Integrating Sustainability Principles in the Selection of a Remedial Option: A Case Study in the Oil and Gas Sector


Sustainable Remediation
Presentation Content

- Introduction
- Context
- Sustainable Remediation
- Developed Framework
- Case Study: Oil and Gas sector
- Conclusions
R&D Project for an Oil and Gas Company to Integrate Sustainability Principles into Contaminated Sites Management Using GoldSET©

**Project objectives:**
- develop a framework specific to the oil and gas sector;
- perform an integrated evaluation of remedial options at two preselected sites using the developed framework; and,
- evaluate the resulting sustainability performance for different remedial scenarios.

**Framework objectives:**
- must reinforce compliance;
- must assess remedial options in the context of an industrial site where pipelines could be located within the impacted zone;
- must assess appropriateness of remedial options regarding site specific context; and,
- should allow indirect stakeholder involvement.
What is Sustainable Remediation?
“remedy or combination of remedies whose net benefit on human health and the environment is maximized through the judicious use of limited resources and provides the best combined solution when considering environmental, social, and economic considerations” (SuRF).

Why Sustainable Remediation?
“balancing economic viability, conservation of natural resources and biodiversity, and the enhancement of the quality of life in surrounding communities” (SuRF)

How to Integrate Sustainable Remediation?
“through the application of tools or calculators that measure the sustainability of remediation technologies according to certain metrics” (ITRC).
Proposed Framework Based on GoldSET

### Problem Formulation

- **Step 1:**
  - Review of available information (previous investigations, databases, etc)
  - 3D site conceptual modelling
- **Step 2:**
  - Technical prefeasibility (fatal flaw analysis)
- **Step 3:**
  - Literature review

### GoldSET – Iteration 1

- **Step 4A:**
  - Qualitative evaluation
  - Indirect stakeholders involvement - Indicator weighting
  - Client workshop - Indicator weighting
  - Selection of a subset of options for further investigation

### GoldSET – Iteration 2

- **Step 4B:**
  - Preliminary design of retained options
  - Process flowchart/diagram
  - Quantification of indicators (Water, Waste, Greenhouse Gas, Energy, Net present value, Duration)
  - Technical performance evaluation

### Interpretation & Decision Making

- **Step 5:**
  - Review of results: Sensitivity and Optimization Analyses
  - Reporting
Case Study : Context

Large Industrial Facility

- Active since late 1950s.
- Located in an agricultural surrounding
- Presence of a historical landfill on site
- Impacted soils and groundwater
- Pipelines within the impacted zone
- Adjacent to a Creek
- Located within a wetland
- Water table 1.5 m below ground surface
- Water source (Agricultural and Irrigation uses)

Image Source: Golder Associés ltée, 2011
## Problem Formulation

<table>
<thead>
<tr>
<th>Technical Criteria</th>
<th>Site Specificities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objectives</strong></td>
<td>Comply with the Provincial and CCME guidelines. Prevent off-site migration of contaminated groundwater. Prevent any damage to pipelines</td>
</tr>
<tr>
<td><strong>Nature of Media and Contaminants</strong></td>
<td>3 zones : Silt/Sand/Clay. Soil contaminants (% of total contamination weight): Phenols (0.1%wt), PH F2 (1.2%wt), PH F3 (97.5%wt), PCBs (1.1%wt). Groundwater contaminants: All of the above, plus dissolved metals</td>
</tr>
<tr>
<td><strong>Physical Constraints</strong></td>
<td>Adjacent Creek located to the southeast. Natural gas pipelines within the impacted zone. Meter building located nearby to the west.</td>
</tr>
<tr>
<td><strong>Health and Safety Considerations</strong></td>
<td>Multiple underground sensitive infrastructures (including gas pipelines)</td>
</tr>
<tr>
<td><strong>Environmental Impacts</strong></td>
<td>Migration towards the adjacent Creek, groundwater (livestock water, irrigation, domestic uses), agricultural lands, wetlands, biodiversity, etc.</td>
</tr>
<tr>
<td><strong>Social Impacts</strong></td>
<td>Workers safety, traffic, land use, etc.</td>
</tr>
</tbody>
</table>
## Case Study: Option Development

