    - CO_2 emissions (kg)
    - Waste re-use (%)

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Remediation Techniques

- Landfilling,
- Screening/sorting
- Soil washing,
- Ex-situ bioremediation,
- Direct-fired thermal desorption,
- Solidification/soil stabilisation.

- Why? - because they represent most projects in programme and contribute to current targets. More in future

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REMEDIATION PROCESS DIAGRAM

Site Name: Dundee Gasworks
Site Address: East Dock Street
Dundee

Postcode: DD1 3JS

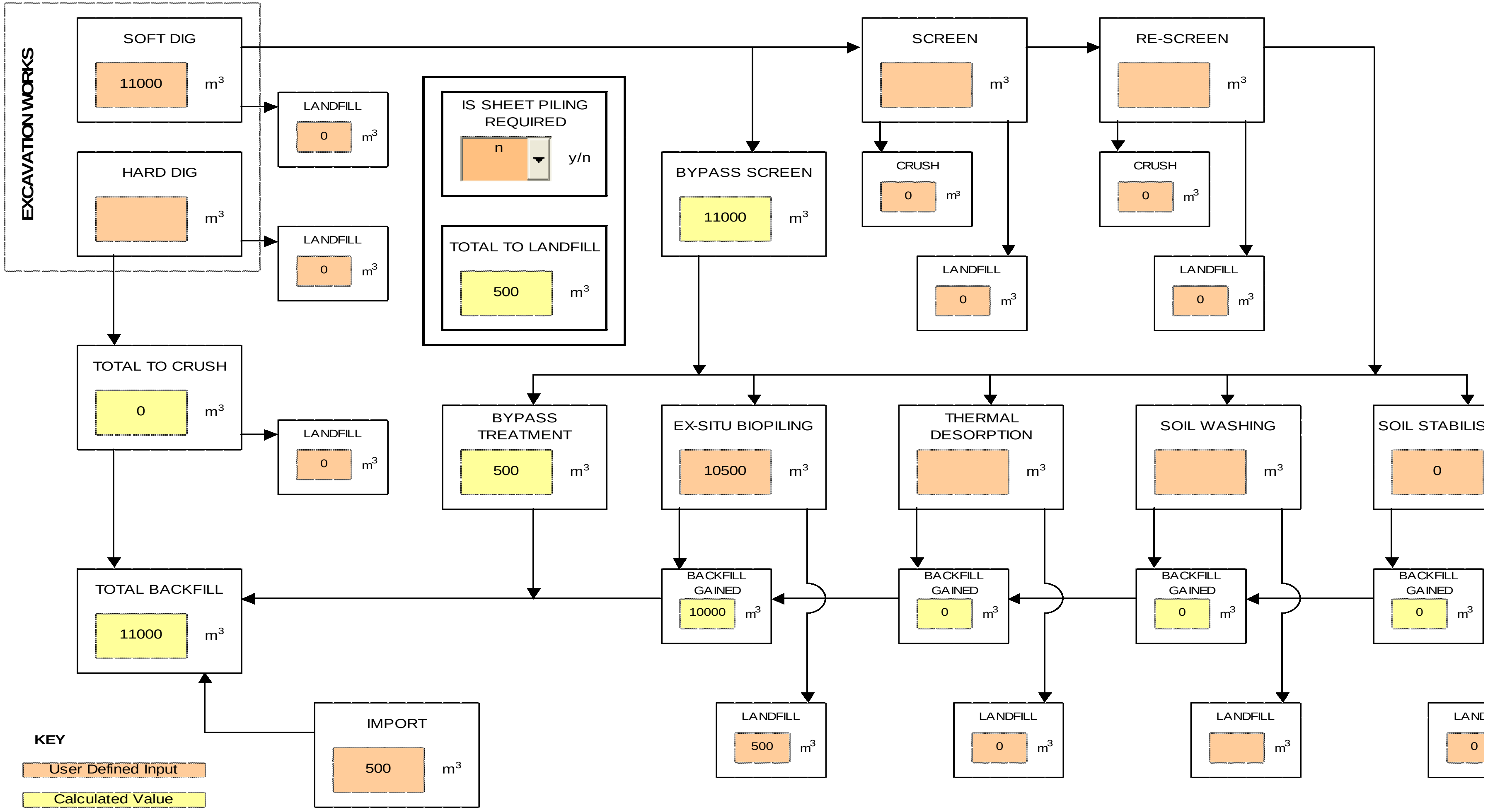
NGPH Project No.:
NGPH Manager: Frank Evans
Consultant: WYGE

