



Steam Enhanced Remediation In Fractured Rock

(and a little about the other sites)

Gorm Heron, Scientist/Engineer

Hank Sowers, CEO/Chief Operator

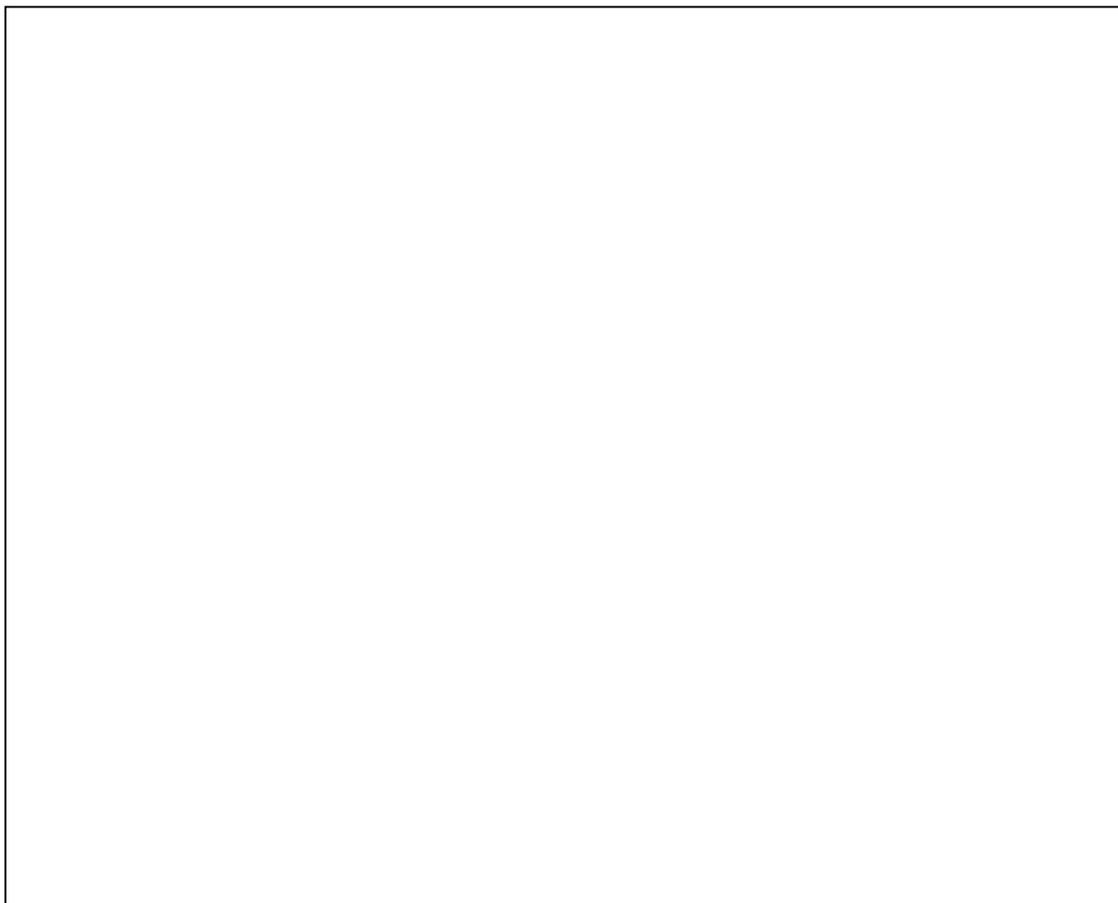
Dacre Bush, Geologist/Program Manager

Gregg Crisp, Site manager

SteamTech Environmental Services

Bakersfield, CA

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Visalia Pole Yard

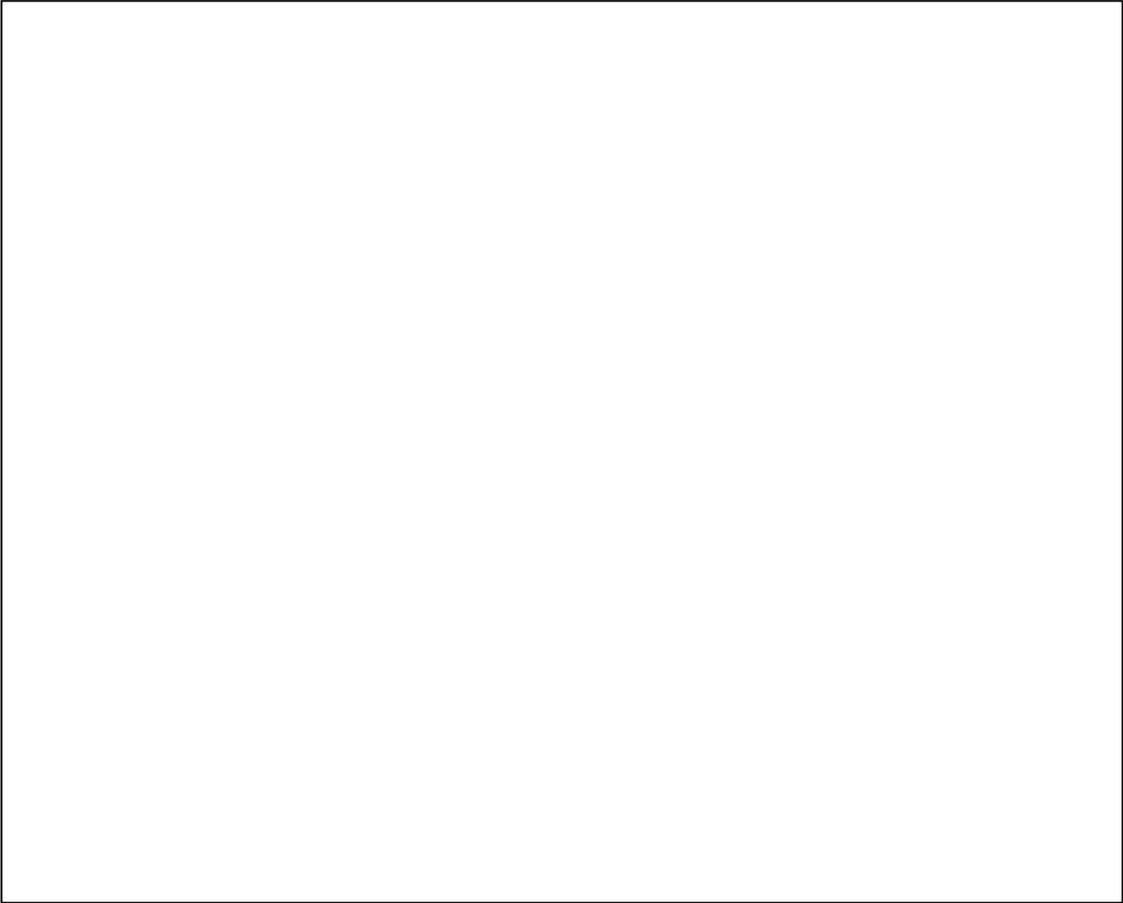
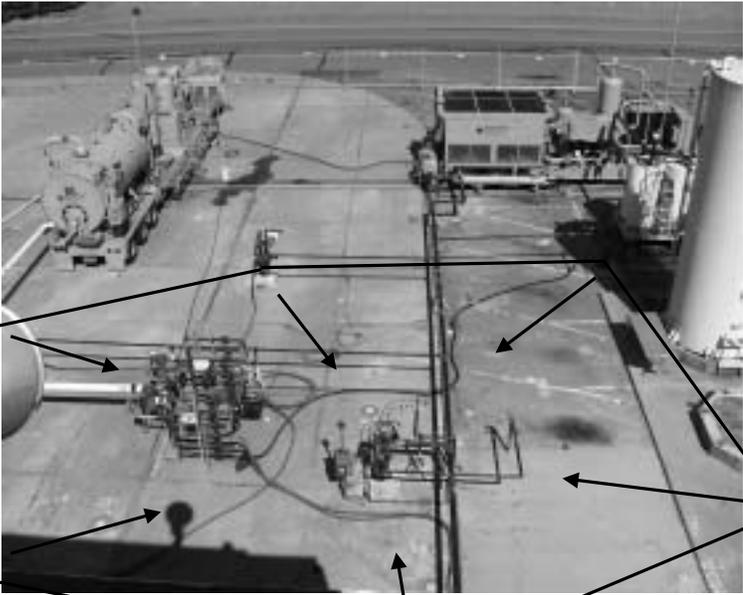


