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**National Association
of Remedial Project Managers**

Green Remediation

**Estimating the Environmental Footprint
at a Corrective Action Clean-up**

Pilot Study at Romic East Palo Alto

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Green Remediation



Theory:

Consider all environmental effects of remedy implementation and incorporate options to maximize the net environmental benefit of cleanup actions.



Implementation:

Installation of “greener” remedies

Development of metrics for estimating environmental footprints

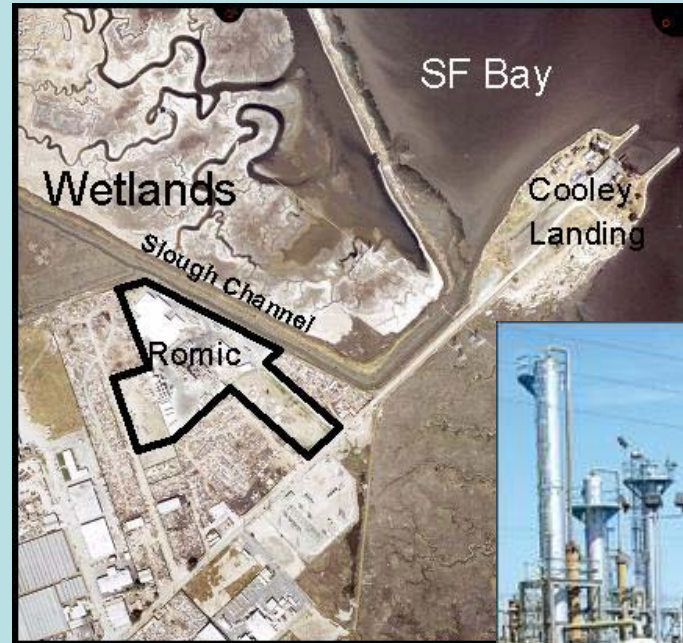
Overview



- ★ **How we conducted our Pilot Study:
methodology and results**
- ★ **Applying the results to our clean-up sites**
- ★ **Importance of using Life-Cycle Assessment
principles**

Pilot Site: Romic East Palo Alto

- 14-acre hazardous waste management facility
- Soil and ground water contaminated with VOCs (such as TCE and PCE)
- Contamination to a depth of 80 feet



Purpose of the Pilot Study



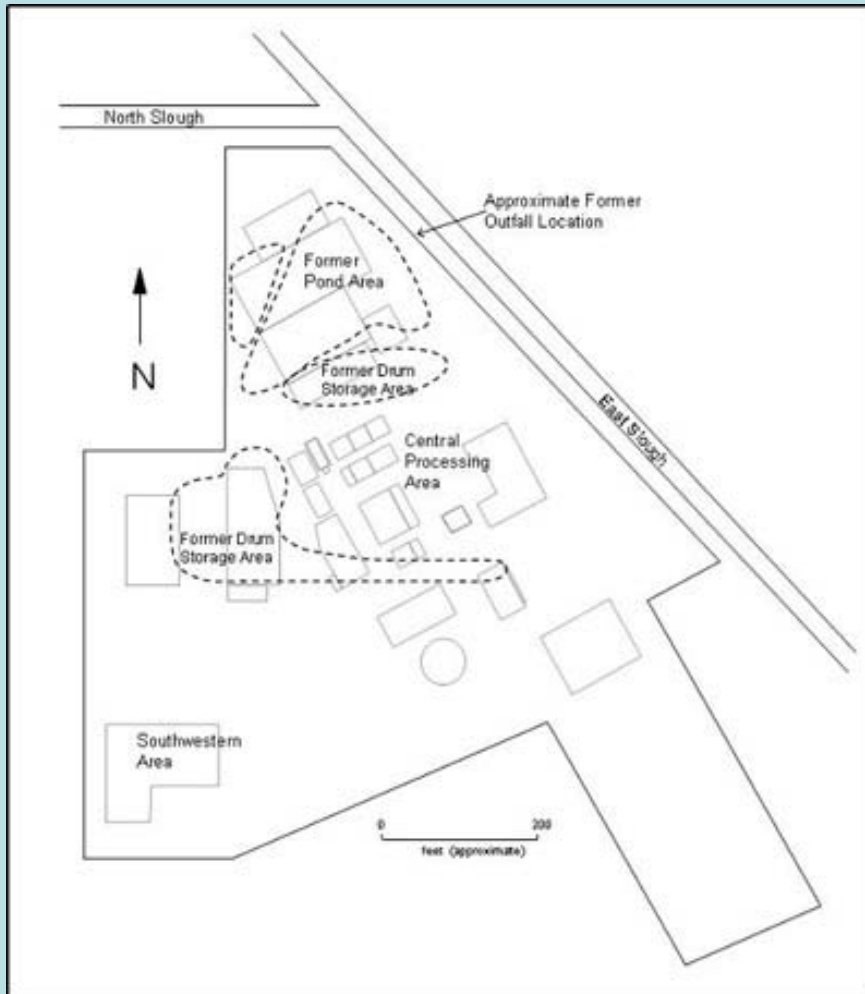
Compare the environmental footprints of three alternative remedies at Romic

- Is it possible to determine the environmental footprint of the alternative remedies?
- Did we select the “greenest” remedy?
- How important is off-site manufacture for the environmental footprint?



Develop a methodology to be used for estimating environmental footprints

Remedy Alternatives at Romic



Alternative 2 (Hybrid)

Extraction wells *and*
bioinjection wells

30 years to complete

Alternative 3 (Bioremediation)

Bioinjection wells only

10 years to complete

Alternative 4 (Pump and Treat)

Extraction wells only

40 years to complete

Alternative 3 has already been chosen for Romic, so this analysis did not affect the remedy decision.