REMEDIATION OPTION No.:

National Grid Ref.: E 341250 N 730750

RESE
ALL

RESE
OPTIO



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SITE DATA

Dundee Gasworks	NGPH Project No.:		REMEDIATION O
East Dock Street			
Dundee	NGPH Manager:	Frank Evans	
DD1 3JS	Consultant:	WYGE	National Grid Ref.:

KEY

	Landfill Options				**Import**	
		Volume (m^3)	Landfill/ Quarry ID	Distance from Site (km)		Volume (m^3)
USER DEFINABLE INPUT	Disposal Site 1:	500	Teesport	350	Inert import Site 1:	500
	Disposal Site 2:				Inert import Site 2:	
VALUE DERIVED FROM PROCESS DIAGRAM	Disposal Site 3:				Inert import Site 3:	

WORKS TOTALS

Area Type - residential, commercial or industrial?	Residential	Total Excavation Volume	11000	m^3	Total Volume To Landfill	500	m^3	Reuse & Recycle	95 %

PROCESS ASSESSMENT DATA

	GROUNDWORKS			TREATMENT						DISPOSAL	
	Soft Dig	Hard Dig	Piling	Screen	Crush	Ex-situ Biopiling	Thermal Desorption	Soil Washing	Soil Stabilisation	Load to Landfill	Disposal Haulage
Is process required? (y/n)	y	n	n	n	n	y	n	n	n	y	y
Estimated Duration of Process (weeks)	6					24				1	1
Treatment Volume(m^3)	11000					10500				500	500
Material Odour Ranking	3 - mod					3 - mod				3 - mod	n/a

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LOCAL IMPACTS

	Soft Dig	Hard Dig	Screen	Crush	Load to Landfill	Disposal Haulage	Import Haulage	Placing Backfill
Noise	HIGH	HIGH	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	HIGH
Vibration	HIGH	HIGH	HIGH	LOW	HIGH	MEDIUM	MEDIUM	HIGH
Odour	LOW	n/a	LOW	n/a	MEDIUM	n/a	n/a	n/a
Dust	MEDIUM	LOW	HIGH	HIGH	LOW	LOW	MEDIUM	HIGH

SAFETY

	Soft Dig	Hard Dig	Screen	Crush	Load to Landfill	Disposal Haulage	Import Haulage	Placing Backfill	TOTAL
Statistical Site Safety									
Deaths	1.91E-05	7.65E-06	1.53E-05	1.53E-06	1.91E-05	1.91E-05	1.15E-05	1.15E-05	**1.05E-04**
Major injuries	1.81E-03	7.22E-04	1.44E-03	1.44E-04	1.81E-03	1.81E-03	1.08E-03	1.08E-03	**9.89E-03**
Over 3 day	3.68E-03	1.47E-03	2.95E-03	2.95E-04	3.68E-03	3.68E-03	2.21E-03	2.21E-03	**2.02E-02**
All Injuries	5.51E-03	2.20E-03	4.41E-03	4.41E-04	5.51E-03	5.51E-03	3.30E-03	3.30E-03	**3.02E-02**
Theoretical Road Traffic Injuries									
Theoretical fatalities	n/a	n/a	n/a	n/a	n/a	1.22E-02	1.96E-03	n/a	**1.42E-02**
Theoretical other injuries	n/a	n/a	n/a	n/a	n/a	7.51E-01	1.20E-01	n/a	**8.71E-01**
All injuries	n/a	n/a	n/a	n/a	n/a	7.63E-01	1.22E-01	n/a	**8.85E-01**

