RESULTS OF TANDEM IN-SITU CHEMICAL OXIDATION AND ACCELERATED ANAEROBIC BIOREMEDIATION

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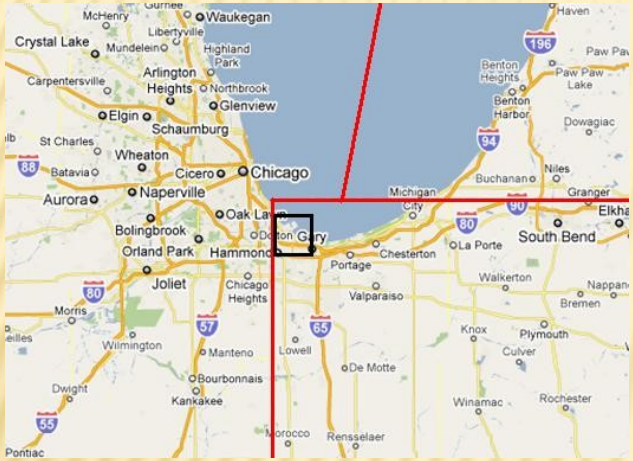
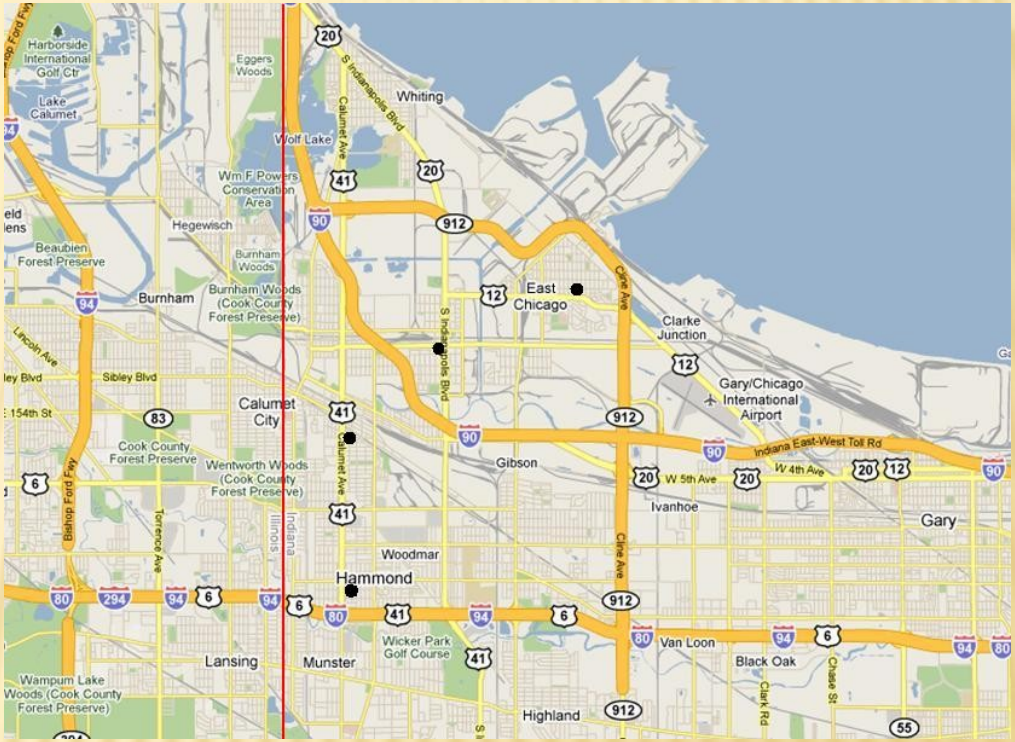
FOUR SITE COMBINED STUDY





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TWO PRIMARY CONSIDERATIONS

- Money/Politics
- Remedial Technologies

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MONEY AND POLITICS

- Property transactions needed… pending buyer risk comfort level
- Insurance settlement – limited money
- No private pay funding
- Brownfield possibilities
- Client required fast responsible action

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COUPLED REMEDIATION TECHNOLOGIES