Remedy Alternatives at Romic

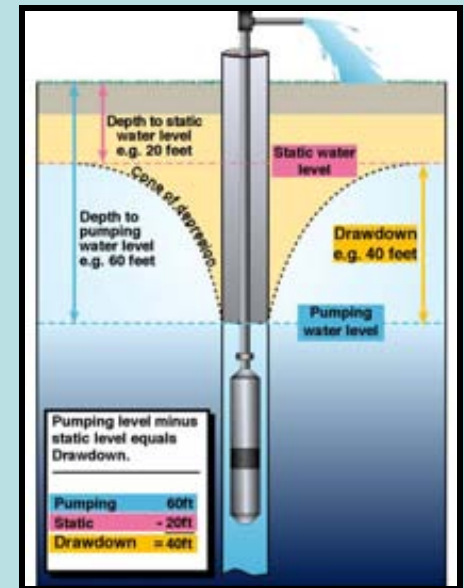


Bioremediation:

uses injections of cheese whey and molasses mixed with fresh water

Pump and Treat:

treatment of ground water in an air stripper followed by carbon filters



Boundaries of the Pilot Study



Functional Unit:

Ground water remediation.



Temporal Boundary:

Construction and active life of each alternative remedy.



System Boundary:

On-Site Activities (Level 1)

Transport To and From Site (Level 2)

Manufacture Off-Site (Level 3)

At Romac We Evaluated...