Creosote DNAPL to +140 ft depth
Alluvial sands and gravels with clays
Both LNAPL and DNAPL
Approaching MCLs in 2002
Craig Eaker, SCE

160,000 gallons removed from subsurface
In-situ destruction significant
UC Berkeley – LLNL - SCE



Alameda Point (Berkeley Environmental Restoration Center)



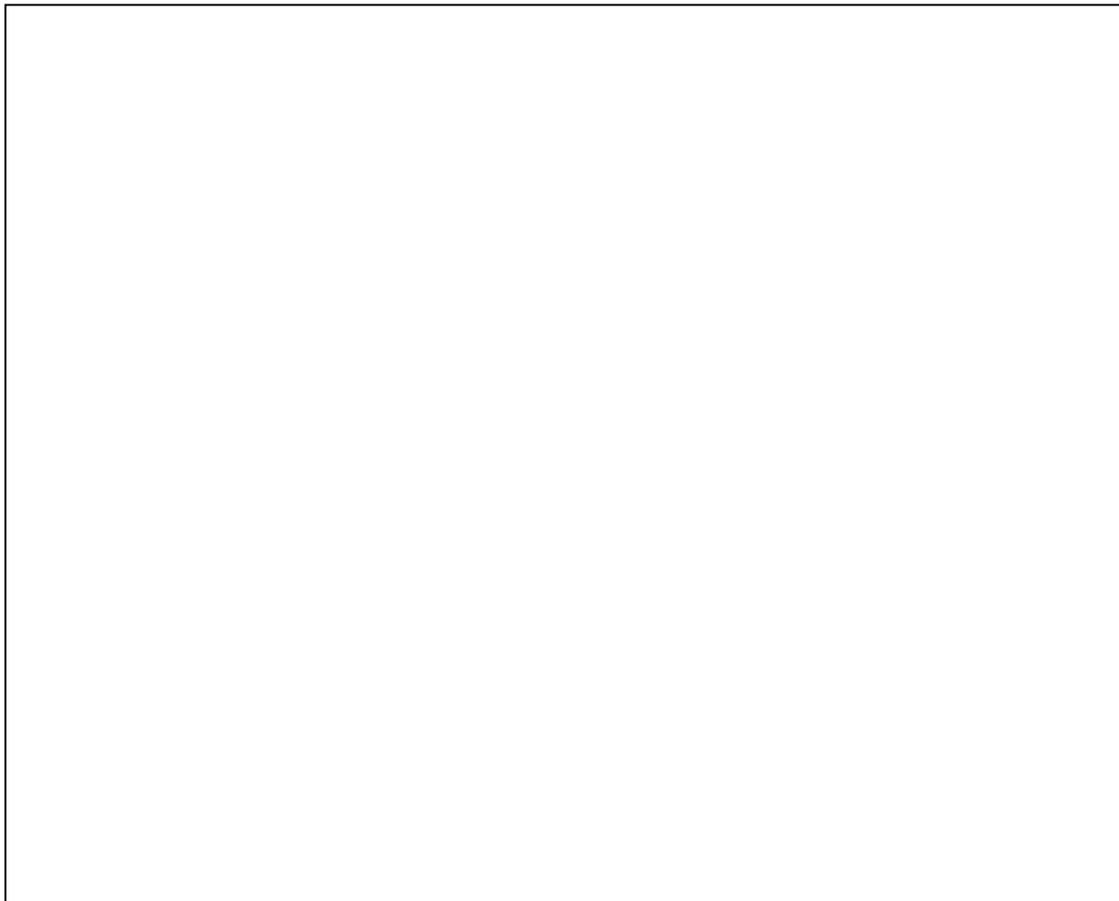
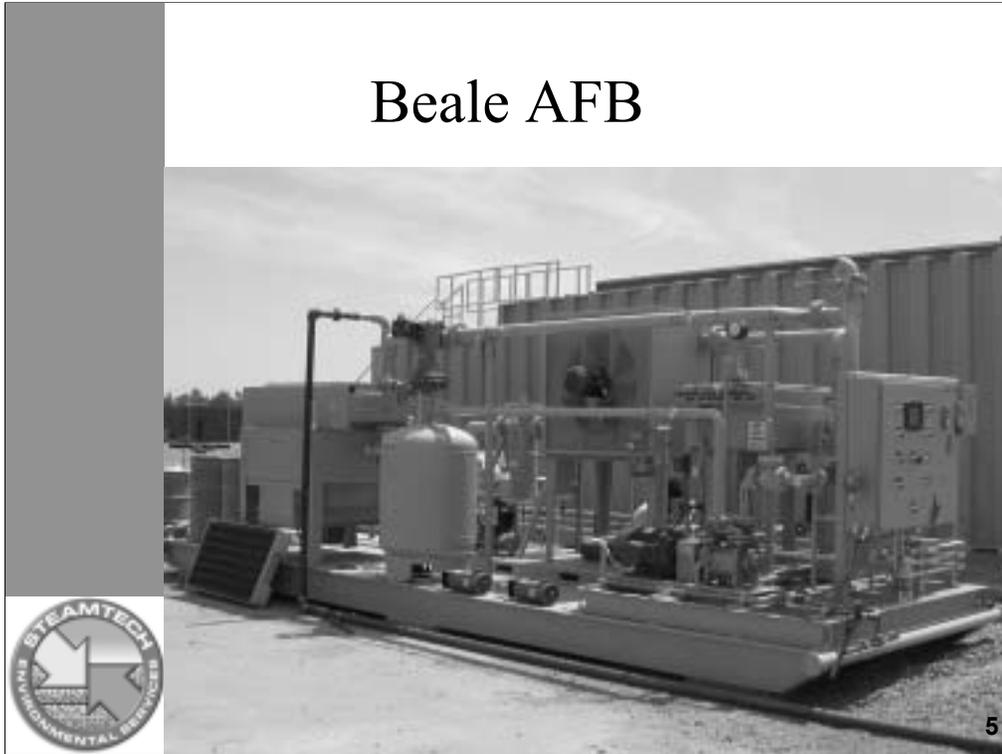
Edwards AFB Site 61