REGIONAL IMPACTS

	Soft Dig	Hard Dig	Screen	Crush	Load to Landfill	Disposal Haulage	Import Haulage	Placing Backfill	
Site Based Engine Emissions									
Fuel consumption (L of diesel)	79342	15868	32171	3217	10646	17743	17743	51750	**2.28E+05**
CO_2 emissions (Kg)	246754	49351	100052	10005	33109	55182	55182	160942	**7.11E+05**
CO emissions (Kg)	672	134	272	27	90	150	150	438	**1.94E+03**
NO_x emissions (Kg)	672	134	272	27	90	150	150	438	**1.94E+03**
Particulate emissions (Kg)	410	82	166	17	55	92	92	268	**1.18E+03**
Emissions Road Traffic									
Estimated Total Distance (Km)	n/a	n/a	n/a	n/a	n/a	912000	145600	n/a	**1.06E+06**
Fuel consumption (L of diesel)	n/a	n/a	n/a	n/a	n/a	2679685	427809	n/a	**3.11E+06**
CO_2 emissions (Kg)	n/a	n/a	n/a	n/a	n/a	7375432	1177481	n/a	**8.55E+06**
CO emissions (Kg)	n/a	n/a	n/a	n/a	n/a	20086.8	3206.8	n/a	**2.33E+04**
NO_x emissions (Kg)	n/a	n/a	n/a	n/a	n/a	60948.1	9730.3	n/a	**7.07E+04**
Particulate emissions (Kg)	n/a	n/a	n/a	n/a	n/a	4126.4	658.8	n/a	**4.79E+03**
Emissions Totals									
Fuel consumption (L of diesel)	79342	15868	32171	3217	10646	2697429	445553	51750	**3.34E+06**
CO_2 emissions (Kg)	246754	49351	100052	10005	33109	7430614	1232663	160942	**9.26E+06**
CO emissions (Kg)	672	134	272	27	90	20237	3357	438	**2.52E+04**
NO_x emissions (Kg)	672	134	272	27	90	61098	9881	438	**7.26E+04**
Particulate emissions (Kg)	410	82	166	17	55	4218	751	268	**5.97E+03**

How do you use output?

- Company Objectives include:
  - Maximise materials re-use
  - Minimise impact on Climate
  - Maximise land value
  - Minimise costs
  - Safety performance is high priority

- Challenges for project and programme managers in balancing all of the above

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The easy project to select!

	Option A1	Option A2	Option A3
Materials Re-use	☺	☺	☹
Climate impact	☺	☹	😐
Local Impact	😐	😐	☺
Land Value	☺	☺	☺
Cost of project	☺	😐	😐

The harder decision to be made!

	Option B1	Option B2	Option B3
Materials Re-use	😐	🙂	☹️
Climate impact	🙂	☹️	😐
Local Impact	😐	😐	🙂
Land Value	☹️	🙂	🙂
Cost of project	🙂	😐	😐

Safety Performance

- Unreliable to use predictive tool
- Road traffic statistics give a reliable indicator of risks associated with road travel
- Construction statistics do not take into account remediation technology selection or Company H&S cultures
- Need a reliable dataset to use effectively otherwise unrealistic predictions
- Communications challenge in selecting projects that are predicted to have ‘higher’ safety risk irrespective of environmental gains and cost savings

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Next Stages

- Roll out model to supply chain for their consideration in remediation design process
- Refine and validate model based on measured site data (e.g. fuel consumption, local complaints)
- Consider adding further aspects and remediation techniques in later versions
- Evaluate internal decision making as a consequence
  - Wider view: Environment-Economic-Society balance
  - Environmental view only