Resources and Energy Used

- Water
- Construction Materials
- Electricity
- Fossil Fuel



Wastes Generated

- Spent Carbon
- Wastewater



Air Emissions

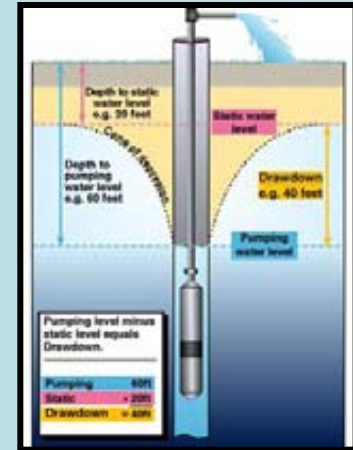
- NO_x, SO_x, PM, CO₂



Level 1: On-Site Activities



Well Construction



Groundwater Extraction



BioInjections

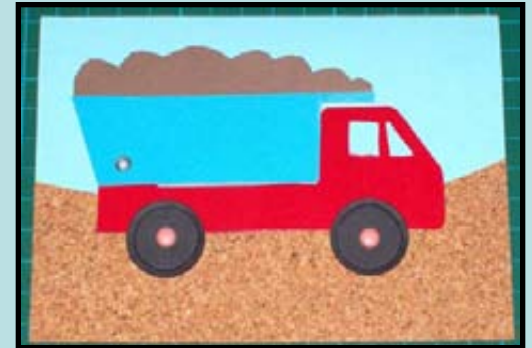


Groundwater Treatment

Level 2: Transport To and From Site



Operators to Site



Wastes off Site



Materials to Site

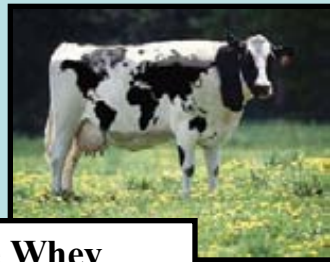
Level 3: Off-Site Manufacture



**PVC Pipe
Manufacture**



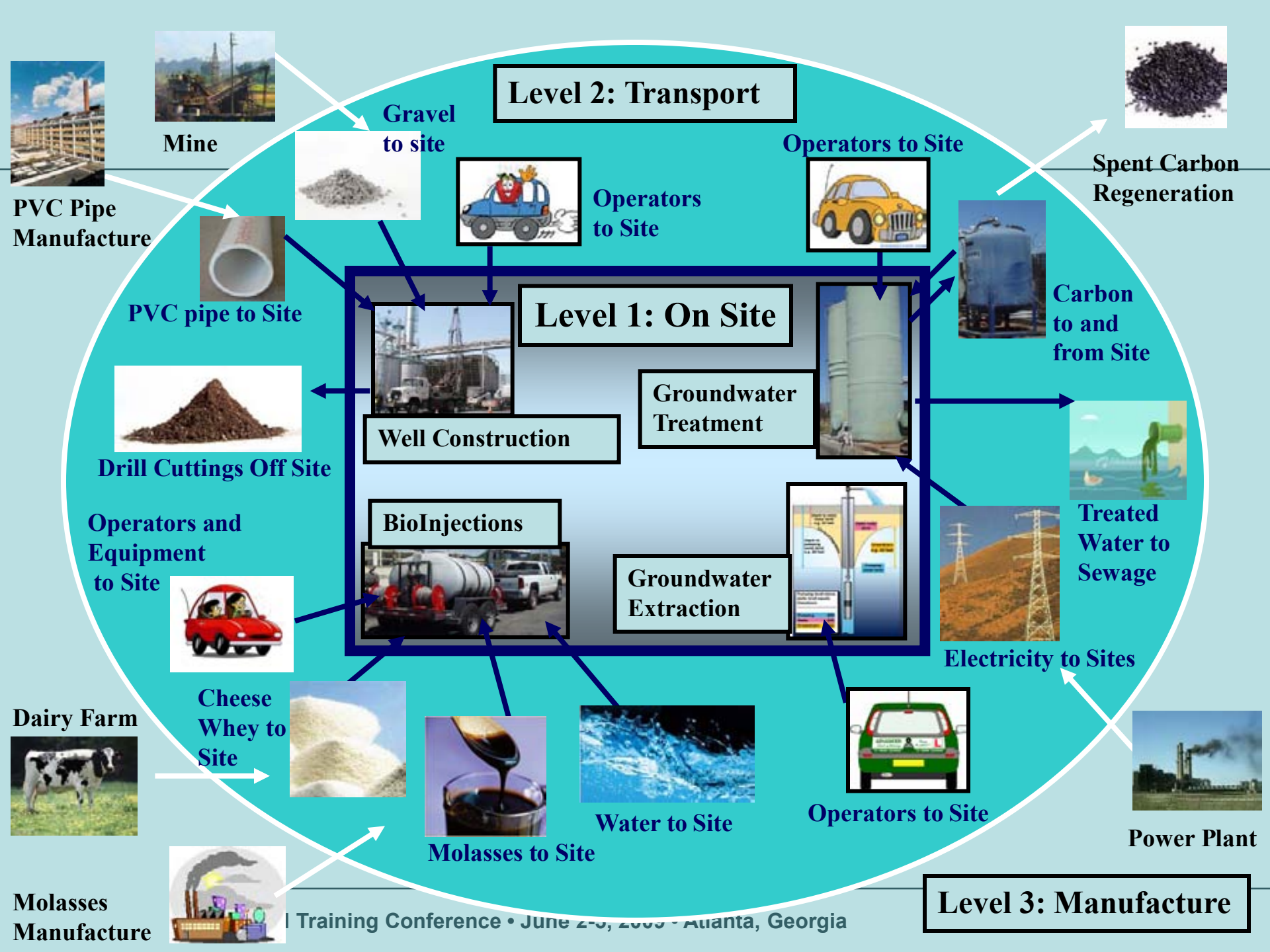
Gravel Mining



**Cheese Whey
Processing**



**Electricity
Production**

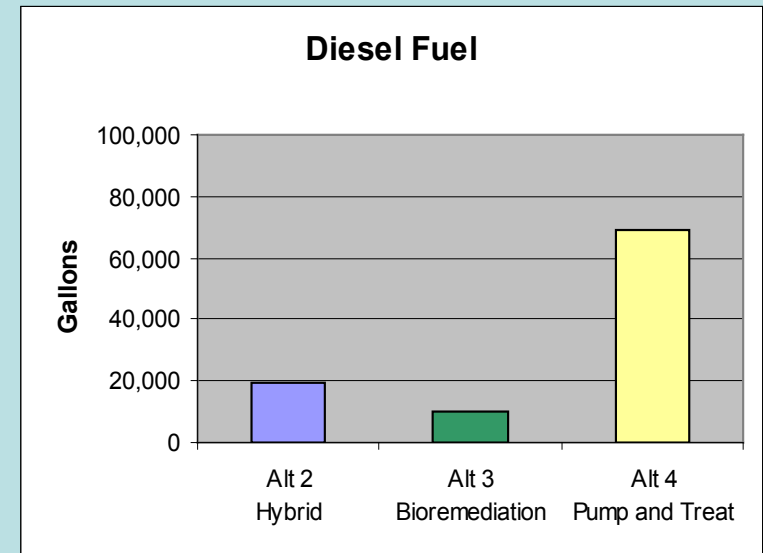
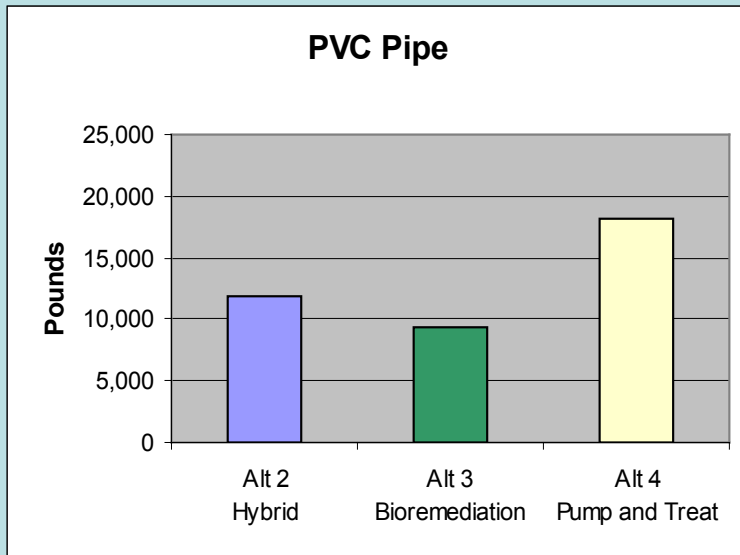




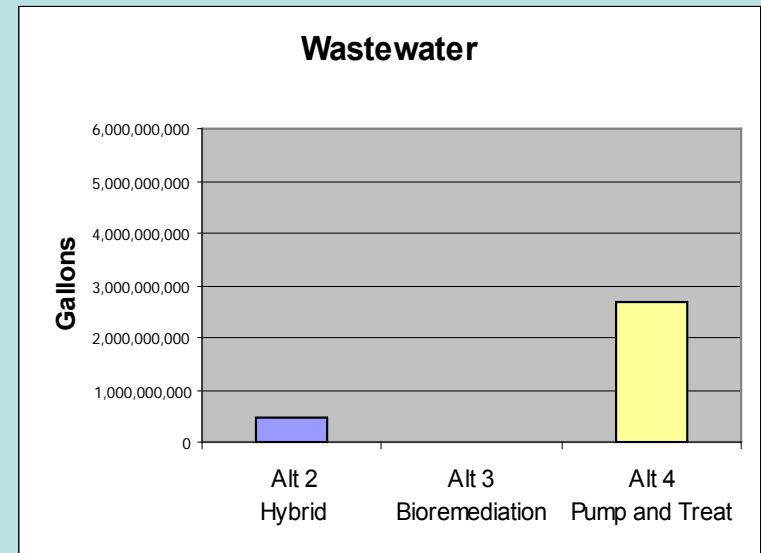
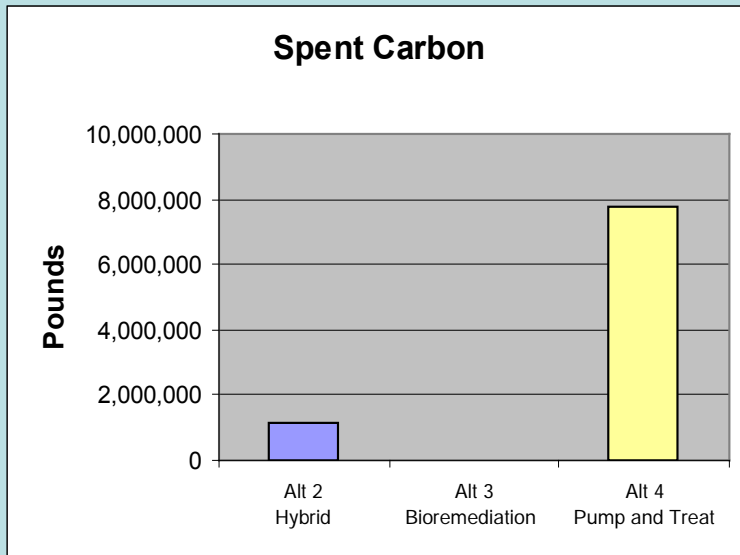
Results!