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Beale AFB



Loring: Fractured limestone



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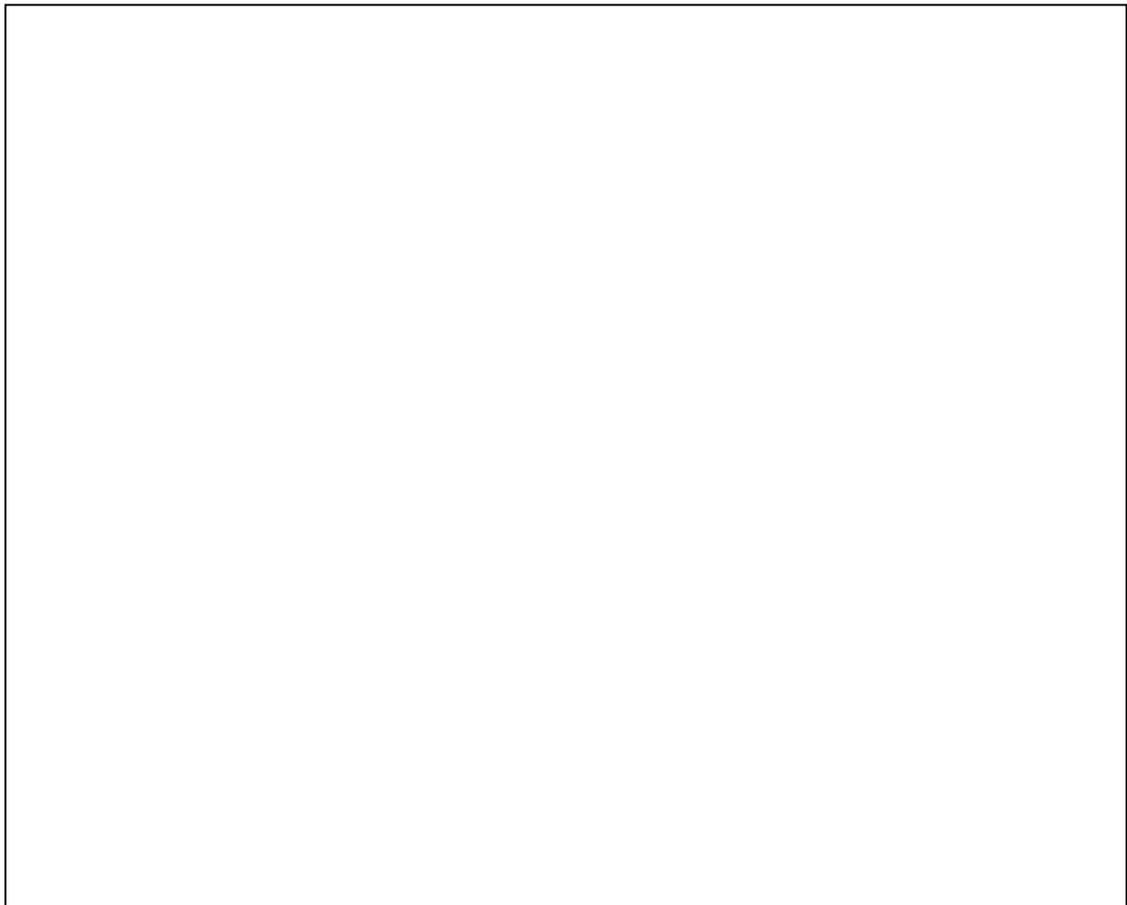
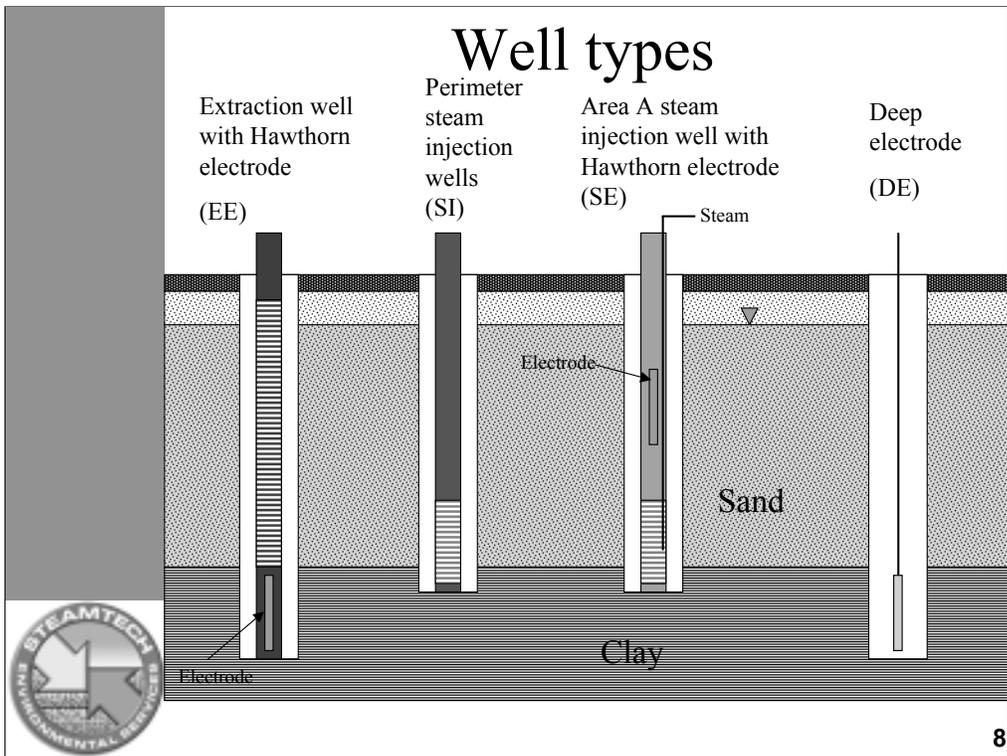


Florida site

- Full-scale clean-up with performance guarantee
- Steam enhanced remediation and electrical heating
- Tight pneumatic and hydraulic control
- Stimulated oxidation reactions for reduction of TPH concentrations in oily areas
- Detailed subsurface monitoring (temperature and electrical resistance tomography)



Well types



Preliminary results, Edwards AFB

Acknowledgments to:

- Stephen Watts, Edwards AFB project manager
- Dave Leeson, AFCEE
- Scott Palmer, Earth Tech project manager
- Gregg Crisp, site manager and operator
- Layi Oyelowo, Edwards AFB



Results are preliminary, conclusions have not been published or confirmed by the above persons

Fractured granite (quartz monzonite)



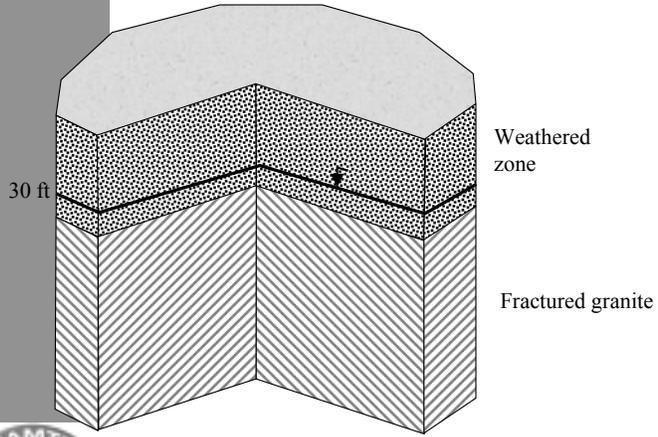
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Objectives/questions

