

Evaluating sustainable remediation methods for brownfields redevelopment projects (BRPs)

Dr.-Ing. Uwe Hiester
Dr.-Ing. Volker Schrenk

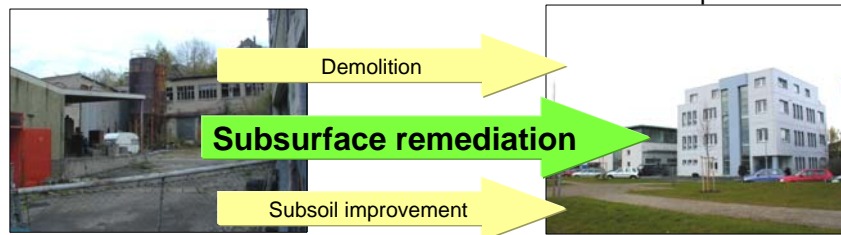
Introduction

Brownfield redevelopment

Technical preparation of the construction site

Brownfield

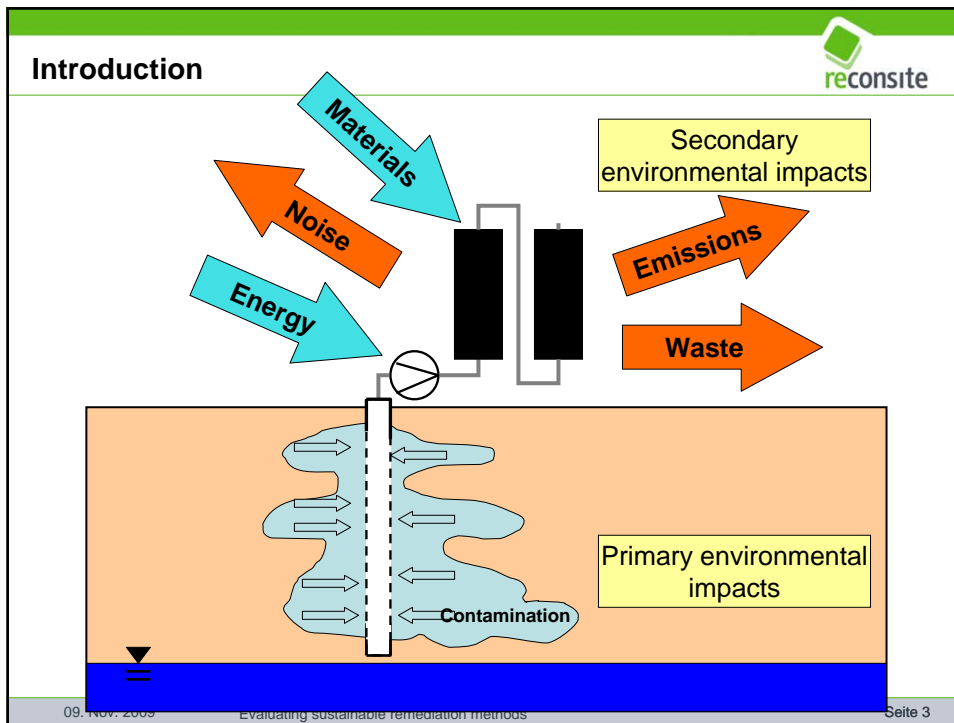
Redeveloped site



Environmental Protection

Life cycle assessment

Environmental Impacts



- Research objectives** reconsite
- Providing
new insights and tools
on the basis of LCA in order to
minimize environmental impacts
of remediation measures**
1. Development of methods for a simplified quantitative estimation of environmental impacts
 2. Development of new procedures for the evaluation of environmental impacts
 3. Formulation of recommendations for a sustainable remediation management
09. Nov. 2009 Evaluating sustainable remediation methods Seite 4

Basic information about remediation techniques

Overview of remediation technologies applied in NRW

| | Landfill sites | Contaminated sites |
|--------------------------|----------------|--------------------|
| Decontamination | 153 | 1,072 |
| Containment | 591 | 841 |
| Relocation on-site | 117 | 358 |
| External disposal | 561 | 2,389 |
| Total | 1,422 | 4,660 |

Overview of remediation technologies applied in NRW



3 remediation methods

• Excavation and Disposal

• 'cold' SVE

• Pump & Treat

cover 2/3 of the market

| | Landfill sites | Contaminated sites |
|------------------------------|----------------|--------------------|
| Decontamination | 153 | 1,072 |
| Thermal technologies | 8 | 80 |
| Biological technologies | 1 | 177 |
| Soil washing or extraction | 1 | 12 |
| Pneumatic technologies | 39 | 360 |
| Soil vapour extraction (SVE) | 37 | 360 |
| Landfill gas extraction | 62 | 0 |
| Hydraulic technologies | 40 | 443 |
| Pump & Treat (P&T) | 25 | 403 |
| Others | 15 | 40 |