Pilot study is still in progress and results at this stage are preliminary.

Results – Materials and Fuel



Results – Wastes Generated

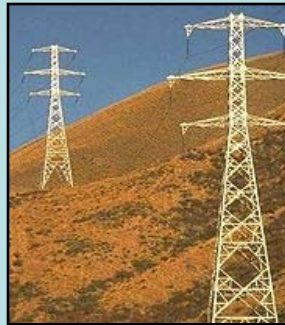


Levels 1, 2, and 3 Combined

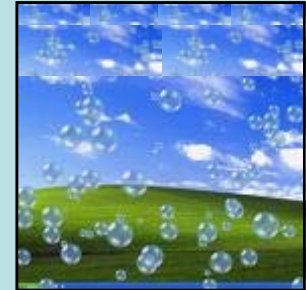
Adding Level 3 (Off-site Manufacture) to the mix



water used

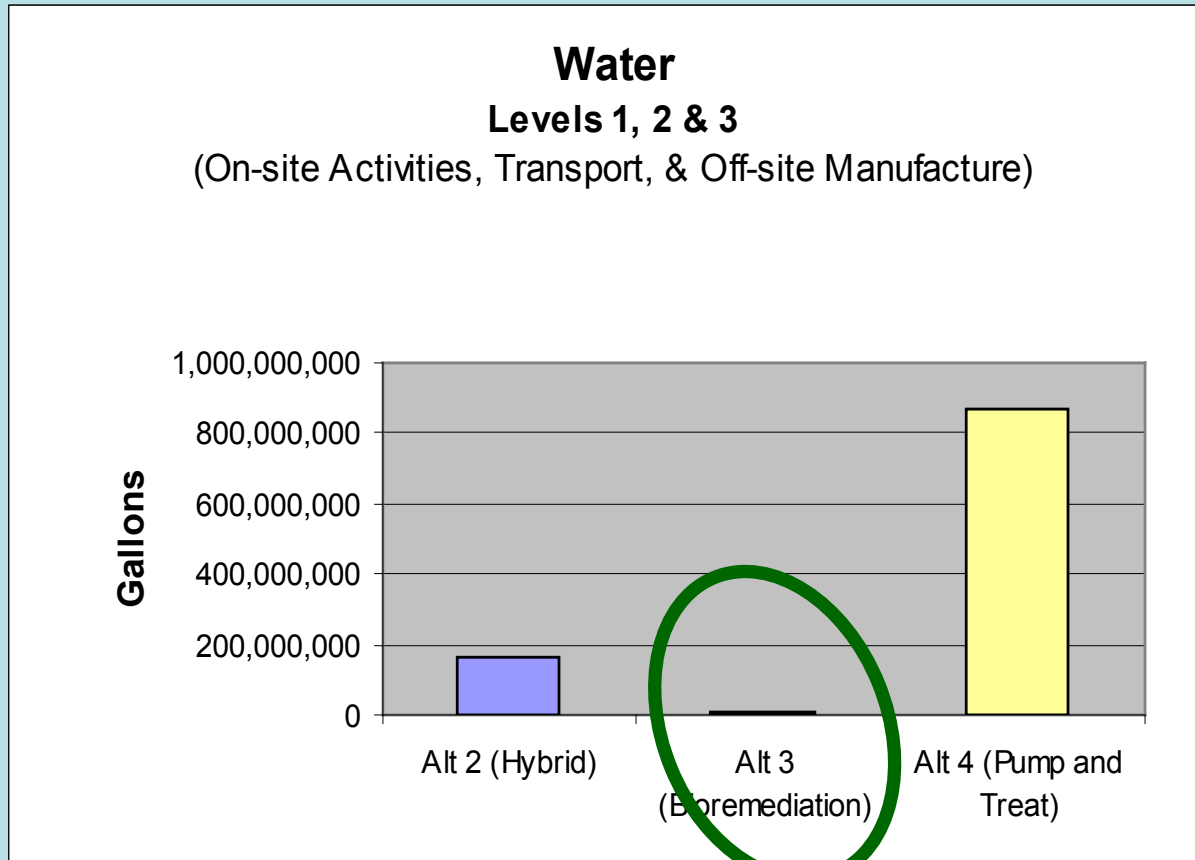


electricity required



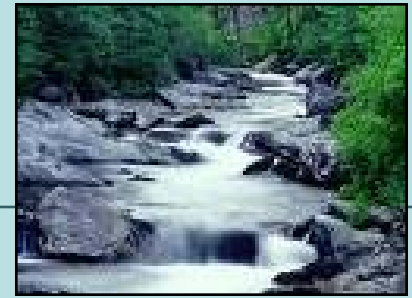
carbon dioxide emitted

Results – Water

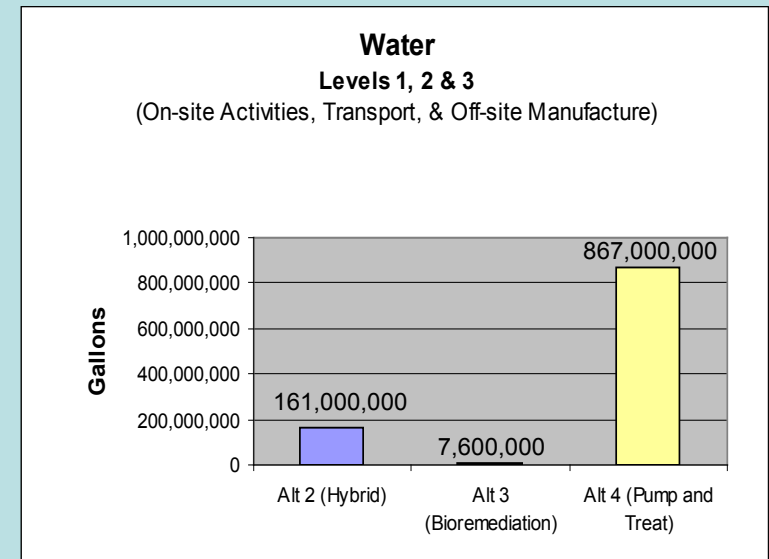
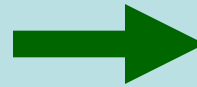
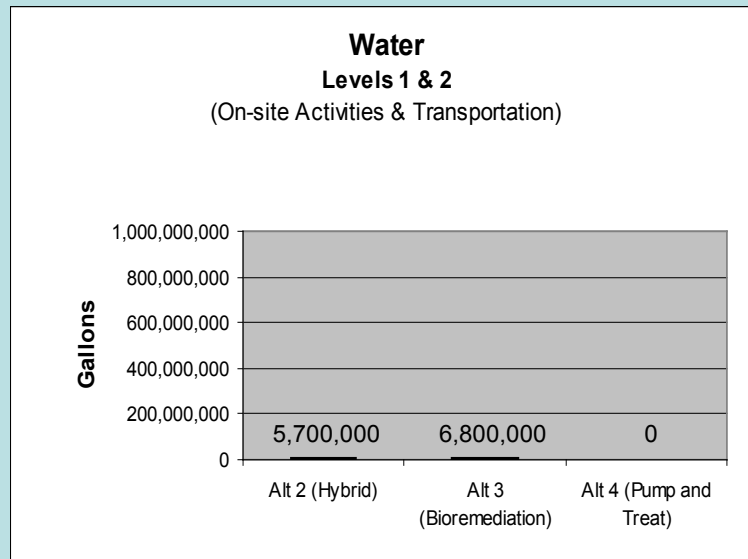