- Many types of remedial action was considered
  - Full ISCO (Permanganates/Persulfates)
  - Sole use of several types of electron donors (non-emulsified oils, emulsified oils, molasses/corn oil injections, viscous glycols, and cheese whey)
  - Decision was based on a combination of short timeframe to attain certain levels, low cost, limited disturbance to surface features and limited risk
  - Multiple technologies were selected based on potential effectiveness, past performance, and expense

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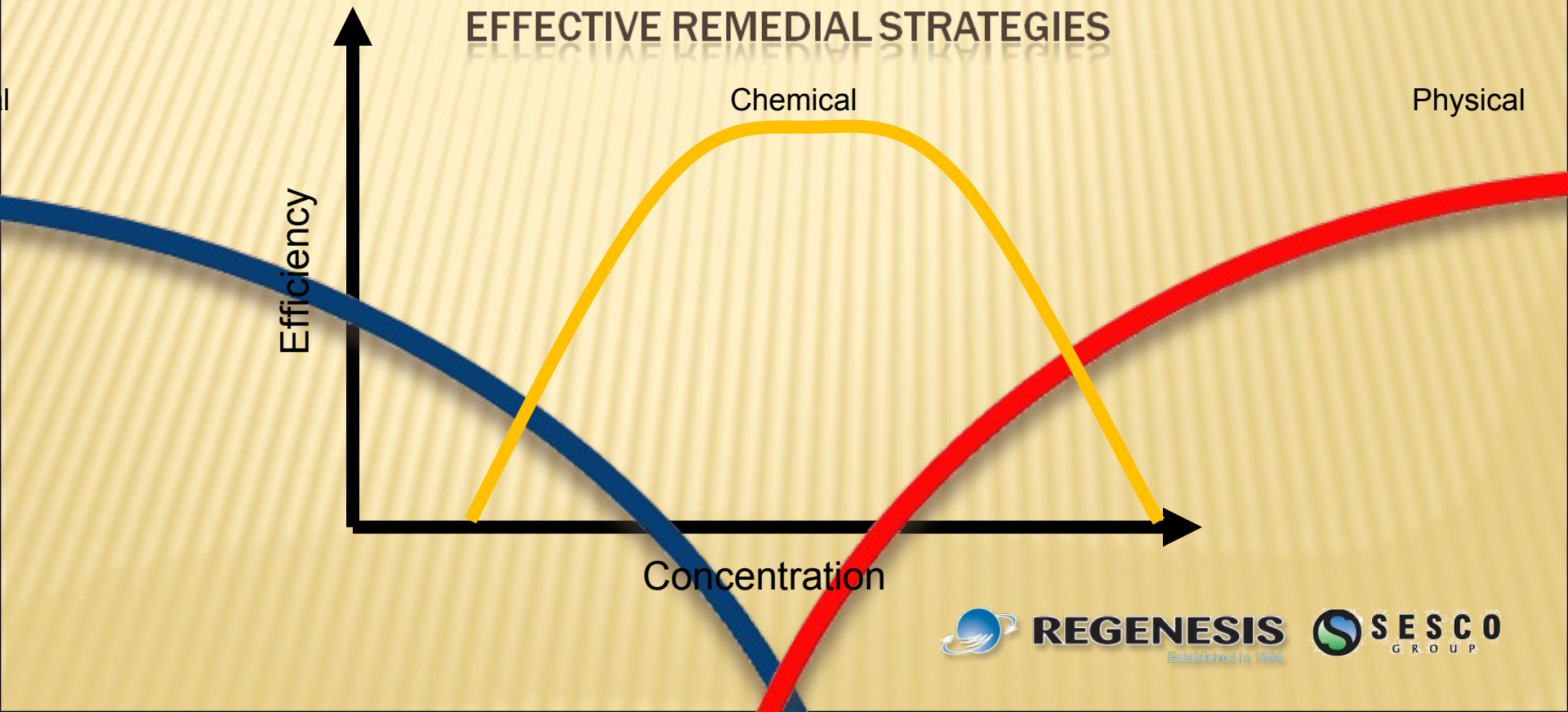
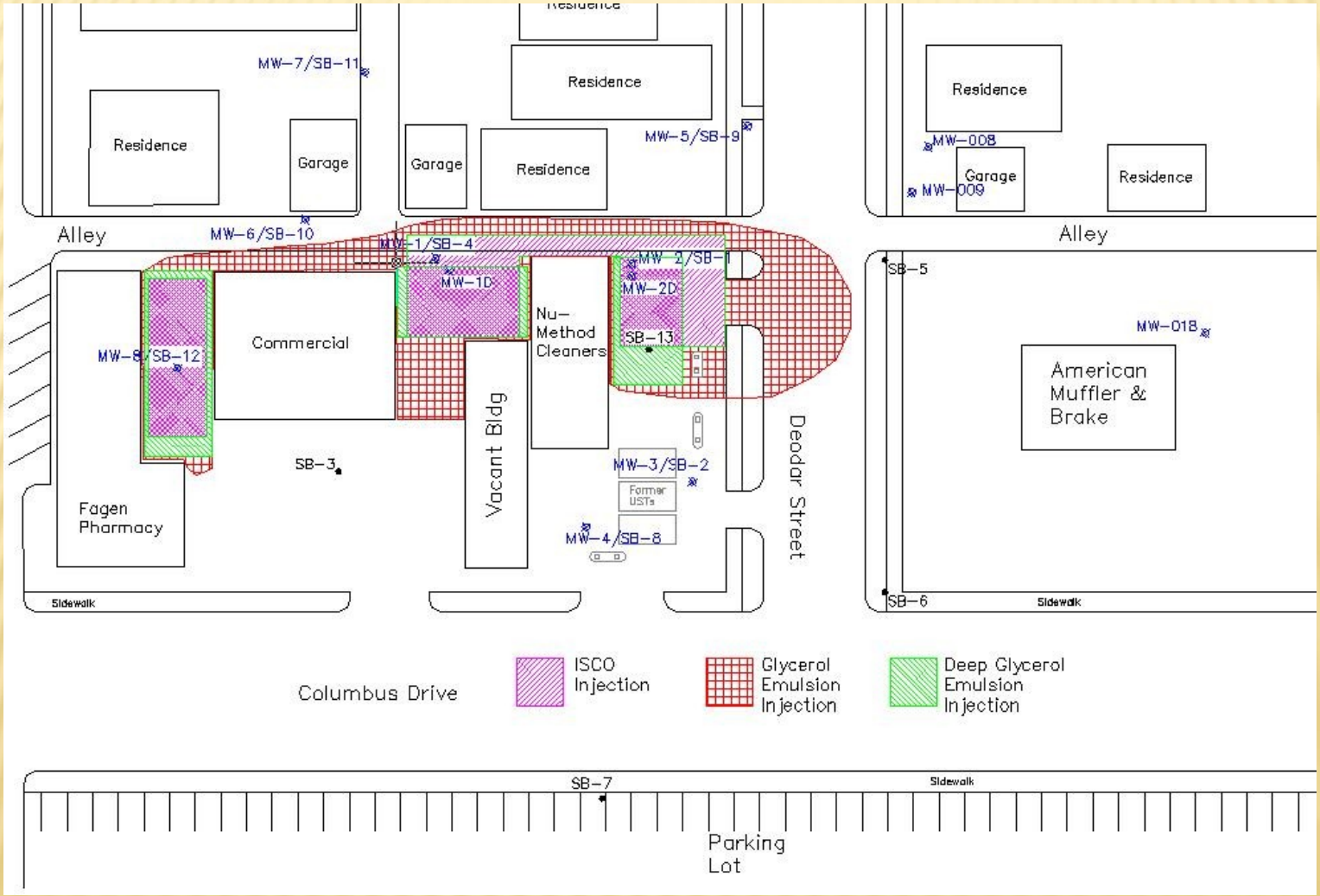
TECHNOLOGY VERSES COST-EFFECTIVENESS