LANUV NRW 2007

Overview of remediation technologies applied in NRW



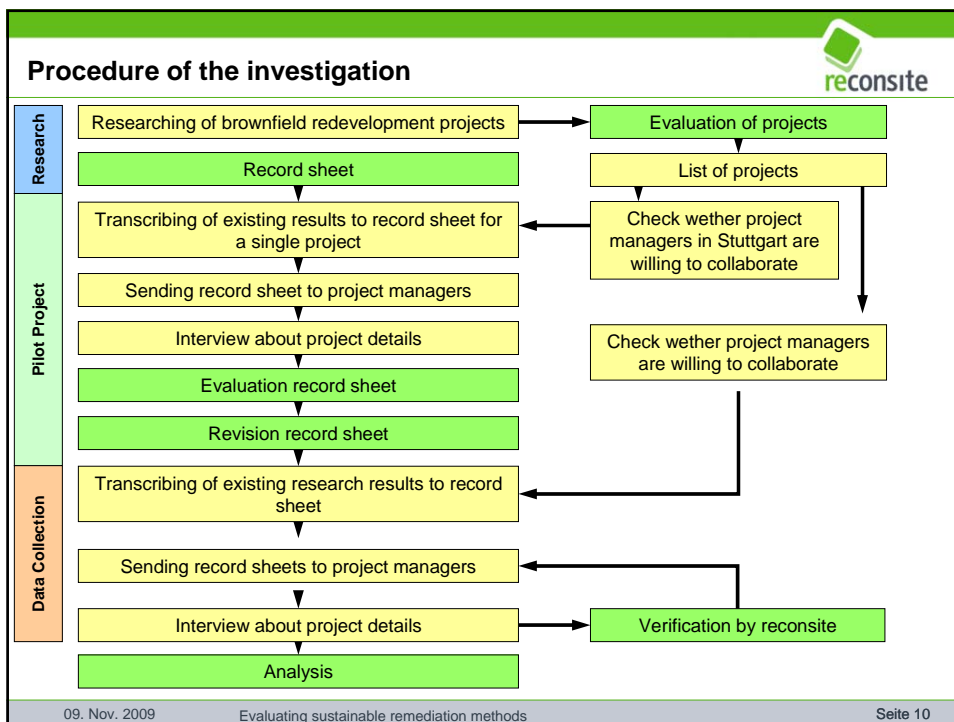
| | Landfill sites | Contaminated sites |
|-----------------------------------|----------------|--------------------|
| Containment | 591 | 841 |
| Encapsulation | 529 | 767 |
| Surface sealing | 125 | 173 |
| Surface coverage | 297 | 300 |
| Sealing for traffic or other uses | 94 | 276 |
| Vertical barrier | 11 | 18 |
| Bottom lining | 2 | 0 |
| Immobilization | 12 | 10 |
| Pneumatic containment | 27 | 20 |
| Hydraulic containment | 23 | 44 |

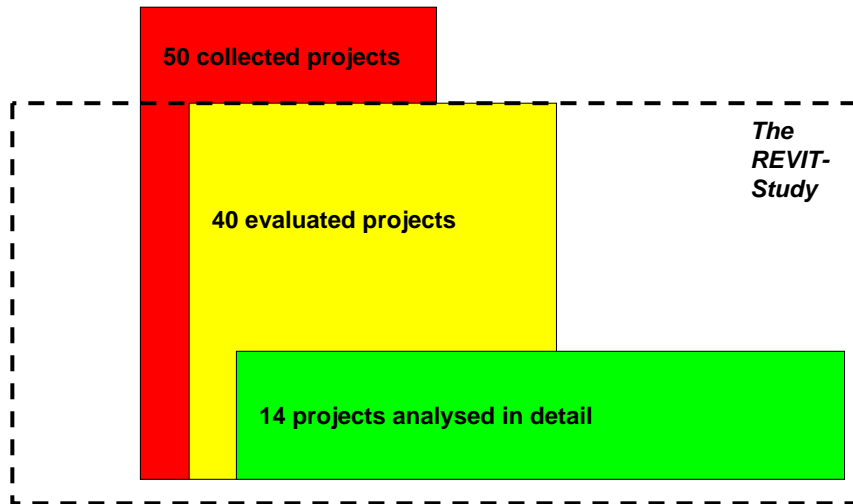
LANUV NRW 2007



The REVIT-study

09. Nov. 2009Evaluating sustainable remediation methodsSeite 9

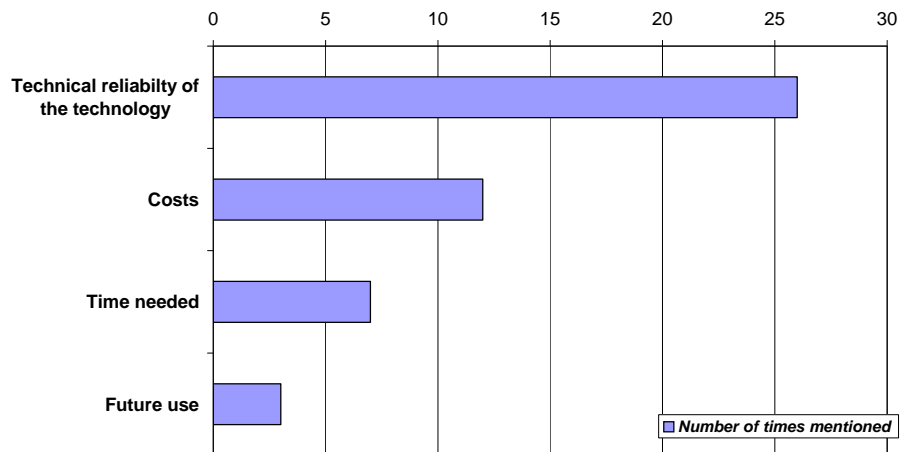




Overview of the projects

| | |
|-------------------------|---|
| Former use | Industry – commerce – military – railway yard |
| Subsequent use | Housing – trade – services |
| Size | 5000 – 320000 m ² |
| Pollutants | LHKW, BTEX, PAH, MKW, heavy metals |
| Duration of brownfields | 0 years to 40 years |
| Duration of remediation | 6 month up to 20 years |
| Success of remediation | All of the 14 in detail examined projects were successful |