These values are for the life-time of each alternative remedy.

Results – Water



Including Level 3 (manufacturing) in the analysis substantially increases our estimate of the water footprint.



Not including off-site manufacturing

Including off-site manufacturing

Results – Water



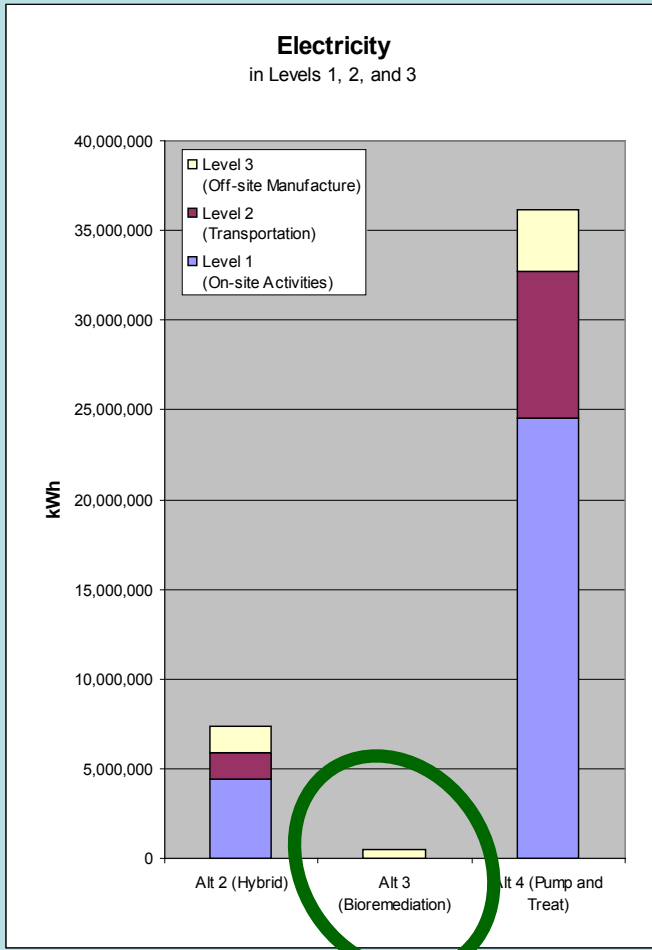
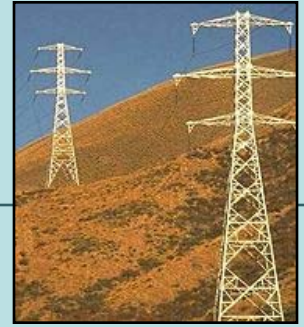
Issues related to water:

- Water withdrawn *versus* water consumed.
- Water withdrawn in “water scarce” areas *versus* water withdrawn in “water abundant” areas.
- Potable *versus* non-potable water.



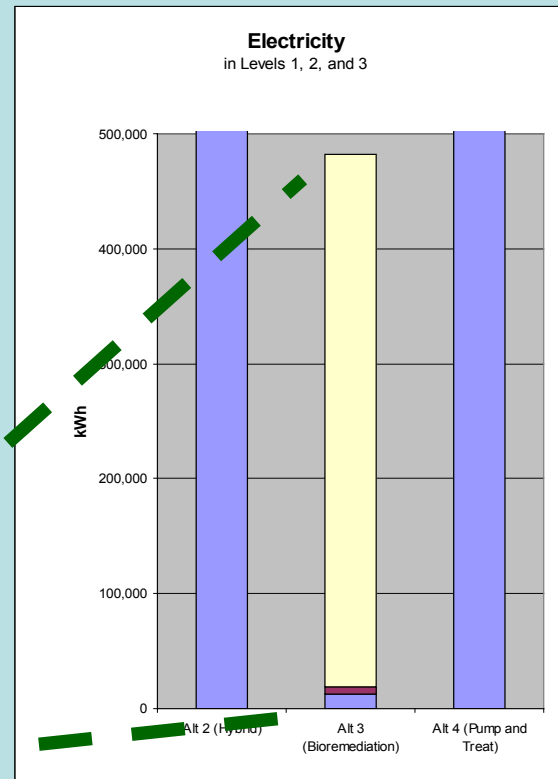
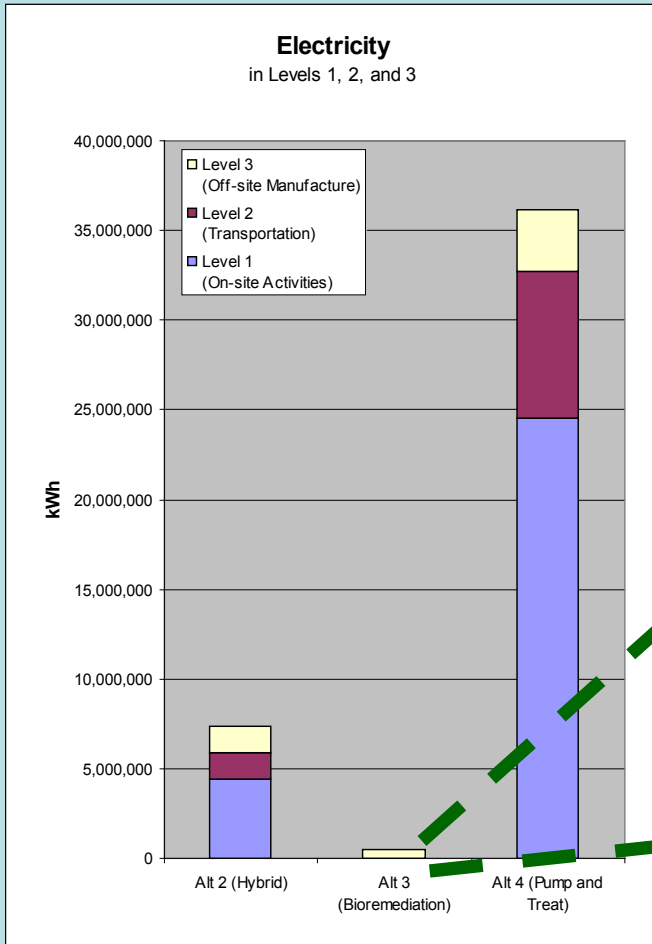
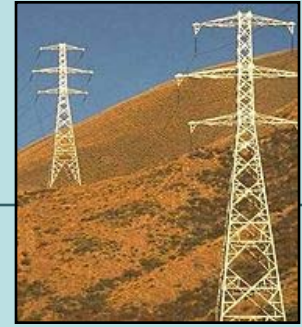
Maybe, not all water is equal... how should we take this into consideration?