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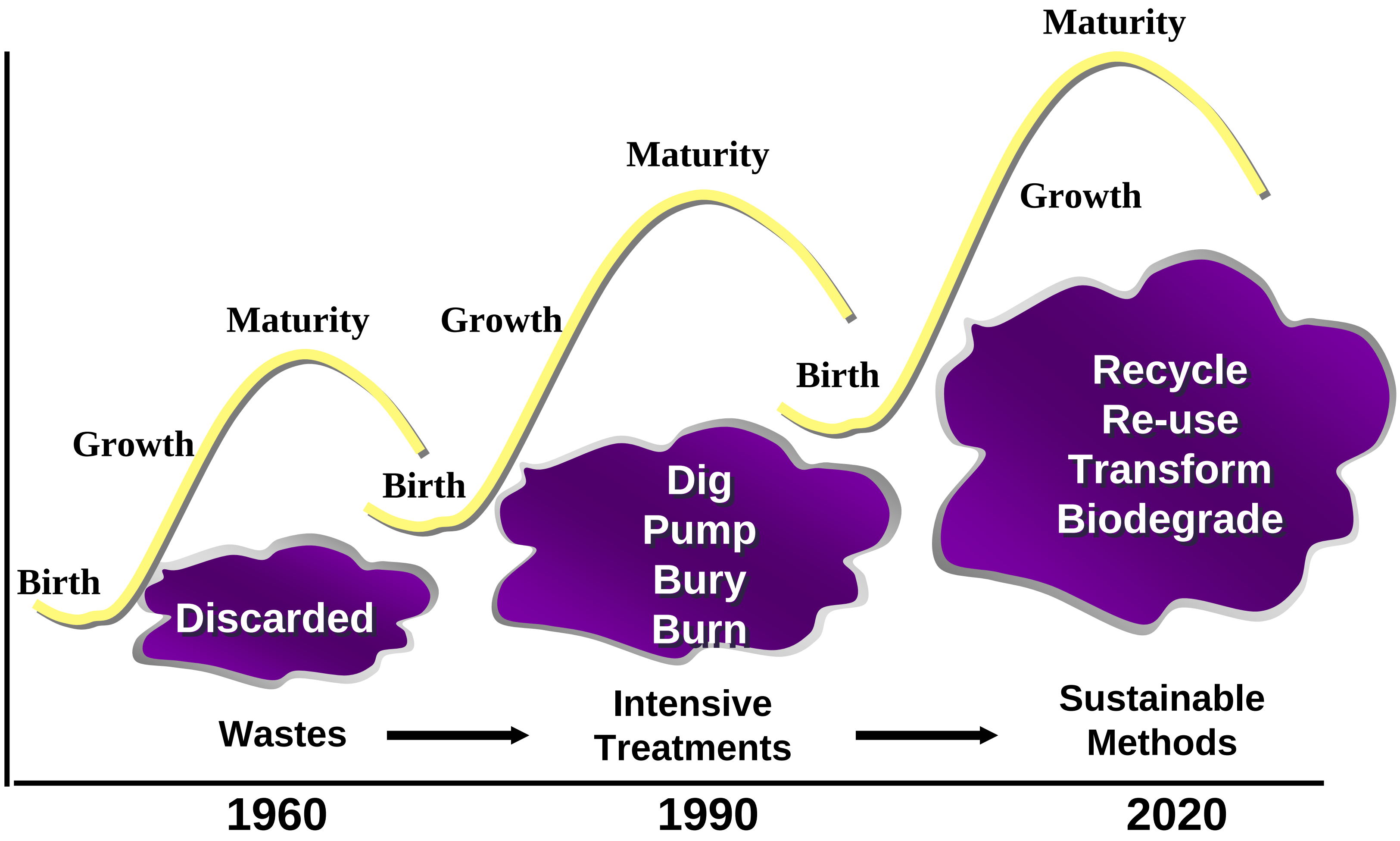
Sustainability in Remediation:

SURF and DuPont

David Ellis
DuPont Engineering

CL:AIRE
June 18, 2007

How Can We Transform Our Thought Process?