- Utilize multiple catalyst sodium percarbonate (RegenOx) in the interior of the sites to treat high concentration areas
- Utilize multistage release glycerol emulsion (3DMe) to treat the plume mass

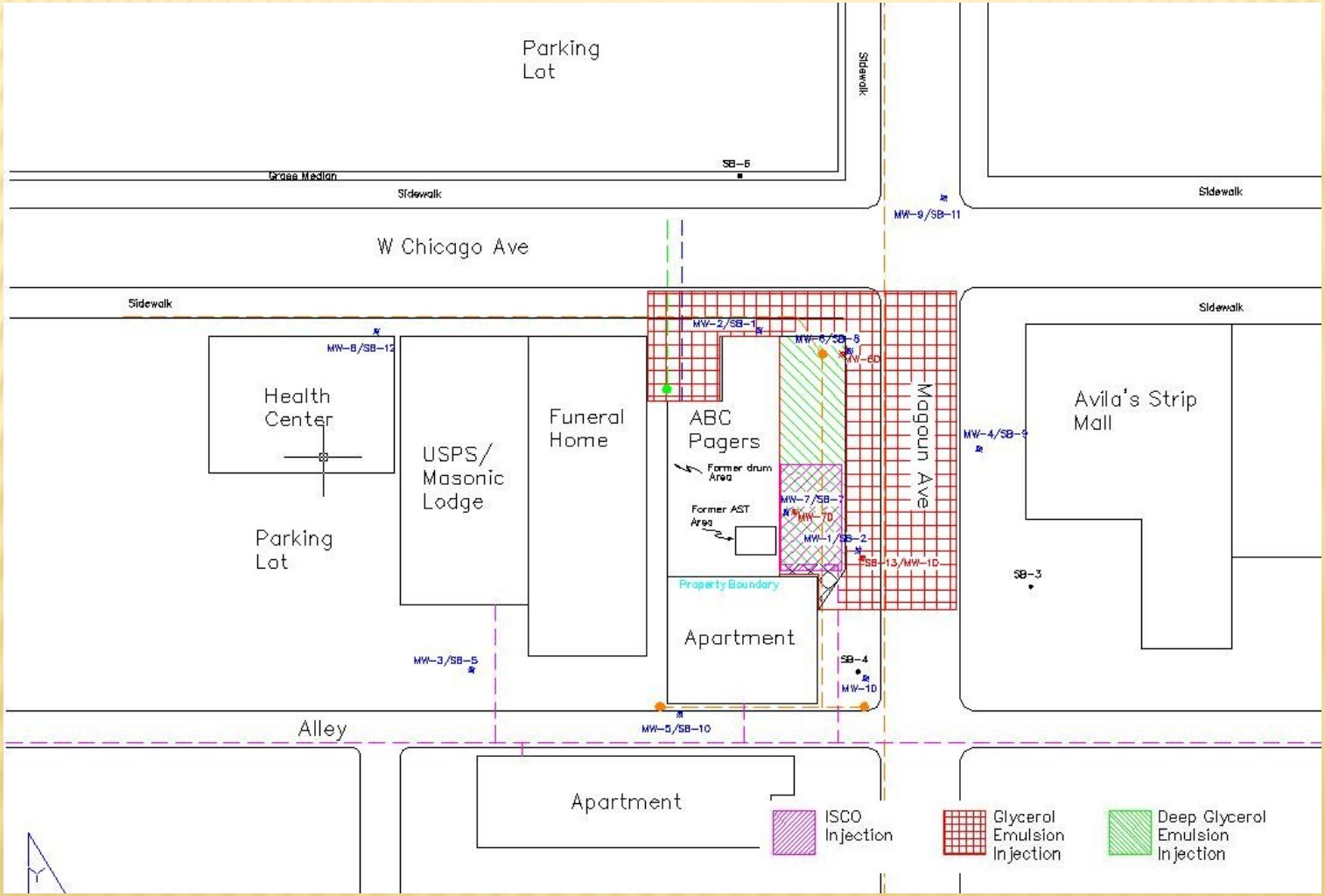