Results – Electricity



These values are for the life-time of each alternative remedy.

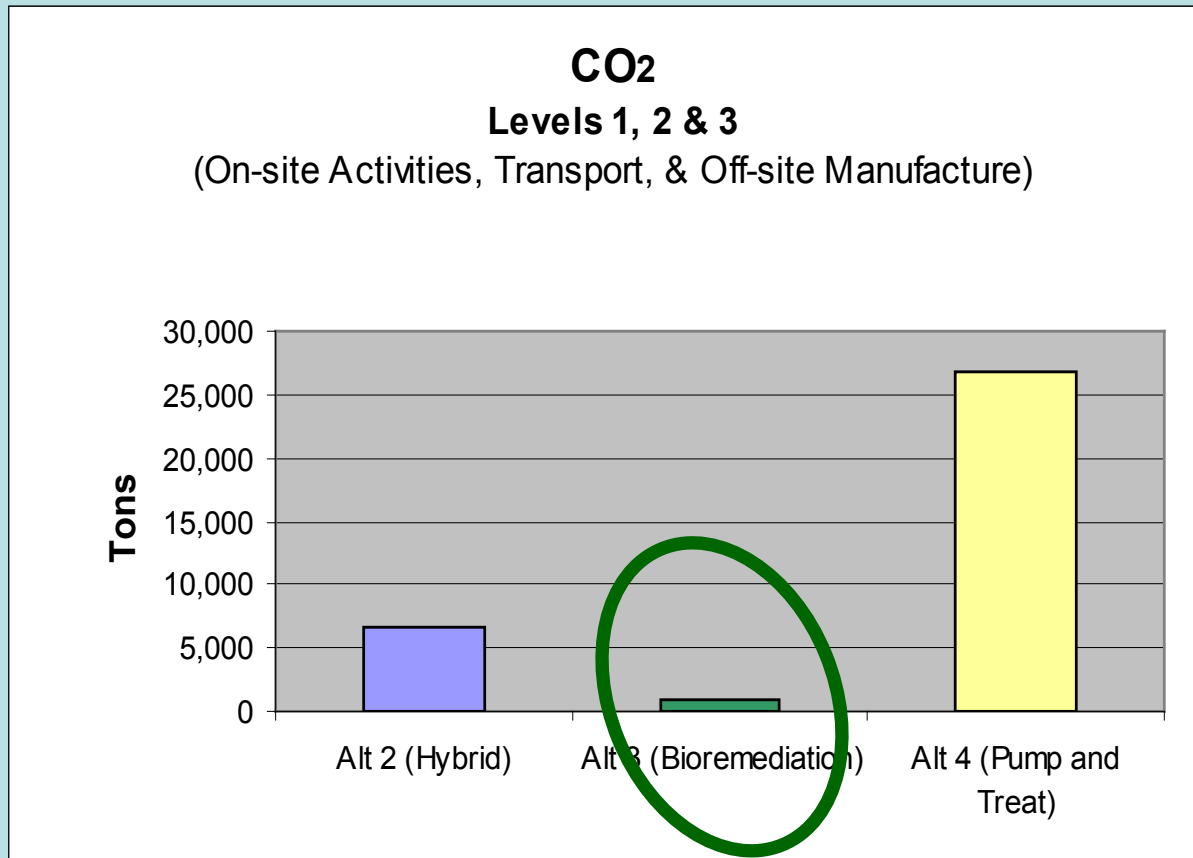
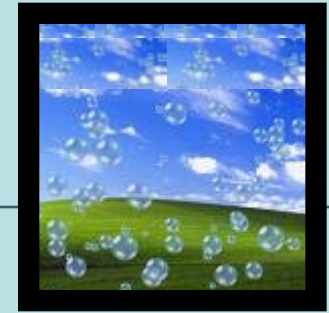
Results – Electricity



We are used to taking into account on-site electricity in evaluating environmental footprints.