Selection criteria for remediation technologies



Results – Overview (new definition)



| Technology | Number of application | Technology rating |
|---------------------------------------|-----------------------|-------------------|
| Excavation & disposal | 29 | Standard |
| Soil washing (ex-situ) | 1 | Alternative |
| Thermal treatment (ex-situ) | 2 | Alternative |
| Biological treatment on-site | 1 | Alternative |
| Biological treatment off-site | 6 | Alternative |
| Soil vapour extraction | 1 | Alternative |
| Surface sealing | 6 | Alternative |
| Containment structures | 5 | Alternative |
| Containment by sealing with buildings | 3 | Alternative |
| Immobilization | 2 | Alternative |

Results – Overview (old definition)



| Technology | Number of application | Technology rating |
|---------------------------------------|-----------------------|--|
| Excavation & disposal | 29 | proven (Standard) |
| Soil Washing (ex-situ) | 1 | proven |
| Thermal treatment (ex-situ) | 2 | proven |
| Biological treatment on-site | 1 | proven |
| Biological treatment off-site | 6 | proven |
| Soil vapour extraction | 1 | proven |
| Surface sealing | 6 | proven innovative character: → sealing material → buildings allowed |
| Containment structures | 5 | proven |
| Containment by sealing with buildings | 3 | proven |
| Immobilization | 2 | proven |

09. Nov. 2009

Evaluating sustainable remediation methods

Seite 15

Results – Overview (new definition)



| Technology | Number of application | Technology rating |
|---------------------------------|-----------------------|--|
| Vertical barrier | 1 | alternative |
| Mixed-in-place vertical barrier | 1 | Alternative |
| Microbiological in-situ methods | 2 | Innovative |
| Groundwater circulation well | 1 | Alternative |
| Pump & Treat | 7 | Standard • innovative Character: → filtration technology |
| Air-Sparging | 1 | Alternative |
| Funnel & Gate | 2 | Alternative |

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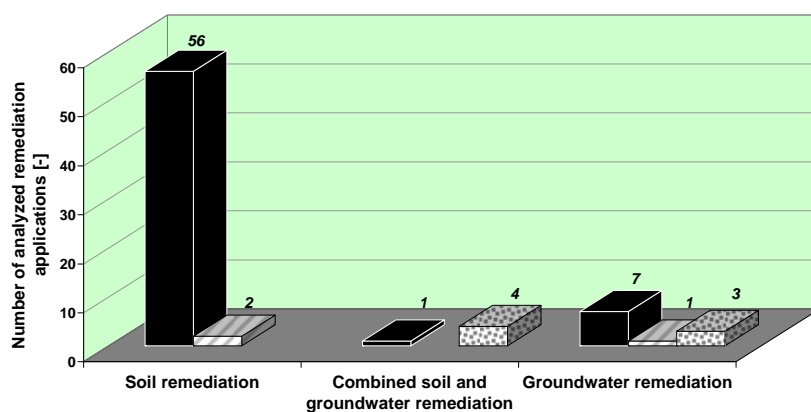
Seite 16

Results – Overview (old definition)



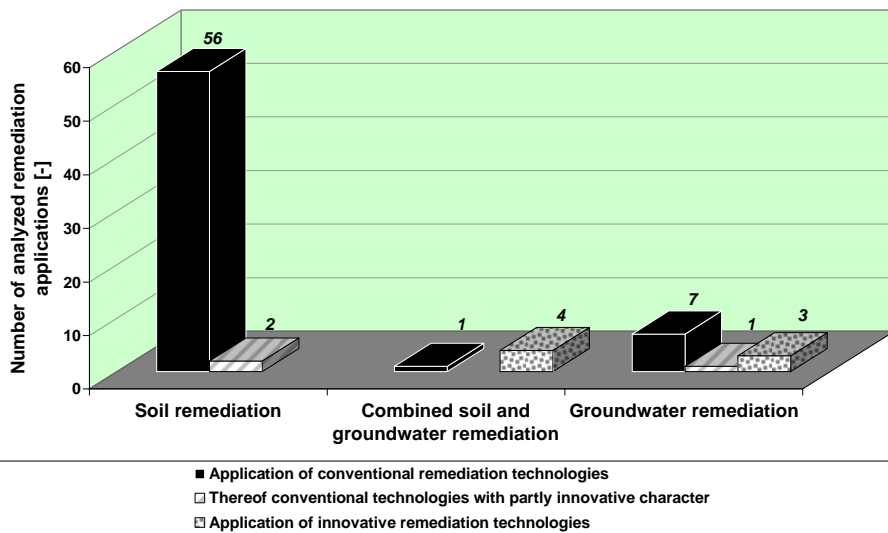
| Technology | Number of application | Technology rating |
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| Vertical barrier | 1 | proven |
| Mixed-in-place vertical barrier | 1 | innovative |
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Results – Overview (old definition)