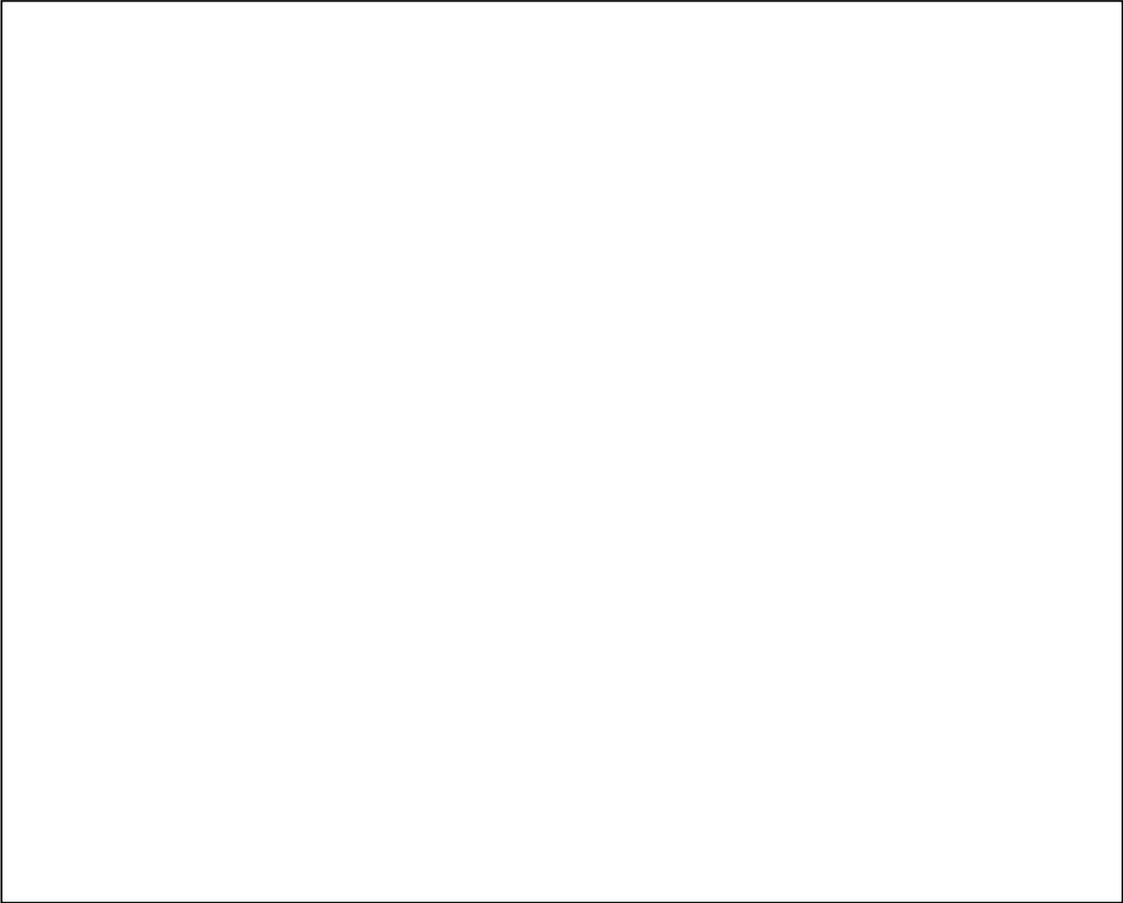
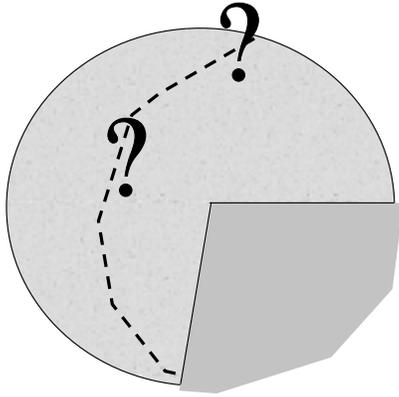
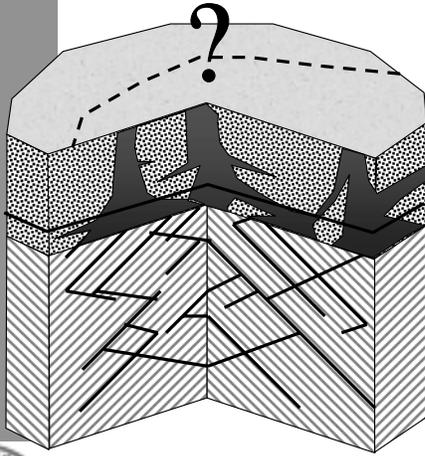
- Will SER be effective for removal of VOCs from fractured rock at Edwards AFB?
- How is the DNAPL mobilized and extracted?
- What are the ultimate VOC cleanup levels that can be expected at Edwards AFB using SER?
- How rapidly will the steam heat Site 61 at Edwards AFB?
- How should steam injection and extraction well-fields be designed for optimum performance at Edwards AFB?
- What is the optimal steam injection and extraction strategy for DNAPL in fractured rock at Edwards AFB?
- How long will the site stay hot after completion of the steaming?



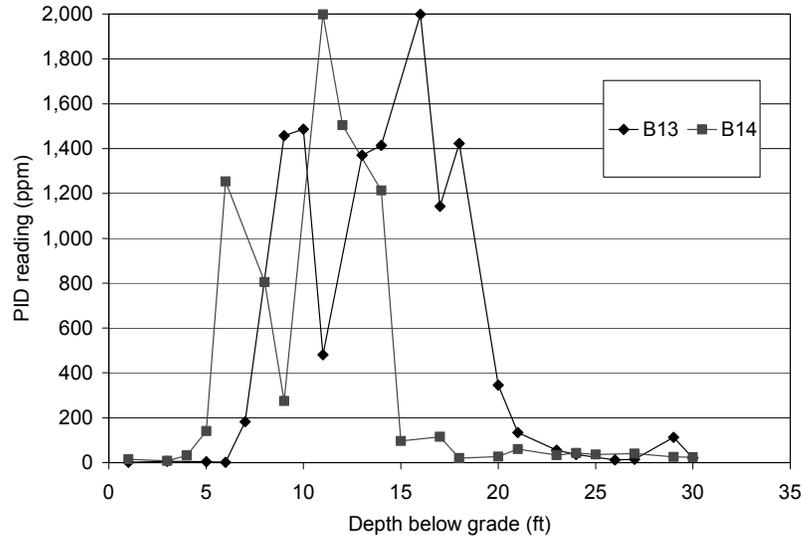
Hydrogeology



TCE distribution



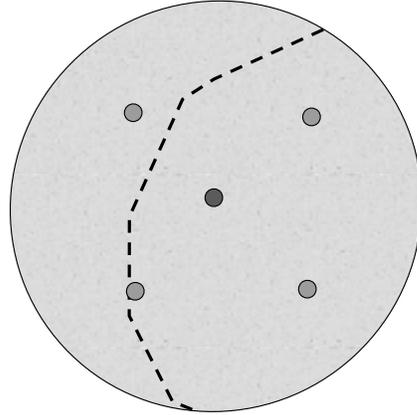
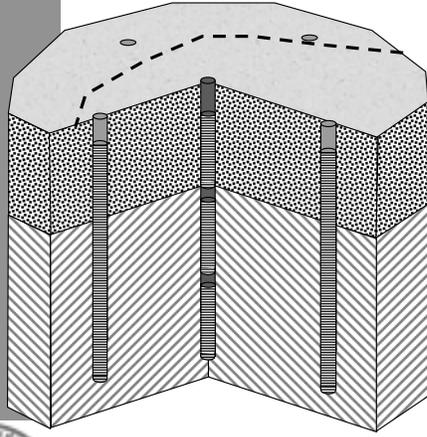
Vertical distribution of contaminants before operations: PID readings on cores