Sustainable Remediation Principles

Our working concepts:

DuPont, in fulfilling its obligation to remediate sites to be protective of human health and the environment will embrace sustainable approaches to remediation that provide a net benefit to the environment.

To the extent possible, these approaches will:

- **Minimize or eliminate energy consumption or the consumption of other natural resources;**
- **Reduce or eliminate releases to the environment, especially to the air**
- **Harness or mimic a natural process;**
- **Result in the reuse or recycling of land or otherwise undesirable materials.**
- **Encourage the use of remedial technologies that permanently destroy contaminants**

Sustainable Remediation Forum (SURF)

Mission Statement:

To establish a framework that incorporates sustainable concepts throughout the remedial action process, that provides long-term protection of human health and the environment, and that achieves public and regulatory acceptance

Sustainable Remediation Forum (SURF)

- **A discussion group facilitated and hosted by DuPont**
- **A core group of highly motivated participants has evolved**
- **SURF shares perspectives, experiences, site-specific examples**
- **DuPont, British Petroleum, Canadian National, Dow, ERM, Roux, Dept of Energy, GeoSyntec, Honeywell, National Grid, Shell, Terra Systems, URS, NJIT, USEPA, SERDP, CA EPA, DNREC, UK Environment Agency, British Geological Survey, CL:AIRE, Univ. of Edinburgh. Anyone is welcome**
- **Met November 13, February 8, May 10. SURF-4 will be August 22 & 23 at NJIT, SURF-5 November 28 & 29 at California EPA**
- **Meeting records publicly available**

DuPont’s Conceptual Framework for Sustainability Analysis

Remediation Project Data

- Size
- Volume
- Quantity
- Distance
- Etc.

→

Remedial Options

- Excavation
- Soil Treatment A
- Soil Treatment B
- Soil Treatment C
- Groundwater Treatment A
- Groundwater Treatment B
- Vapor Treatment
- Others, as Identified

→

Calculation modules

- Transportation
- Treatment
- Off-site transfers
- Water losses
- Exposure hours
- Air releases
- Land use
- Others, as Identified

→

Remediation Sustainability Parameters

- Pollutants
  - Green House Gases
  - Air
  - Water
  - Waste
- Resources
  - Energy
  - Water
  - Land
  - Air
- People

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Sustainability Analysis Modules Available

- Constructed Wetlands
- Excavation & Landfill
- In-situ Aerobic Stimulation
- In-situ Reductive Dechlorination / Bioaugmentation
- Ex-situ Stablilization
- Off-site GW Disposal
- On-site GW Disposal
- Geomembrane Cap
- Bioventing
- Landfill Bioreactor
- Stabilization
- Off-site Haz Waste Disposal
- Off-site Waste Disposal
- On-site Haz Waste Landfill
- Slurry Wall
- Soil Cover / Cap
- Spray Irrigation
- ZVI / Clay
- SVE
- Catalytic Oxidation
- Surfactant Flushing
- Pump and Treat

Future Sustainability Analysis Modules

- **Permeable Reactive Barrier**
- **Sediment Removal**
- **Sediment Capping**
- **Sediment Covers**
- **Soil Washing**
- **Chemical Oxidation**
- **Electro-osmosis**
- **Air Sparging w SVE**
- **In-well stripping**
- **MNA**
- **In-Situ 6-Phase heating**
- **In-Situ Steam Heating**
- **Horizontal Wells**
- **Phytoremediation**
- **Dual-phase Extraction**
- **Others……**