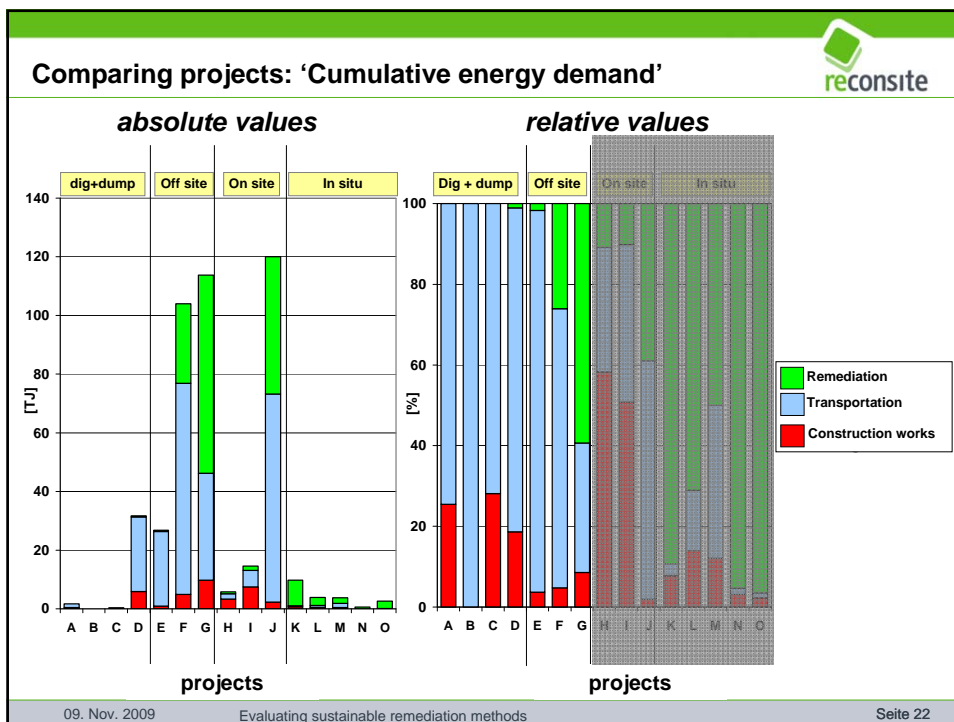
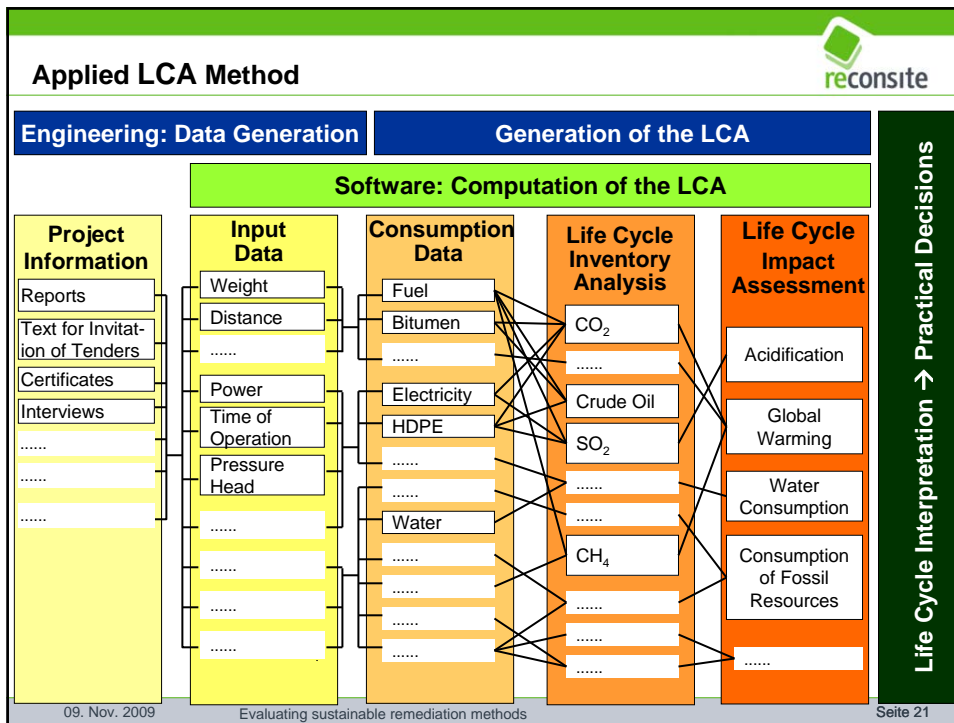


- Application of conventional remediation technologies
- ▒ Thereof conventional technologies with partly innovative character
- Application of innovative remediation technologies

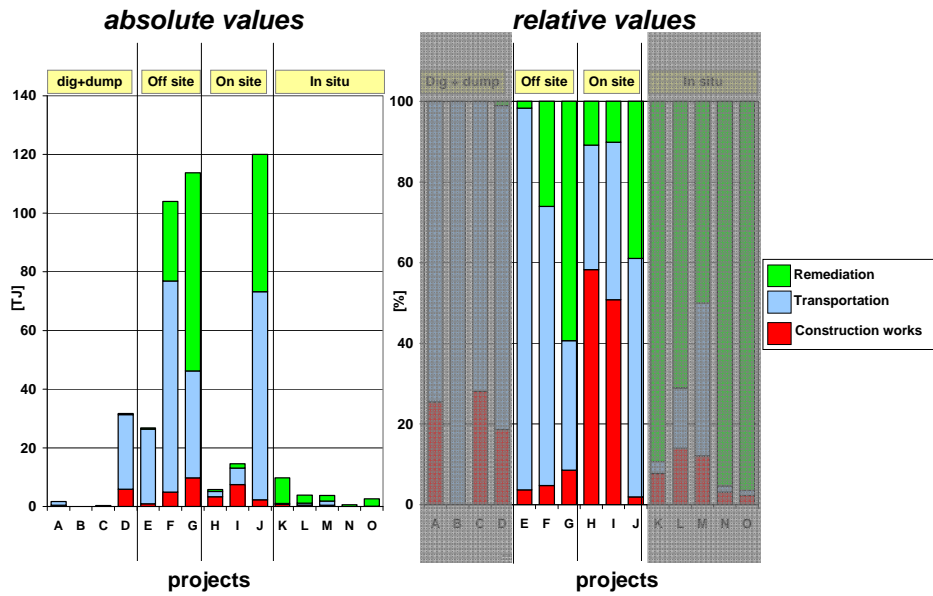
Application of remediation methods



The LCA of remediation techniques



Comparing projects: 'Cumulative energy demand'