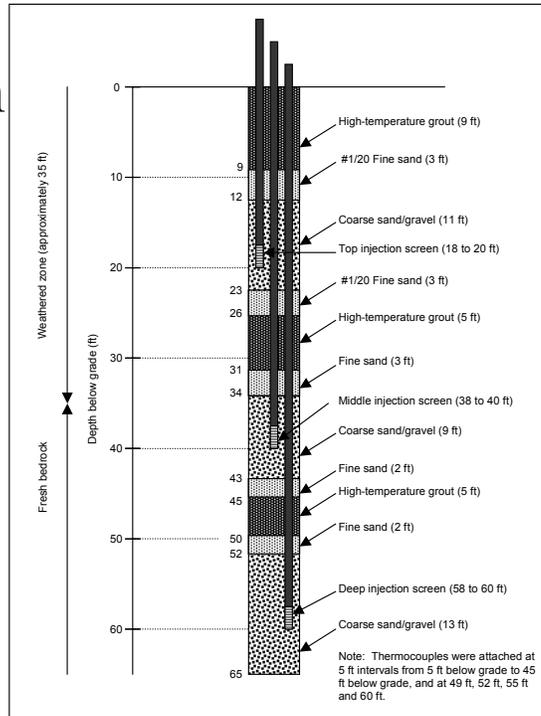
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Extraction and steam injection wells



Injection well design







Strategy

Vacuum test: Vapor capture radius ~ 80 ft

Initially steam injection deep only, extraction shallow

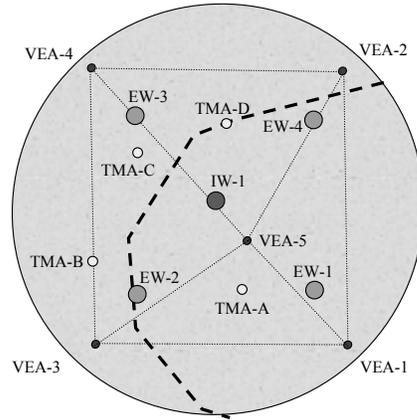
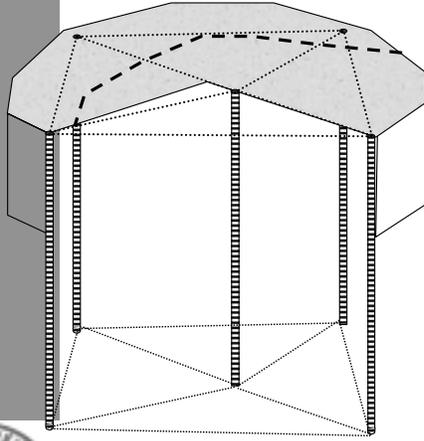
Air co-injection

Extract 25 to 50 % more than injected

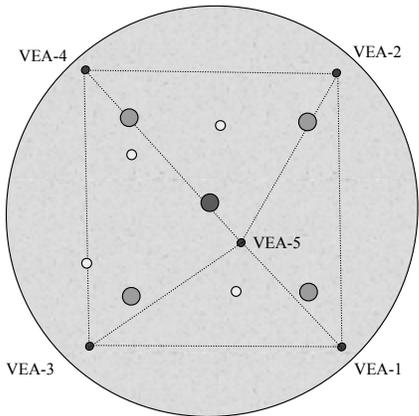
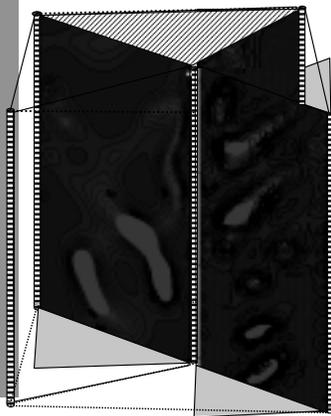
Monitor carefully and adjust strategy