Proposed Sustainability Credits and Debits

Media or Impact	Credit (+)	Debit[1] (-)
Greenhouse Gas (CO_2 equivalents)	❑ Sequestration in-situ ❑ Sequestration by plants ❑ Destroying GWP equivalents	❑ Generated by fuel consumed during activity ❑ Generated by manufacture of consumables ❑ Vegetation removed ❑ Ex-situ contaminant destruction
Resource Use		
Soil	❑ Reused-recycled soil or soil-substitute ❑ Improved soil usability	❑ All soil required ❑ Off-site disposal ❑ Sterilized sterilized
Land	❑ Unrestricted reuse ❑ Restricted reuse – i.e. renewable energy or brownfield ❑ Wetlands created or upgraded	❑ Permanently deed restricted ❑ Permanent access restriction
Water	❑ Restored aquifer or surface water ❑ Reused-recycled	❑ All water used or captured for treatment ❑ Water for dust control ❑ Used for ongoing O&M (i.e. grass)
Air	❑ Odor control	❑ Contaminant emissions ❑ PM10 and PM 2.5 & acid rain compounds
Energy Use	❑ Renewable energy used for remedial action ❑ Renewable energy production	❑ Required by remediation activity ❑ Required for manufacture of consumables
Occupational Risk	❑ Controls or measures to reduce hazardous exposure	❑ Exposure hours on-site ❑ Exposure hours for travel or delivery of consumables

DUPONT

Brief Real World Examples

Source Area Quantities

Areas	Acreage	Depth, ft	Volume, CY
Landfill-A	28.2	42	1,910,832
Landfill-B	20.0	20	645,333
DNAPL Area	6.2	40	400,107
Northern Basin Area	26.7	10 - 15	567,087
Western Fill Area	30.1	20	971,227
Southern Fill Area	14.5	20	467,867
Total	125.7		4,962,452
Unimpacted Area	11.3	-	
Total	137.0	-	4,962,452

Measures of Sustainability and Reduction

	Excavation	Stabilization	Bioventing
Destruction	No	No	Yes
In-situ	No	Yes	Yes
Mobility	↓↓	↓↓	↔
Toxicity	↔	↔	↓
Volume	↑	↑	↓
Tons CO_2	2,700,000*	920,000	190,000*
Exposure Hours	4,900,000	540,000	82,000
Highway Miles	56,000,000	8,000,000	1,000
Odor	High	Moderate	None
Light	High	Moderate	None
PM10, tons	50,500	7,200	24

Martinsville– DNAPL Remediation

- 60 days — Duration
- 5,300 — Man hours
- 225 ton — Zero Valent Iron
- 340 ton — Kaolinite
- 445 ton — Kiln Dust
- 886 ton — Asphalt and Sub-base
- 240,000 gal — Water
- 9,900 gal — Gallons of fuel
- 0.5 acre, 20 ton CT
- $900,000
- $500,000 if optimized

Martinsville– DNAPL Remediation

A Policy Question:
Can destruction of global warming or ozone depleting chemicals become an incentive for source treatment?

Example data:

CCl_4 Destroyed:	20 tons
CO_2 Emissions:	664 tons
GWP of CCl_4:	2,540
GWP of destroyed CCl_4:	50,800 tons
Net CO_2 including GWP destruction:	-50,136 tons
Actual cost:	$ 900,000
Net CO_2 credit at $4/ton:	$ 200,544
Net CO_2 credit at $25/ton:	$1,253,400

Some Process Observations

- **Only remedies that are fully protective of human health and the environment should be considered**
- **Considering sustainability changes thinking**
- **Engineers work together more closely, improved quality**
- **Some unexpected and very creative remedies have been proposed**
- **Some remedies are less costly, others about the same**
- **Processing remedies and sustainability with agencies leads to a faster consensus on which remedies to seriously consider**

What Sustainable Remediation Is – and What It's Not

It is:

- A thought process – with luck it is inclusive and creative
- A method to evaluate local, regional, and global impacts
- A way to express your organization's values and select cleanup methods that are fully consistent with them

It is not:

- A cost containment tool
- A fully developed method
- A regulatory guidance or regulation
- Voodoo

Discussion