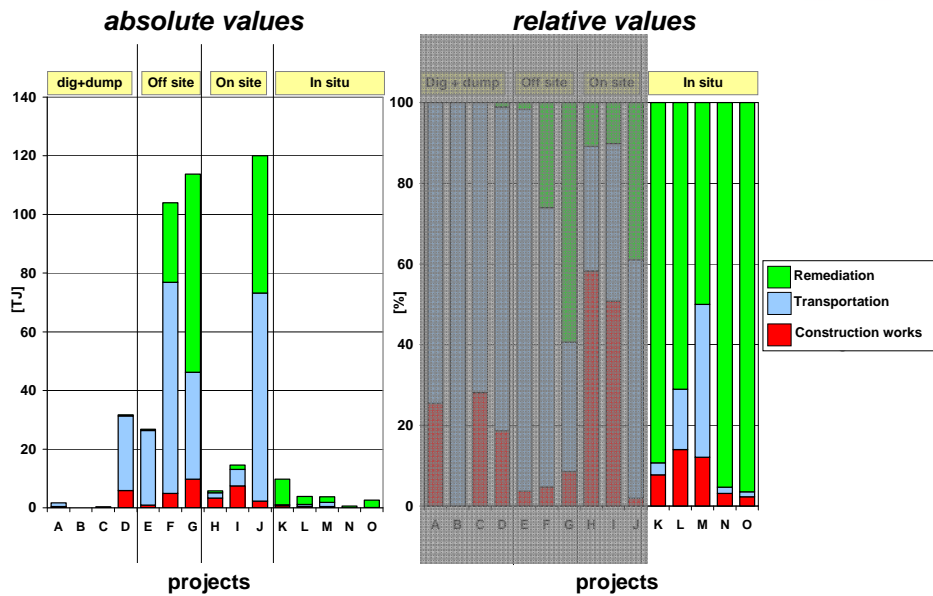


09. Nov. 2009

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Seite 23

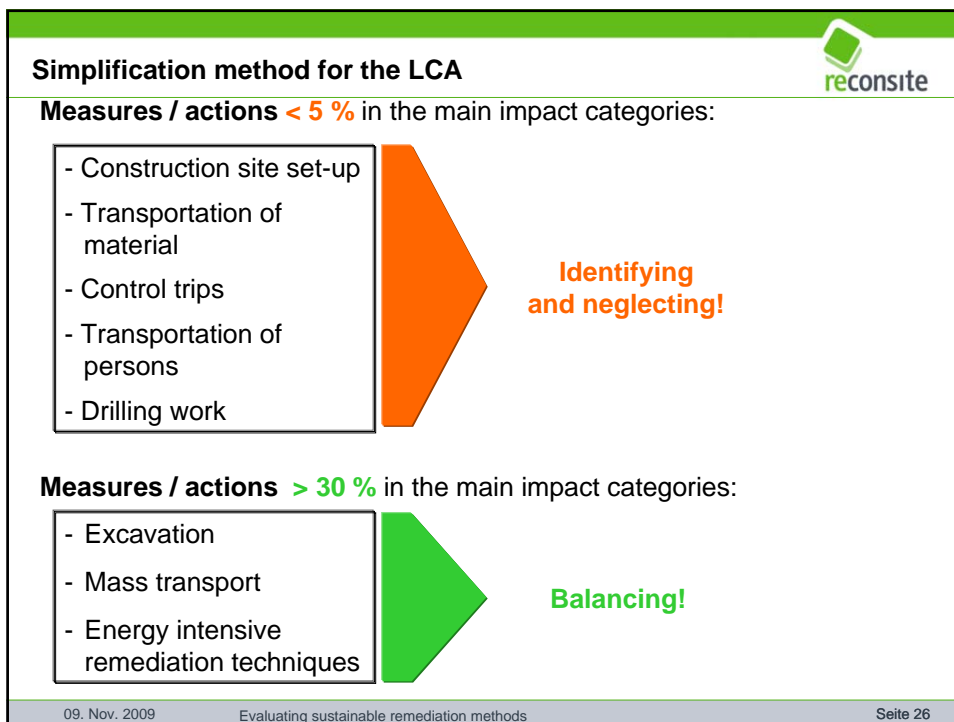
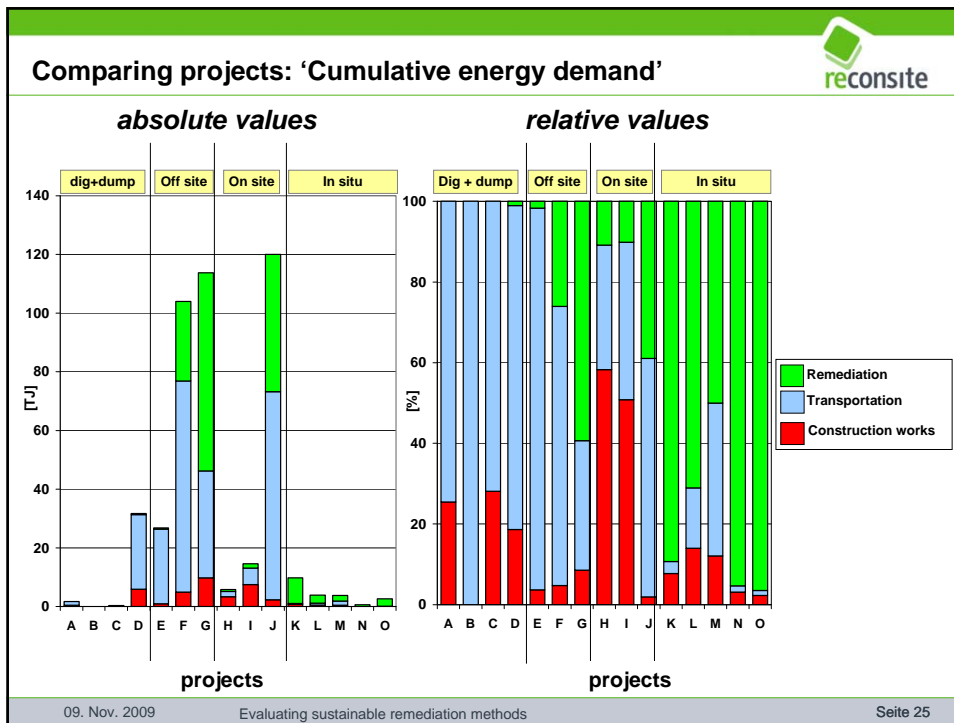
Comparing projects: 'Cumulative energy demand'