Subsurface monitoring network

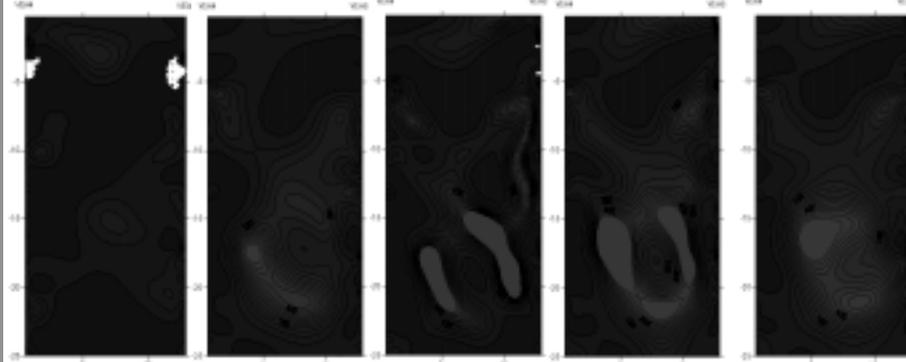


ERT data planes

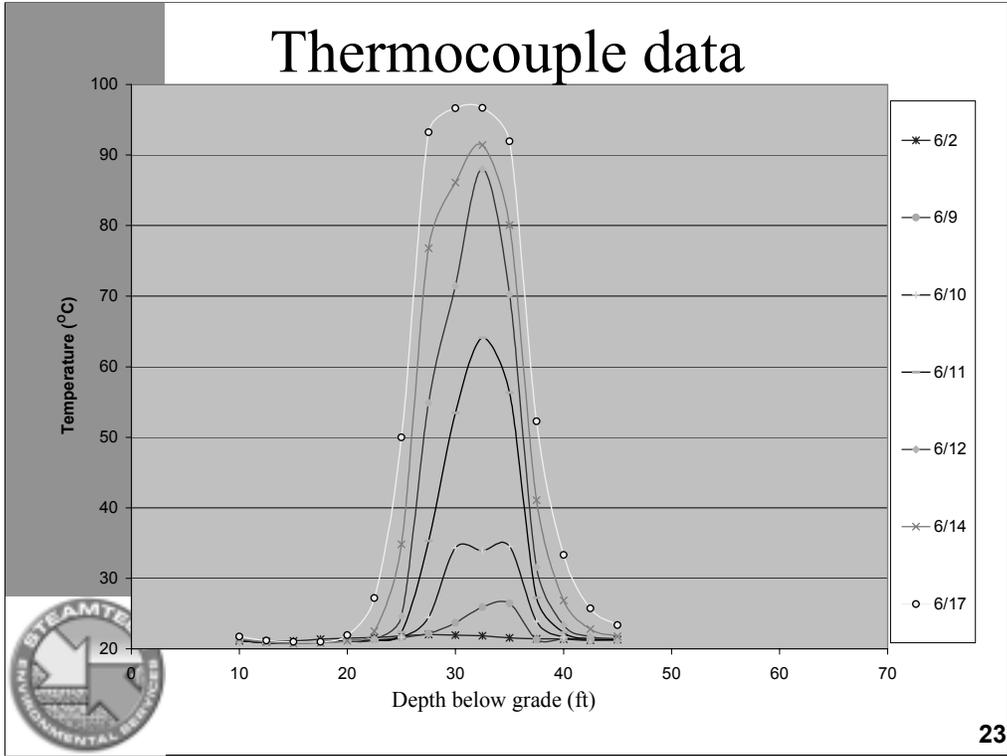


Example ERT data plane

6/10 6/23 6/27 7/6 7/10

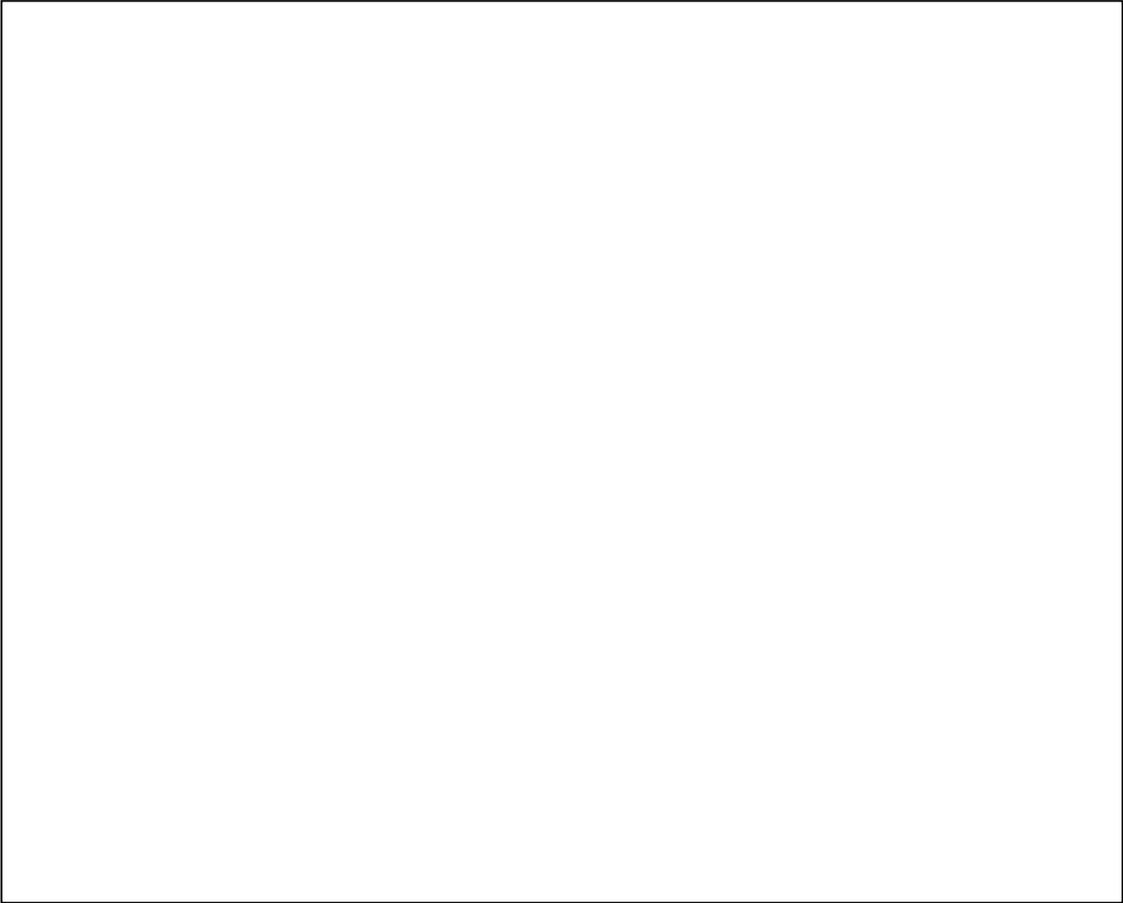
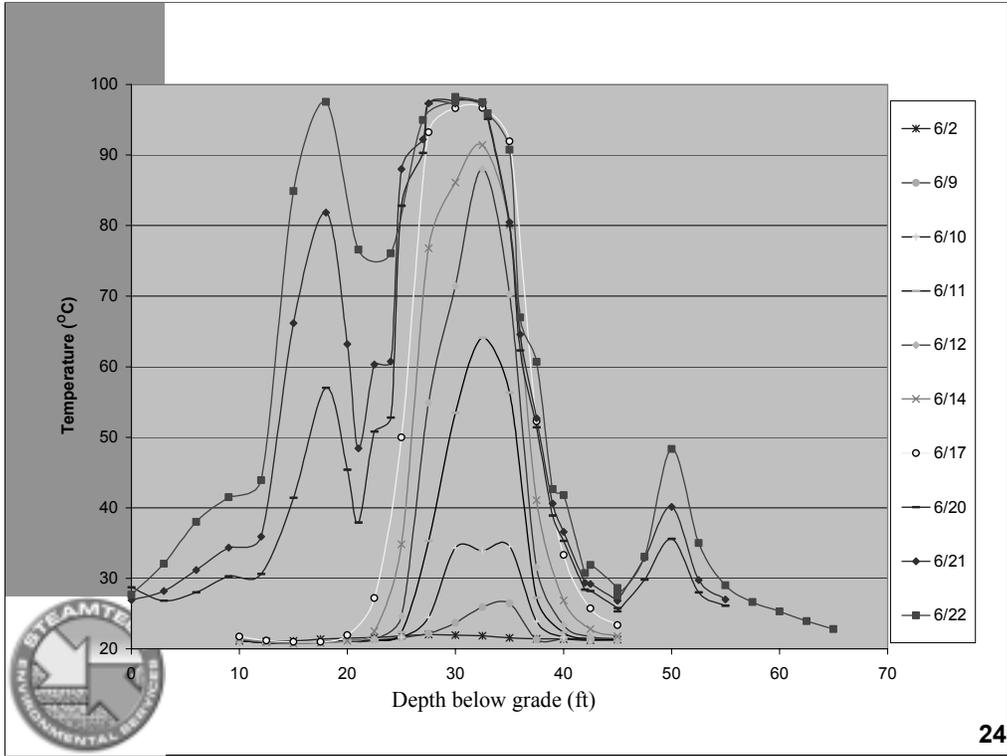