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Retained or Rejected/ Reasons for Rejection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phytoremediation (0–1.5 m) &amp; Soil Heating &amp; ISCO (1.5-6 m)</td>
<td>Retained / -</td>
</tr>
<tr>
<td>Dig &amp; On-Site Treatment (0-2 m) Soil Heating &amp; ISCO (2-6 m)</td>
<td>Retained / -</td>
</tr>
<tr>
<td>Bioventing (0-2 m) Soil Heating &amp; ISCO (2-6 m)</td>
<td>Retained / -</td>
</tr>
<tr>
<td>Excavation &amp; Disposal</td>
<td>Rejected / Numerous underground installations, water infiltration</td>
</tr>
<tr>
<td>Soil Flushing &amp; Pump and Treat</td>
<td>Rejected / Soil heterogeneity, surface water nearby</td>
</tr>
<tr>
<td>Soil Heating</td>
<td>Rejected / Shallow soils, low volatility of PCBs</td>
</tr>
<tr>
<td>ISCO</td>
<td>Rejected for deep and shallow soils, high contaminant mass Retained for hot spot PCBs</td>
</tr>
<tr>
<td>Bioremediation</td>
<td>Rejected for deep and shallow soils, high contaminant mass, not effective on PCBs</td>
</tr>
<tr>
<td>Natural Attenuation &amp; Long-term Monitoring</td>
<td>Rejected/ - impacts on surface water</td>
</tr>
</tbody>
</table>
GoldSET Evaluation – Iteration 1 (Qualitative)

A 5-Step Evaluation Process

1. Background information
2. Scenario Description
3. Indicators selection
4. Scoring of indicators
5. Interpretation & Decision Making

Environmental Aspect

<table>
<thead>
<tr>
<th>Code</th>
<th>Indicator</th>
<th>Phytoremediation &amp; Soil Heating &amp; ISCO</th>
<th>Dig &amp; On-Site treatment &amp; Soil heating &amp; ISCO</th>
<th>Bioventing &amp; Soil heating &amp; ISCO</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENV-1</td>
<td>Soil Quality</td>
<td>0</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>ENV-2</td>
<td>Contaminated Soil Erosion and Transport</td>
<td>33</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>ENV-3</td>
<td>Groundwater Quality</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>ENV-4</td>
<td>Waterborne Contaminant Migration</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>ENV-5</td>
<td>Water Usage</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>ENV-6</td>
<td>Impacts on Fauna and Flora Resulting from the Project</td>
<td>100</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>ENV-7</td>
<td>Impacts on Fauna and Flora During the Project</td>
<td>50</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>ENV-8</td>
<td>Greenhouse Gas Emissions</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ENV-9</td>
<td>Energy Consumption</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ENV-10</td>
<td>Quantity of Wastes</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>ENV-11</td>
<td>Residual Impact of Technology</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Social Aspect

Phytoremediation & Soil Heating & ISCO

<table>
<thead>
<tr>
<th>Environment</th>
<th>Society</th>
<th>Economics</th>
</tr>
</thead>
<tbody>
<tr>
<td>59%</td>
<td>58%</td>
<td>49%</td>
</tr>
</tbody>
</table>

Dig & On-Site treatment & Soil heating & ISCO

<table>
<thead>
<tr>
<th>Environment</th>
<th>Society</th>
<th>Economics</th>
</tr>
</thead>
<tbody>
<tr>
<td>52%</td>
<td>32%</td>
<td>60%</td>
</tr>
</tbody>
</table>

Bioventing & Soil heating & ISCO

<table>
<thead>
<tr>
<th>Environment</th>
<th>Society</th>
<th>Economics</th>
</tr>
</thead>
<tbody>
<tr>
<td>60%</td>
<td>58%</td>
<td>60%</td>
</tr>
</tbody>
</table>

June 11, 2012
Case Study: Preliminary Design

Option 1
- Phytoremediation
- Soil Heating
- ISCO
- Bioremediation

Option 2
- Dig & On-Site Treatment
- Soil Heating
- ISCO
- Bioventing
- Bioremediation

Option 3
- Soil Heating
- ISCO
- Bioventing
- Bioremediation

Image Source: Enbridge Inc., based on the National Energy Board (NEB) safety procedures.
## Background Information

### Scoring of Indicators

**Scenario Description**

1. **Indicators Selection**

   - A 5-Step Evaluation Process

   1. **Interpretation & Decision Making**

   2. **Scoring of Indicators**

   3. **Indicators Selection**

   4. **Scenario Description**

   5. **Background Information**

   - **Environmental Aspect**
     - Code
     - Indicator
     - Phyto remediation & Thermal Desorption & ISCO
     - Dig/On-Site treatment & Thermal Desorption & ISCO
     - Bioventing & Thermal Desorption & ISCO