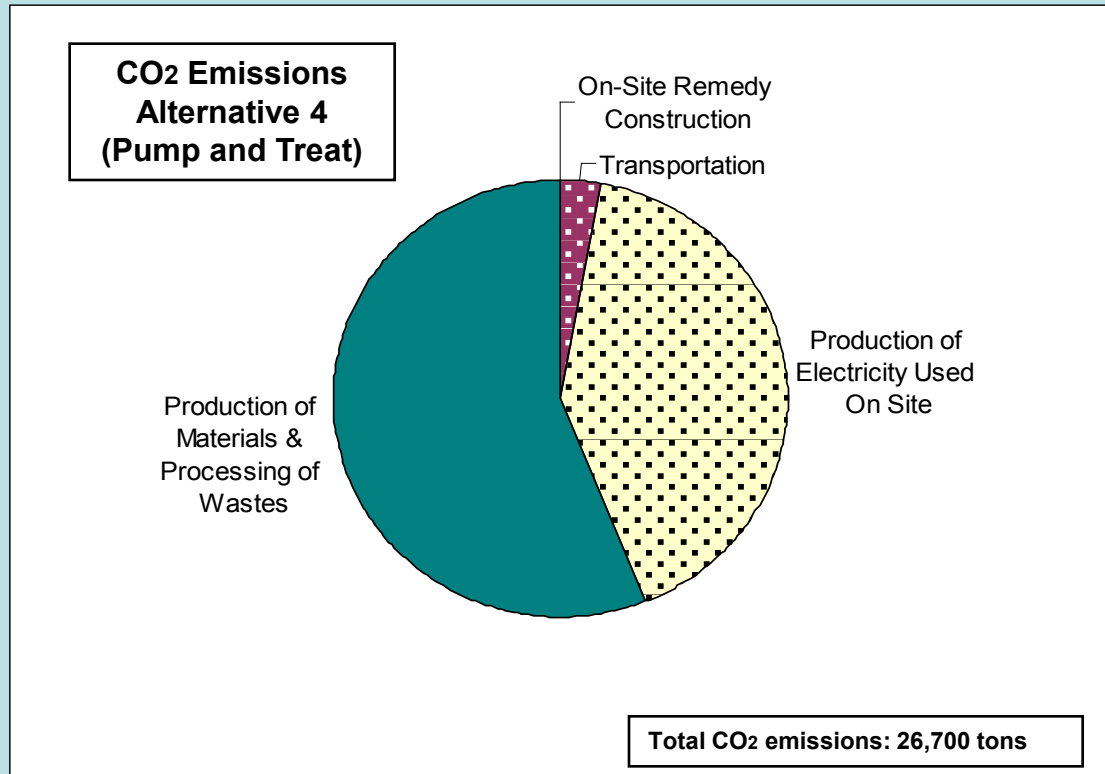
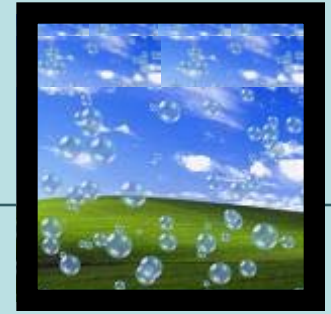
However, electricity required for transport and manufacture are also important.

Results – CO₂ Emissions



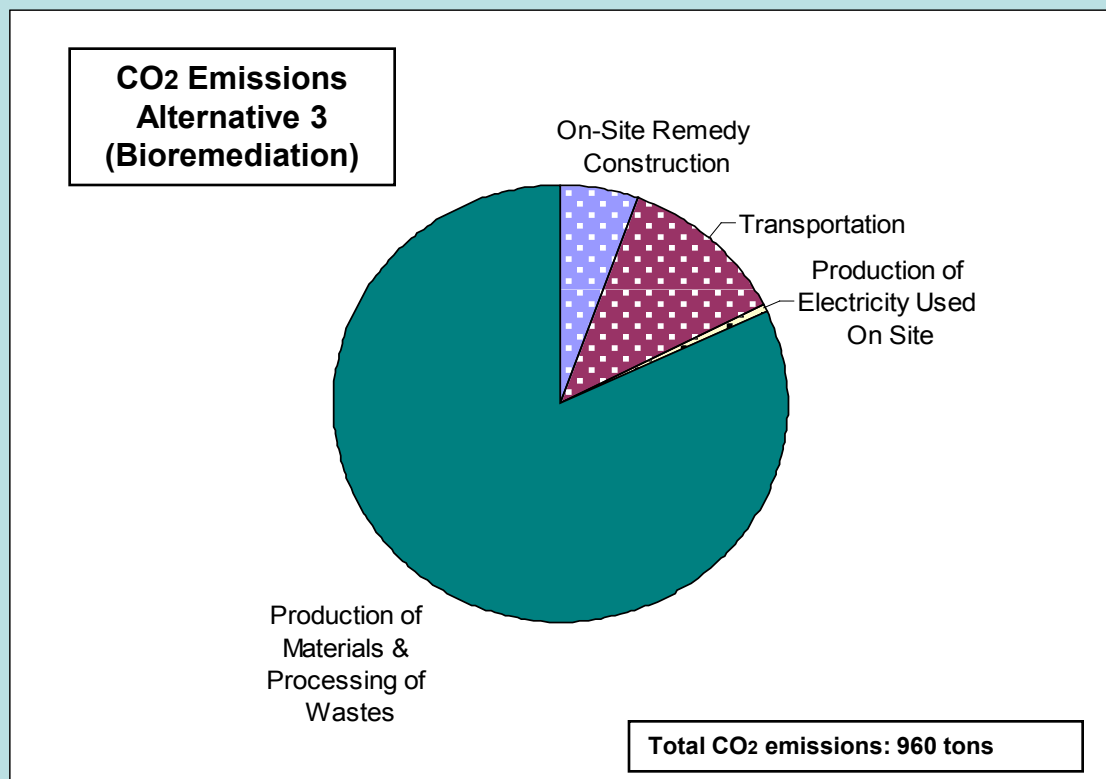
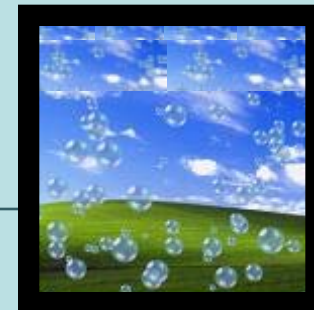
These values are for the life-time of each alternative remedy.

