Financial Assessment of the Remediation of Environmental Liabilities

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Agenda

• Purpose
• Content & Methodology
• Conclusions
• Future Work
Content & Methodology

Database:
- 14 Remediation Projects Performed in Brazil
- Groundwater / Soil / Waste remediation

Economics:
- Exchange Rate ($/R$)
- Present Value Calculation ($)

Remediation Management:
- Costs ($/m³)
- Efficiency (% reduction)
- Timeframe (years)
Exchange Rate Fluctuation

Average Exchange Rate ($ / R$): 2.0
Annual Inflation (%) in Brazil

Average Inflation (2000 to 2010): 9% per year
Groundwater Management Remediation Technologies

ISCO (4)
Air-Sparging (1)
DPE (1)
Bioremediation SRS (1)

Remediation Projects: 7
Project # 1: ISCO

Main Contaminants:
PCE and degradation products
Treatment Area: 21,960 m²
Treatment Thickness: 4 m
Treatment Volume: 87,840 m³
Contaminant Reduction: 93%
Total Value: $ 2,185,000
Cost: $/m³ 25

September 2006

June 2008
Project # 2: ISCO

Main Contaminants:
PCE and degradation products
Treatment Area: 8,000 m²
Treatment Thickness: 8 m
Treatment Volume: 64,000 m³
Contaminant Reduction: 53%
Total Value: $1,126,000
Cost: $/m³ 18
Project # 3: ISCO

Main Contaminants:
PCE and degradation products
Treatment Area: 3,564 m²
Treatment Thickness: 5 m
Treatment Volume: 17,800 m³
Contaminant Reduction: 96%
Total Value: $ 467,000
Cost: $/m³ 26
Project # 4: ISCO

Main Contaminants:
PCE and degradation products

Treatment Area: 1,176 m²
Treatment Thickness: 20 m
Treatment Volume: 23,520 m³
Contaminant Reduction: 97 %
Total Value: $ 1,403,000
Cost: $/m³ 60

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Project # 5: Air-Sparging

Main Contaminants: Ethylbenzene and Styrene
Treatment Area: 7,296 m²
Treatment Thickness: 4 m
Treatment Volume: 29,184 m³
Contaminant Reduction: 94%
Total Value: $1,218,000
Cost: $/m³ 42
Project # 6: DPE

Main Contaminants:
PCE and Degradation Products

Treatment Area: 1,944 m²
Treatment Thickness: 16 m
Treatment Volume: 31,104 m³
Contaminant Reduction: 90%
Total Value: $1,416,000
Cost: $/m³ 46
Project # 7: Bioremediation

Main Contaminants: PCE and Degradation Products
Treatment Area: 2,000 m²
Treatment Thickness: 12 m
Treatment Volume: 24,000 m³
Contaminant Reduction: 98 %
Total Value: $1,438,000
Cost: $/m³ 60

September 2008

March 2011

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Soil and Waste Management Remediation Technologies

- Waste Removal (4)
- Capping (1)
- Soil Shredder (1)
- SVE (1)

Projects: 7
Project # 8: Waste Removal

Main Contaminants:
Metals

Treatment Area: 49,900 m²
Treatment Thickness: 1.7 m
Treatment Volume: 85,600 m³
Contaminant Reduction: 100 %
Period: April 2010 – December 2010
Total Value: $ 10,161,000
Cost: $/m³ 119 (Non-Hazardous)
Project # 9: Waste Removal

Main Contaminants:
Metals
Treatment Area: 6,900 m²
Treatment Thickness: 1.2 m
Treatment Volume: 8,300 m³
Contaminant Reduction: 100 %
Period: April 2004 – October 2004
Total Value: $ 1,445,000
Cost: $/m³ 174 (Non Hazardous)
Project # 10: Waste Removal

Main Contaminants:
Styrene

Treatment Area: 260 m²
Treatment Thickness: 4.6 m
Treatment Volume: 1,200 m³
Contaminant Reduction: 100 %
Period: September 2008 – November 2008
Total Value: $ 885,000
Cost: $/m³ 735 (Hazardous)
Project # 11: Waste Removal

Main Contaminants:
BTEX

Treatment Area: 186 m²
Treatment Thickness: 3 m
Treatment Volume: 570 m³
Contaminant Reduction: 100 %
Period: October 2005 – December 2005
Total Value: $ 448,000
Cost: $/m³ 791 (Hazardous)
Project # 12: Capping

Main Contaminants:
Metals
Treatment Area: 14,530 m²
Treatment Thickness: 2.3 m
Treatment Volume: 33,850 m³
Contaminant Reduction: 0 %
Period: April 2011 – December 2011
Total Value: $ 1,395,000
Cost: $/m³ 41
Project # 13: Soil Shredder

Main Contaminants: PCE and degradation products
Treatment Area: 2,708 m²
Treatment Thickness: 4 m
Treatment Volume: 10,835 m³
Contaminant Reduction: 99%
Period: June 2007 to December 2007
Total Value: $1,085,000
Cost: $/m³ 100
Project # 14: SVE

Main Contaminants:
PCE and degradation products
Treatment Area: 5,520 m²
Treatment Thickness: 6 m
Treatment Volume: 33,120 m³
Contaminant Reduction: 95 %
Period: June 2007 to March 2010
Total Value: $ 621,000
Cost: $/m³
Groundwater Management Results

![Graphs showing cost, volume, reduction, and period for different groundwater management techniques.]

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Results Summary

Groundwater / Soil & Waste Remediation

- ISC0 #1
- ISC0 #2
- ISC0 #3
- ISC0 #4
- ISC0 #5
- ISC0 #6
- ISC0 (SRS) #7
- Waste Removal #8
- Waste Removal #9
- Waste Removal #10
- Capping #11
- Soil Shredder #12
- SVE #13
- SVE #14

Cost $/m³  Reduction (%)
## Conclusions

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<thead>
<tr>
<th>Groundwater Remediation</th>
<th>Soil and Waste Remediation</th>
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<tbody>
<tr>
<td>Costs range: $/m³ 18 to 60</td>
<td>Costs range: 19 to 792 $/m³</td>
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<td>Period range: 1 to 3.6 years</td>
<td>Period range: 0.2 to 2.8 years</td>
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<td>Efficiency: 50% to 99%</td>
<td>Efficiency:</td>
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<td></td>
<td>- Capping: 0%</td>
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<td>- Soil Treat. Range: 95% to 99%</td>
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<td>- Removal: 100%</td>
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Future Work: Address Project Life Cycle Costs (from Phase I to Site Closure)