   - **Technical Aspect**
     - Environment
     - Technical

   - **Economic Aspect**
     - Environment
     - Technical

   - **Society**

   - **Public Elevation (Duration of Works):** 22 Years

   - **Net Present Value of Optimal Costs:** $2,206,460

   - **Net Present Value of Optimal Costs:** $2,093,469

   - **Net Present Value of Optimal Costs:** $1,787,106

   - **Year 10 Costs:**

   - **Year 11 Costs:**

   - **Year 12 Costs:**

   - **Year 13 Costs:**

   - **Year 14 Costs:**

   - **Year 15 Costs:**

   - **Year 16 Costs:**

   - **Year 17 Costs:**

   - **Year 18 Costs:**

   - **Year 19 Costs:**

   - **Year 20 Costs:**

   - **Year 21 Costs:**

   - **Year 22 Costs:**

   - **Year 23 Costs:**

   - **Year 24 Costs:**

   - **Year 25 Costs:**

   - **Year 26 Costs:**

   - **Year 27 Costs:**

   - **Year 28 Costs:**

   - **Year 29 Costs:**

   - **Year 30 Costs:**
## Interpretation & Decision Making Grid

### The Grid:
- Only presents the differentiators
- Supports a transparent decision
- Helps to understand differences
- Highlights optimization potential
- Helps to communicate results

<table>
<thead>
<tr>
<th>INDICATOR</th>
<th>Phytoremediation with Thermal Desorption &amp; ISCO</th>
<th>Dig &amp; On-Site treatment with Thermal Desorption &amp; ISCO</th>
<th>Bioventing with Thermal Desorption &amp; ISCO</th>
<th>WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contaminated Soil Erosion and Transport</td>
<td>33</td>
<td>0</td>
<td>66</td>
<td>3</td>
</tr>
<tr>
<td>Water Usage</td>
<td>0</td>
<td>99</td>
<td>100</td>
<td>4</td>
</tr>
<tr>
<td>Greenhouse Gas Emissions</td>
<td>100</td>
<td>45</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Energy Consumption</td>
<td>100</td>
<td>33</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Residual Impact of Technology</td>
<td>66</td>
<td>33</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>Worker’s Health and Safety</td>
<td>66</td>
<td>33</td>
<td>66</td>
<td>3</td>
</tr>
<tr>
<td>Direct Local Employment</td>
<td>66</td>
<td>66</td>
<td>33</td>
<td>1</td>
</tr>
<tr>
<td>Public Disruption (Duration of Work)</td>
<td>0</td>
<td>100</td>
<td>94</td>
<td>3</td>
</tr>
<tr>
<td>Quality of Life (During the Project)</td>
<td>100</td>
<td>66</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>Impact on the Landscape</td>
<td>100</td>
<td>66</td>
<td>100</td>
<td>2</td>
</tr>
<tr>
<td>Management Practices</td>
<td>75</td>
<td>50</td>
<td>50</td>
<td>3</td>
</tr>
<tr>
<td>Net Present Value of Options’ Costs</td>
<td>4</td>
<td>0</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>Potential Litigation</td>
<td>50</td>
<td>90</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td>Corporate Image</td>
<td>100</td>
<td>90</td>
<td>90</td>
<td>3</td>
</tr>
<tr>
<td>Proof of Concept</td>
<td>25</td>
<td>50</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td>Complexity of construction and/or assembly</td>
<td>50</td>
<td>25</td>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>Decommissioning</td>
<td>50</td>
<td>25</td>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>Adaptability of the technology</td>
<td>50</td>
<td>25</td>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>Reusability of the equipment</td>
<td>66</td>
<td>100</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>Technological Uncertainty</td>
<td>25</td>
<td>50</td>
<td>50</td>
<td>3</td>
</tr>
</tbody>
</table>

**Total for Weights = 3**
- Phytoremediation: 3177
- Dig & On-Site: 3237
- Bioventing: 3816

**Total for Weights = 2**
- Phytoremediation: 1016
- Dig & On-Site: 844
- Bioventing: 766

**Total for Weights = 1**
- Phytoremediation: 803
- Dig & On-Site: 789
- Bioventing: 838

**Grand Total**
- Phytoremediation: 32.7%
- Dig & On-Site: 31.9%
- Bioventing: 35.5%

**Bold:** Very important indicators

**Highlights:** most performing option(s)

**Presents:** points per importance

**Presents:** overall percentage
The client aimed at integrating sustainability principles into one simple solution involving stakeholders. We provided a framework applicable to any contaminated site with sensitive infrastructures, addressing client's concerns.

Integrating SD Principles

Involving Stakeholders

Addressing client’s concerns
Questions?

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