Results – CO₂ Emissions



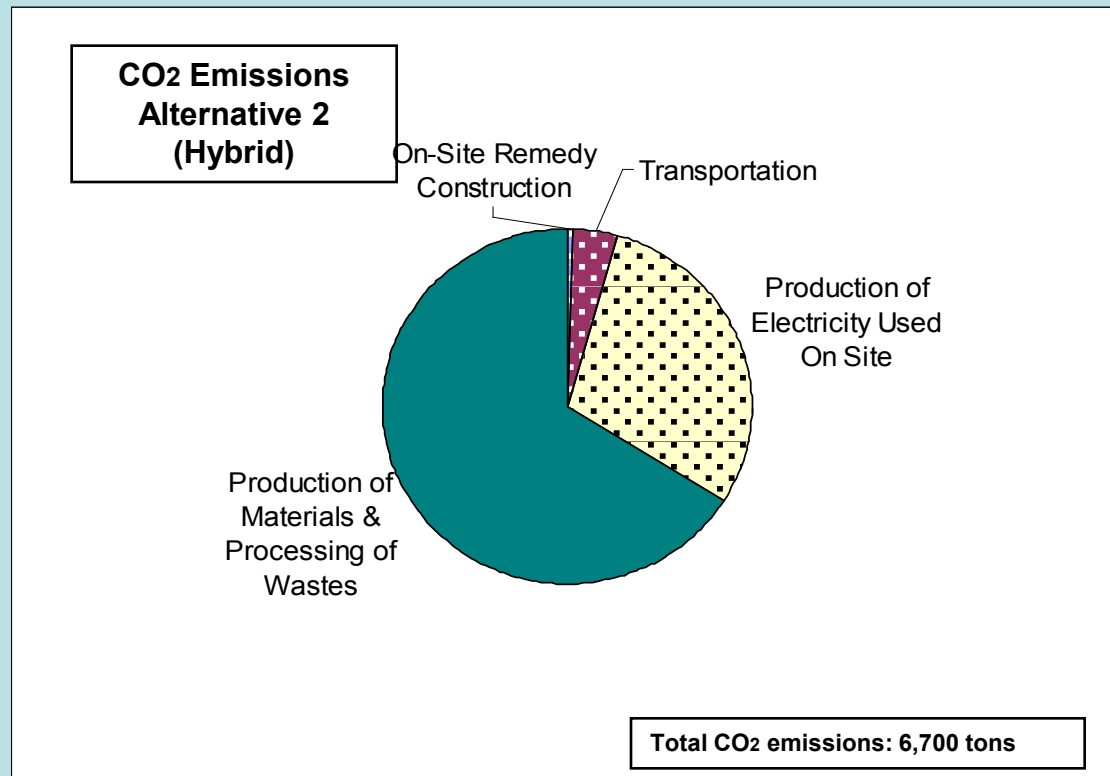
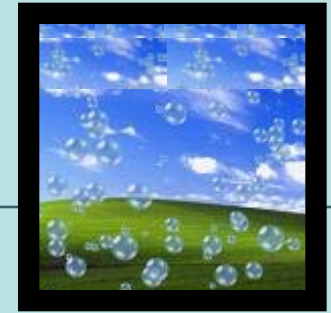
Off-site activities, even those not related to production of electricity used on-site, are a big part of the CO₂ footprint.

Results – CO₂ Emissions



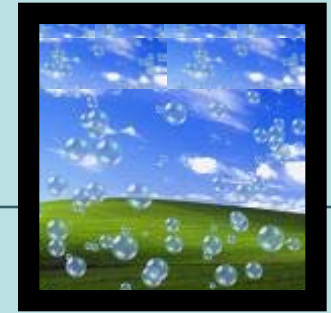
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Results – CO₂ Emissions



Off-site activities, even those not related to production of electricity used on-site, are a big part of the CO₂ footprint.

Results – CO₂ Emissions



Issues related to CO₂:

- Finding CO₂ emissions factors that include resource extraction as well as manufacturing.
- Taking into account likely lower emissions of CO₂ per unit material produced in the future.
- Being careful not to “double count” in reporting electricity requirements and CO₂ footprint of the remedy.



Identify which materials and activities contribute the greatest to the CO₂ footprint and research them thoroughly.

Applying results to our clean-up sites



We need to balance the various aspects of the environmental footprints.

Applying results to our clean-up sites



- **Balance local effects with global effects:**

water resources

greenhouse gas emissions

particulate emissions

- **Balance effects of disparate items:**

natural resource depletion

waste generation

environmental contamination

years to complete remedy

Applying results to our clean-up sites



Balancing disparate environmental impacts will be specific from site to site.



Metrics for environmental impacts are not the only factor at a clean-up site, but should be seen as one of several balancing factors.



In all cases the remedy must first meet threshold criteria, such as protection of human health and the environment.

Life-Cycle Assessment Principles

Improving the Pilot Study --

**We performed complete
(but back-of-the-envelope)
Level 3 calculations for:**

Water use
Electricity use
CO₂ emissions



**We would like to add
Level 3 calculations for:**

Wastes generated
Fossil fuels consumed
Air toxics emitted

We are working with EPA life-cycle analysis experts in ORD (Cincinnati) and with OSRTI to improve and add to our Level 3 calculations.

Life-Cycle Assessment Principles

Improving the Pilot Study --

Run calculations for other remedial activities at Romic:

- soil excavation
- groundwater monitoring
- capping contaminated areas



Life-Cycle Assessment Principles



Life-Cycle Assessment principles helped us greatly in developing our conceptual approach

- Quantify on- and off-site environmental impacts**
- Distinguish between local and global impacts**
- Compare relative impacts of remedial technologies in a more comprehensive way**
- Focus our efforts in reducing the environmental impacts of a remedy**

Life-Cycle Assessment Principles



Develop a methodology based on Life-Cycle Assessment principles for estimating environmental footprints

- **Conduct Pilot Studies at three additional sites**
- **Streamline the methodology**
 - identify aspects of remedies that make the largest contribution to the overall footprints and focus on those
- **Establish a library of data inputs**
- **Designed for regulatory staff and site owners in all clean-up programs**

Key Points

- ★ Yes, it's feasible to estimate the environmental footprint of a clean-up remedy.
- ★ Importance of including off-site manufacturing in estimations of the environmental footprint.
- ★ A streamlined methodology would be helpful for conducting this type of analysis at other sites.



Promoting Green Remediation



Reducing the Environmental Footprints of Our Site Clean-ups