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Seite 24



Unsaturated Zone

Reasons for excavation & disposal

- Deadlines
- Low disposal costs
- Need for a definitely clean site
- Foundation of new buildings
- Clearly defined point sources of contamination



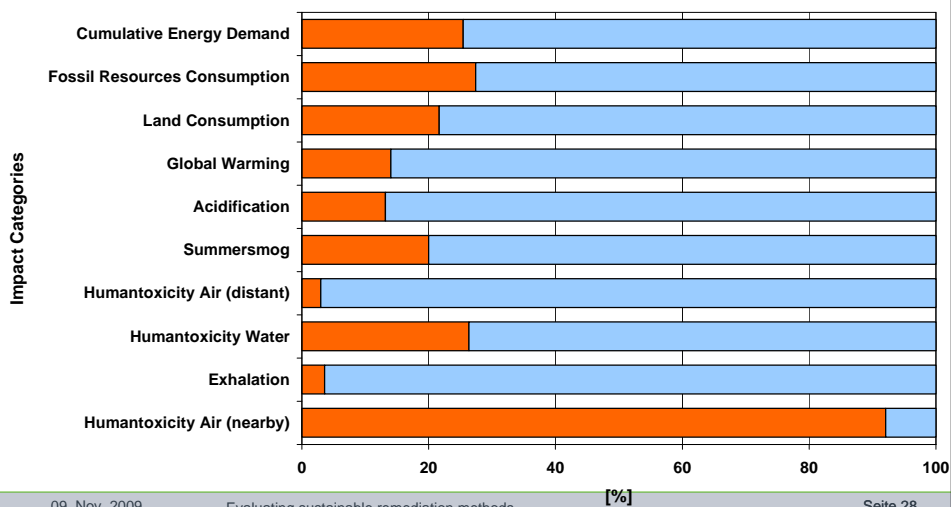
<http://www.carrieresfeldt.lu/>

- Cost of disposal
- Depths of the contaminated zone
- Accessibility
- Surroundings
- Health and safety issues

LCA-Results: Excavation and Removal

Project results *Schrottverwerter*:

■ Construction
 ■ Transportation
 ■ Decontamination



- **Transportation distances** often > 200 km
- **Mass transports** dominate most of the impact categories
- Fate of **excavated material**?
- Refilling material may be necessary

Simplification of the LCA

Mass transports

Excavation & Soil Treatment & Disposal



**Soil washing
(off-site)**

www.schmid-umweltschutz.de



**Biological treatment
(on-site/off-site)**

www.zueblin.de



**Thermal Treatment
(off-site)**

www.al.fh-osnabrueck.de/14251.htm

Results: Off site measures



- Potential environmental impact **emphasis** on transportation and remediation
- Transportation rate often > 50 % in most life cycle assessment impact categories
- Environmental impacts:
Ex-situ thermal treatment > Soil washing > Biological treatment
- Disposal of decontaminated material is very important: recycling or disposal?

Simplification of the LCA

Mass transports
Remediation technique

Results: On site measures



- Potential environmental impacts caused by construction operations, transportation, and the applied remediation technique
- The influence on the impact categories is depending on the type of **remediation technique** and on the extent of **construction measures** and **mass transportation**
- Important: displacement of decontaminated material for backfilling

Simplification of LCA

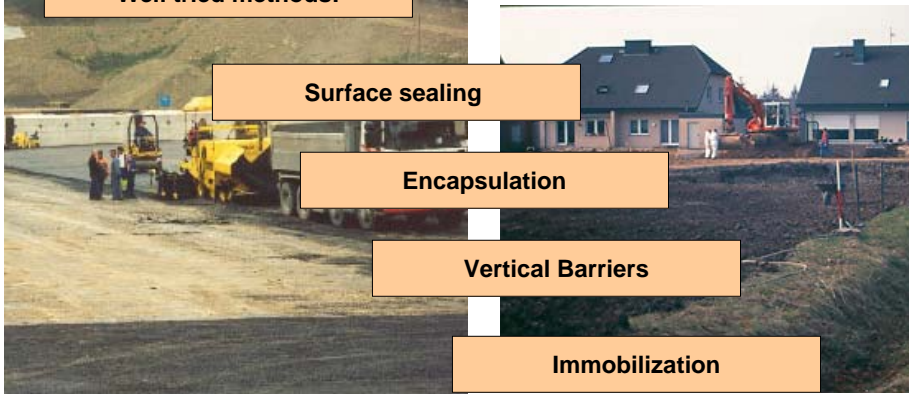
Mass transports
Remediation technique
Construction measures

Unsaturated/Saturated Zone



Containment measures

Well tried methods:



www.walo.ch

www.al.fh-osnabrueck.de/14251.html

09. Nov. 2009

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Seite 33

Saturated Zone



Well tried methods:

Innovation:

Pump & Treat

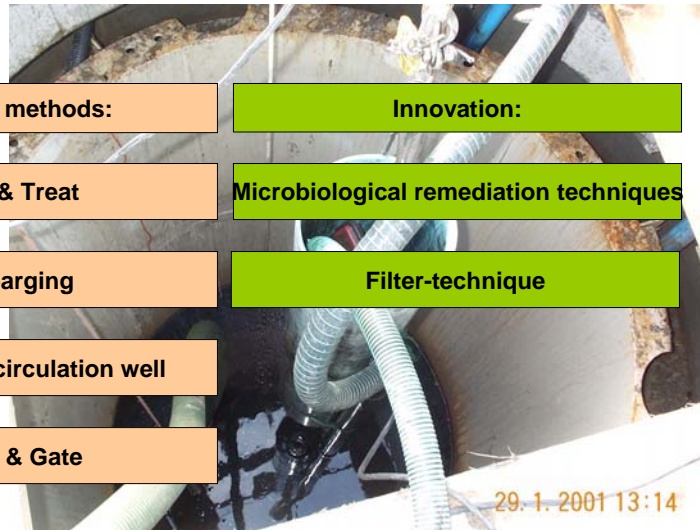
Microbiological remediation techniques

Air-Sparging

Filter-technique

Groundwater circulation well

Funnel & Gate

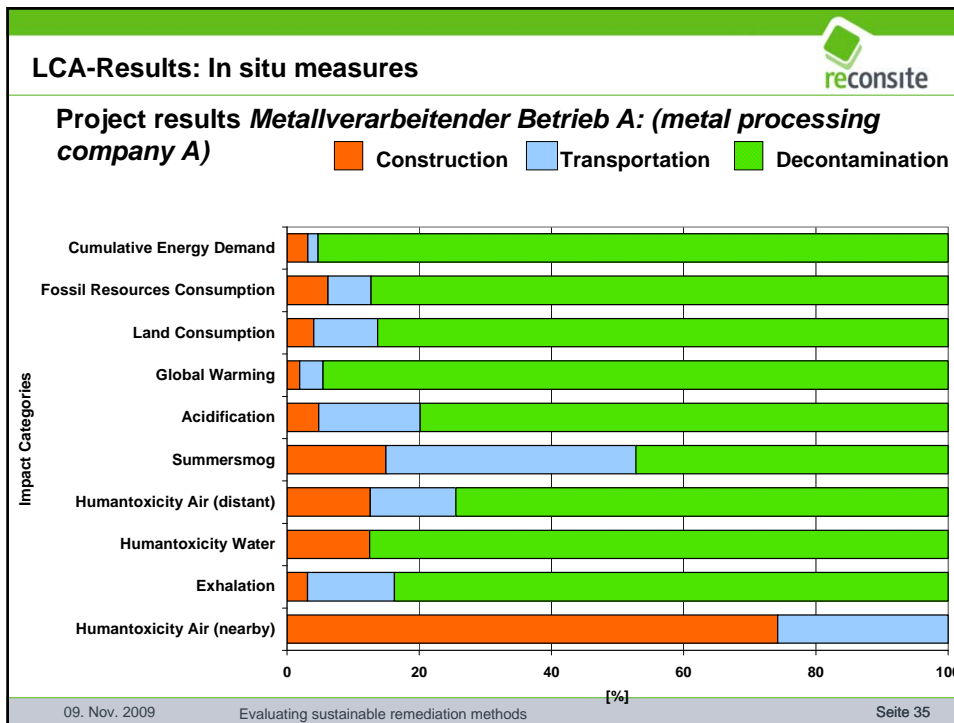



http://dmi.stadtwerke-karlsruhe.de/index_public.html

09. Nov. 2009

Evaluating sustainable remediation methods

Seite 34



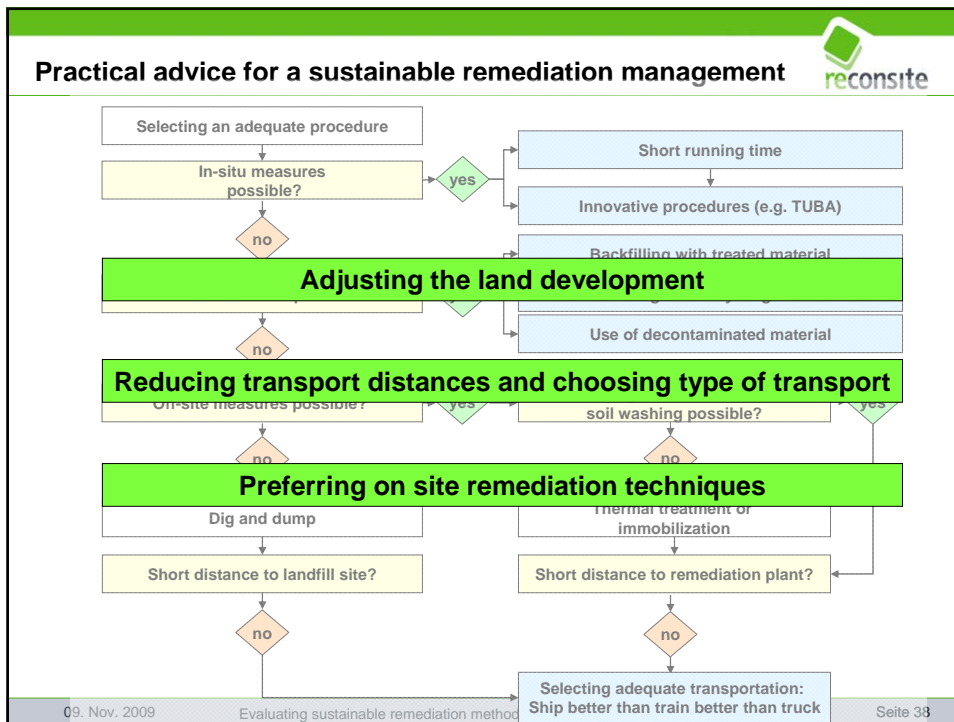
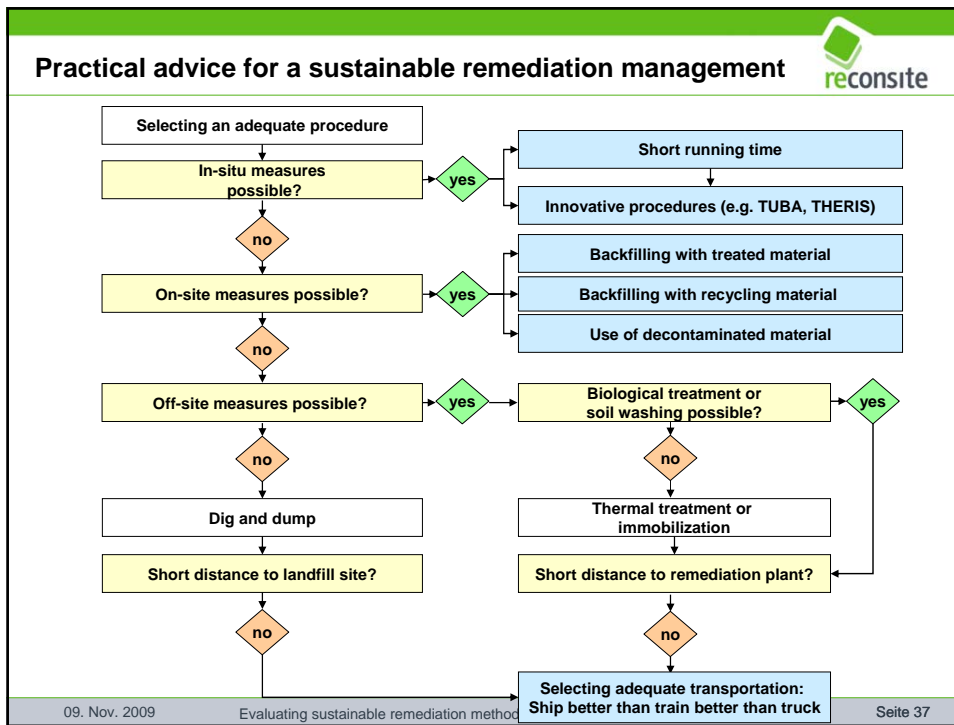
Results: In situ measures 

- Remediation technique and the operation time of the facility are the driving factors
- Essential environmentally relevant facility components:
 - pumps to discharge groundwater and soil-air
 - extracted air cleanup/water cleanup installations
- Transportation and construction operation are often not relevant

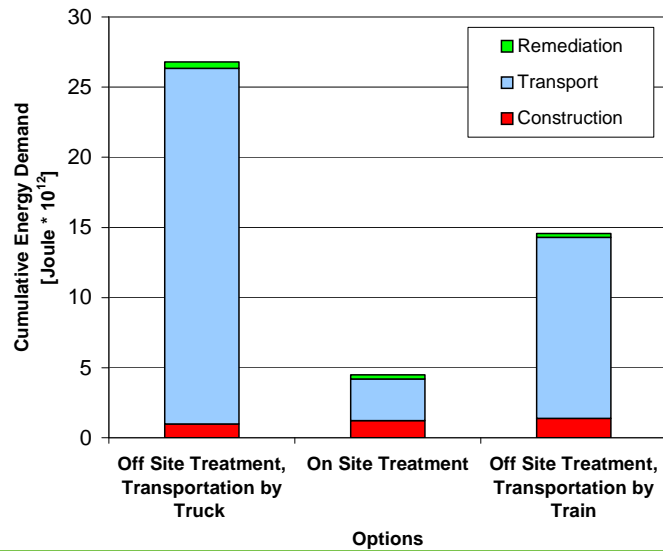
Simplification of the LCA

Operation time of pumps
Consumption of activated carbon

09. Nov. 2009 Evaluating sustainable remediation methods Seite 36



Optimisation



Requirements for remediation technologies

- **Cost efficiency:** Techniques have to be at least equal to the standard technologies or preferably more favorable with respect to cost and efficiency
- **Remediation goals should be reliably obtainable in a certain period of time:** Assessable of remediation time
- **Interfaces:** between remediation technologies and other construction processes in a brownfields redevelopment project should be controllable.

Scale in the unsaturated zone: Excavation & Disposal

Conclusions (1)



1. **The application of innovative remediation technologies in brownfield redevelopment projects is not common**
2. LCA should focus on main parameters of remediation measures
3. **Excavation & disposal in 70 % of all examined cases, because:**
 - only 15 % of the examined remediation were groundwater contaminations
 - decontamination was the main goal
 - combination with the demolishing of buildings and other construction actions
4. **Mass transportation often dominates** the environmental impacts

Conclusions (2)



5. **Saturated zone: pump & treat and the use of alternative remediation technologies:**
 - Funnel & Gate
 - Microbiological remediation methods
6. Impacts of in-situ remediation measures depend on the running time
7. Formulation of **requirements for the application of other remediation technologies instead of excavation & disposal or pump & treat**
 - cost-efficient
 - reliable reaching of remediation goals