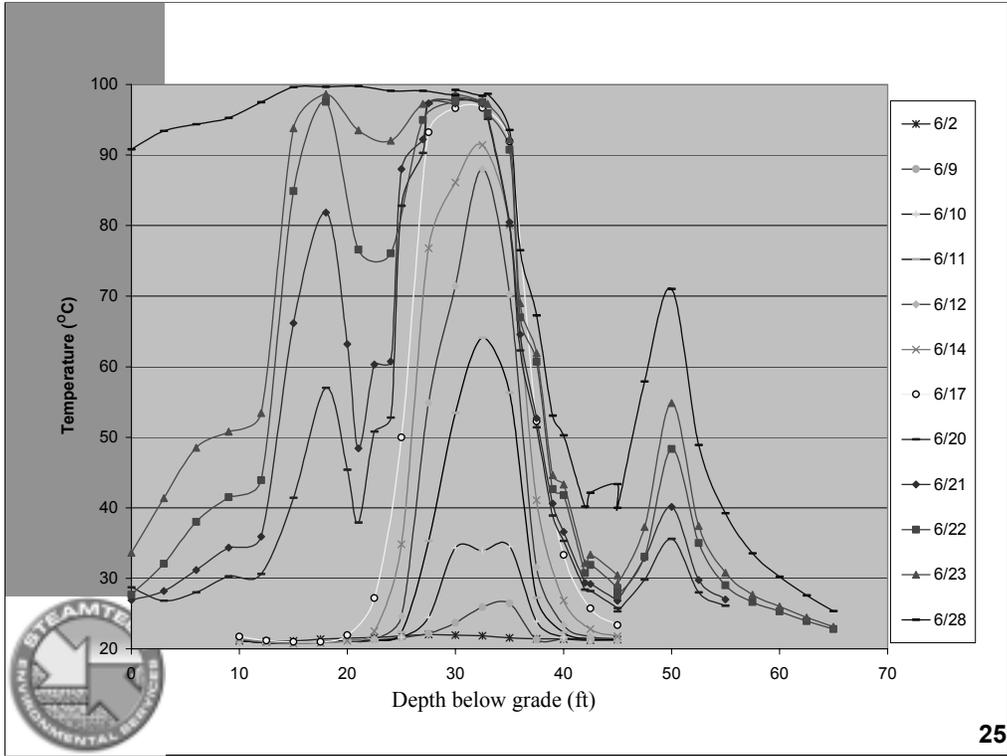
Thermocouple data



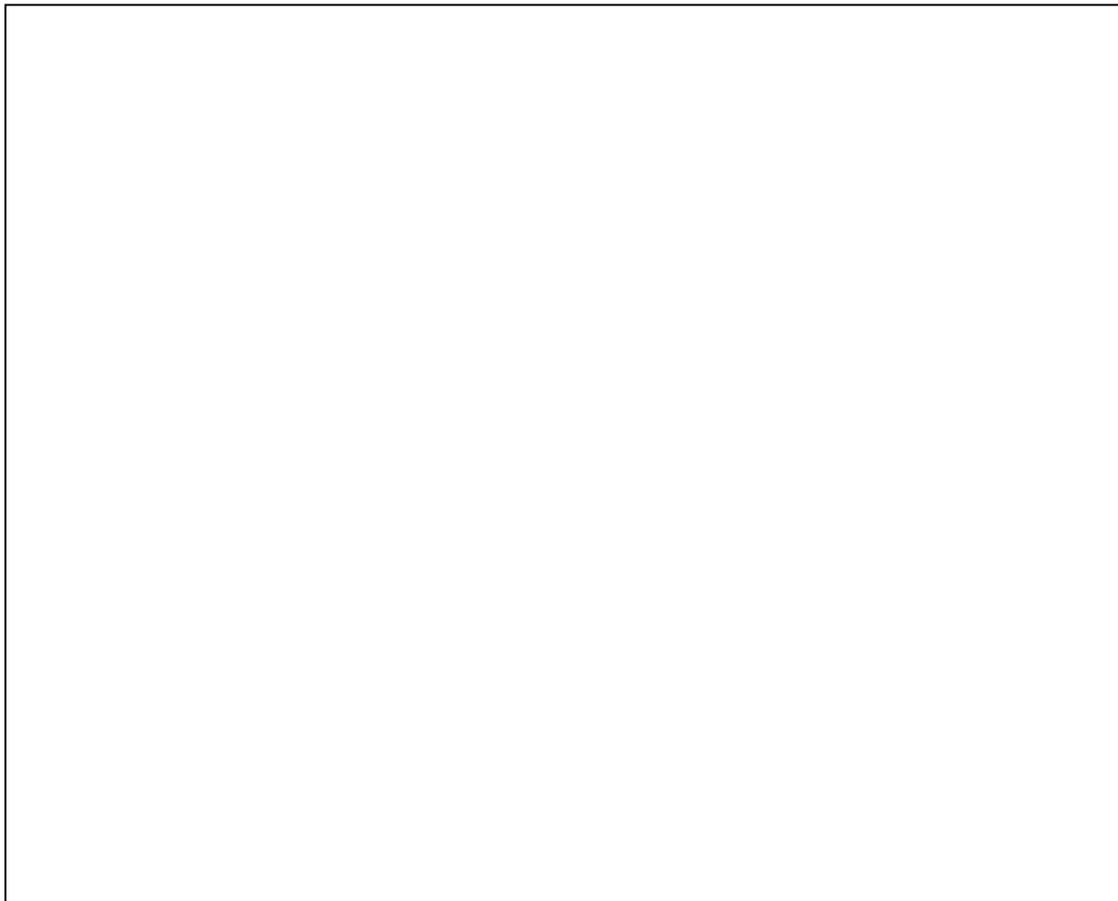
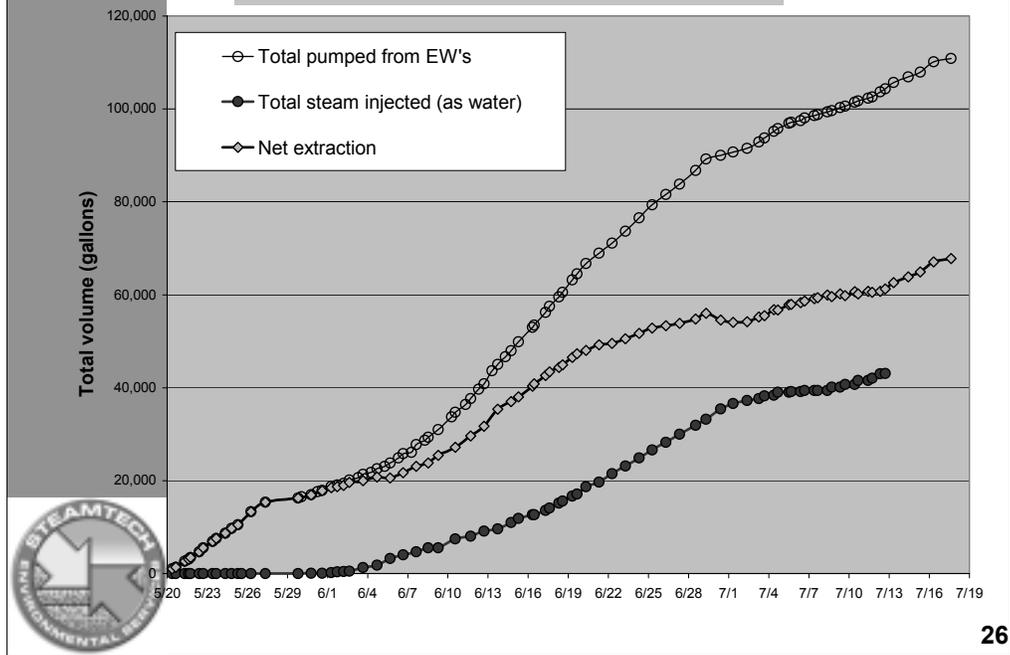
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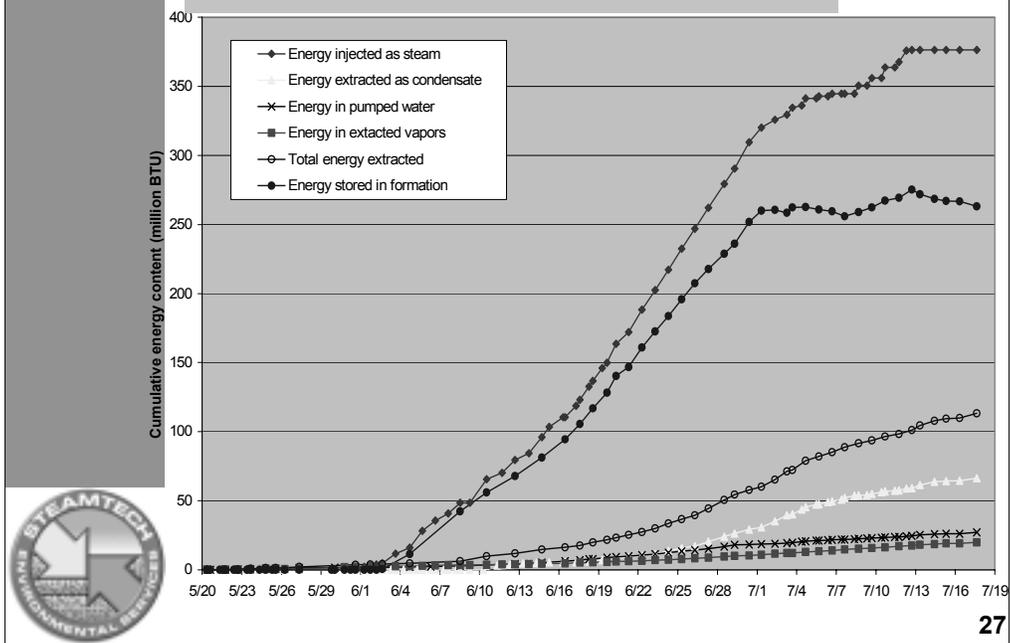


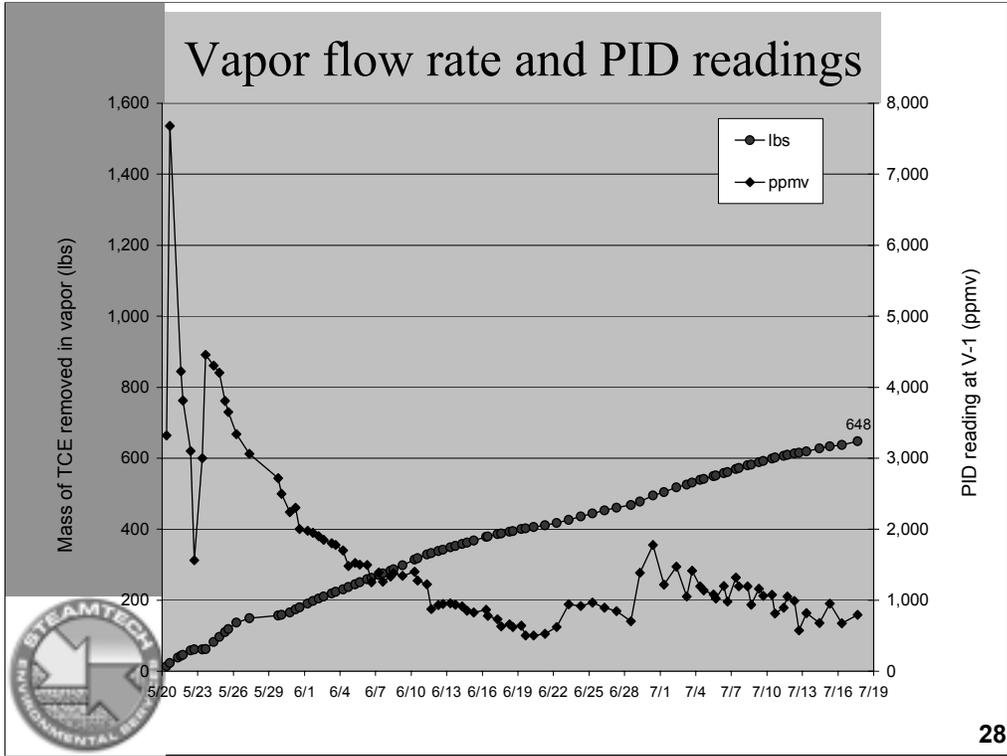


Water balance

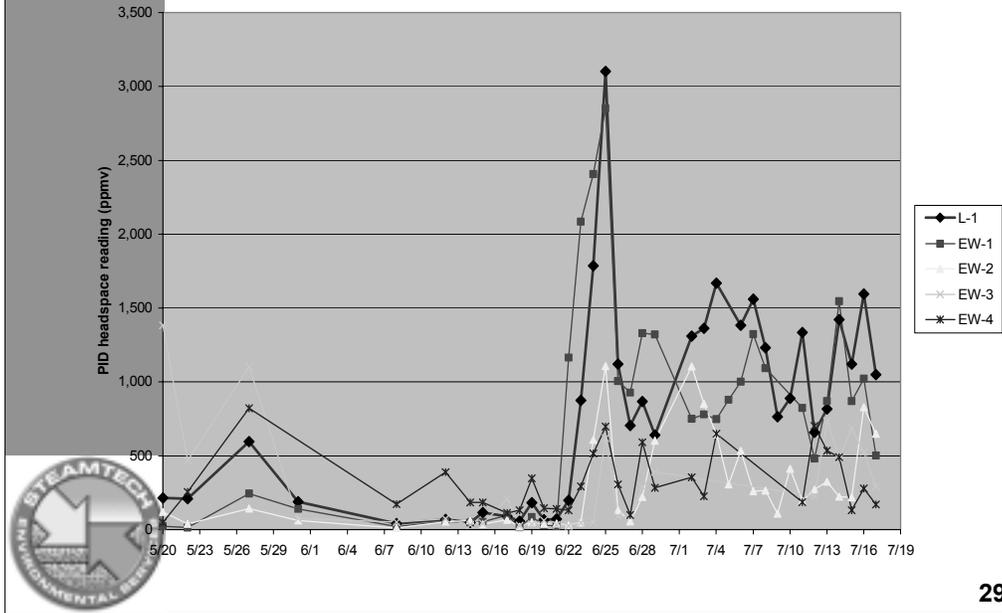


Energy balance

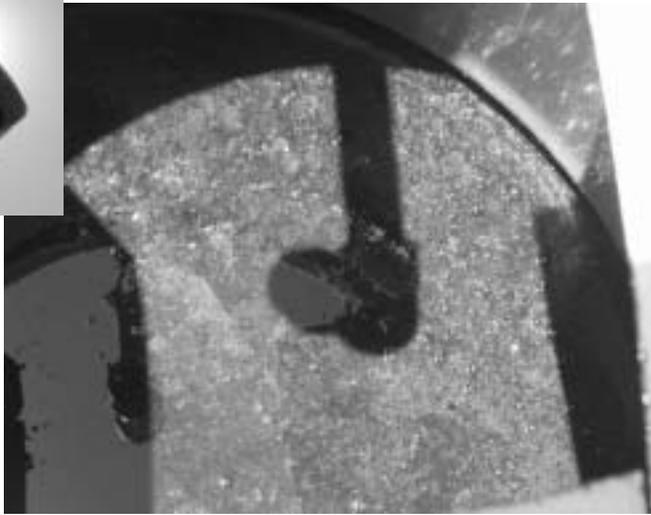




Headspace PID data



Recovery of NAPL



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Results

- Successful treatability study - great data
- Steam heated site partially, and accelerated mass removal
- More than 700 lbs of VOCs removed
- NAPL recovered where no NAPL was expected
- Air injection promising for opening fractures to steam flow, and potentially for reducing risk of NAPL condensation
- ERT apparently valuable at Edwards: Heated zones showed large changes in electrical resistivity
- Very uneven steam distribution: Increased focus on temperature monitoring, also in extraction wells