REGENESIS Established in 1994 SESCO GROUP

SITE PLANS – INJECTION PATTERN



SITE PLAN 2



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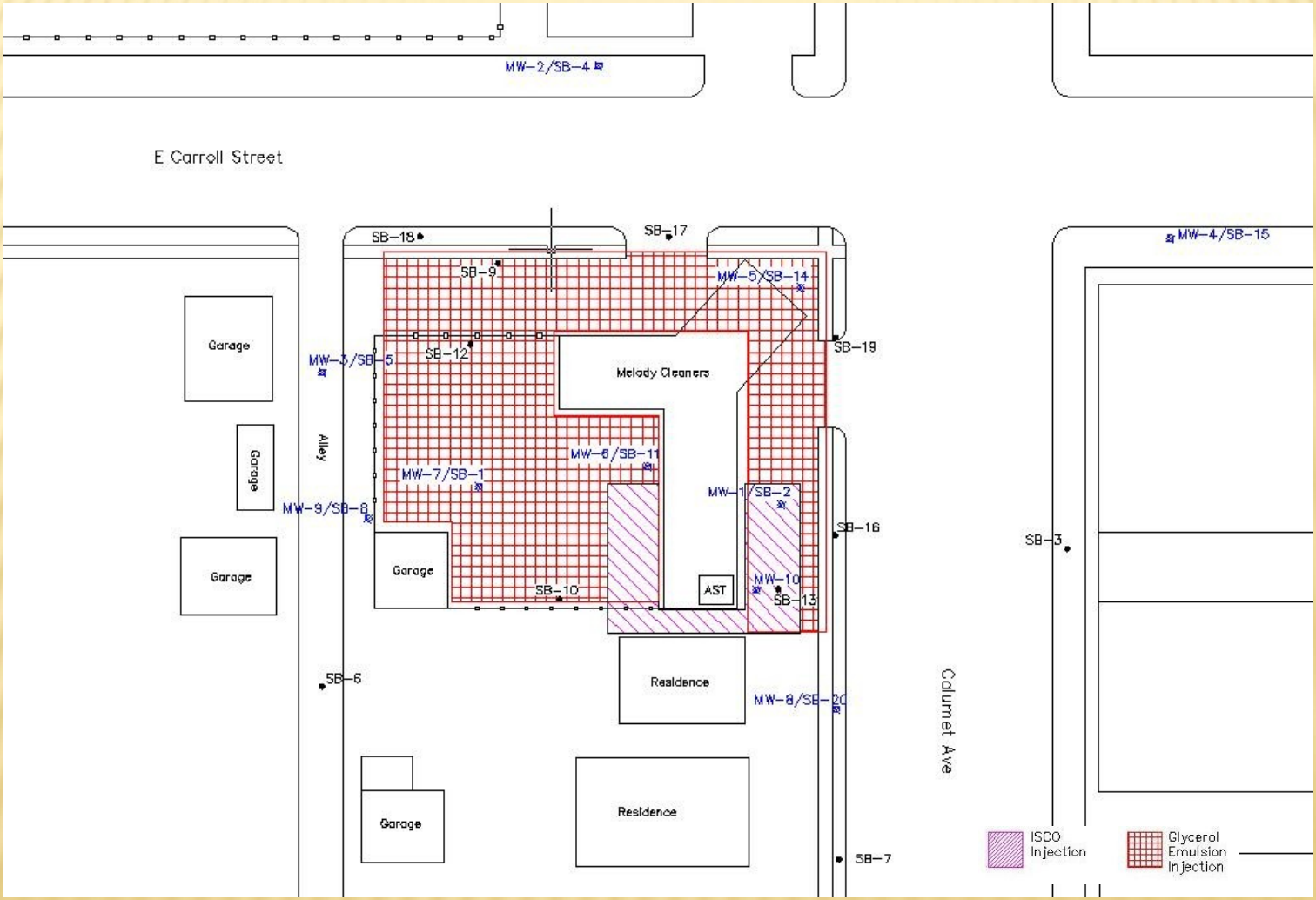
SITE PLAN 3



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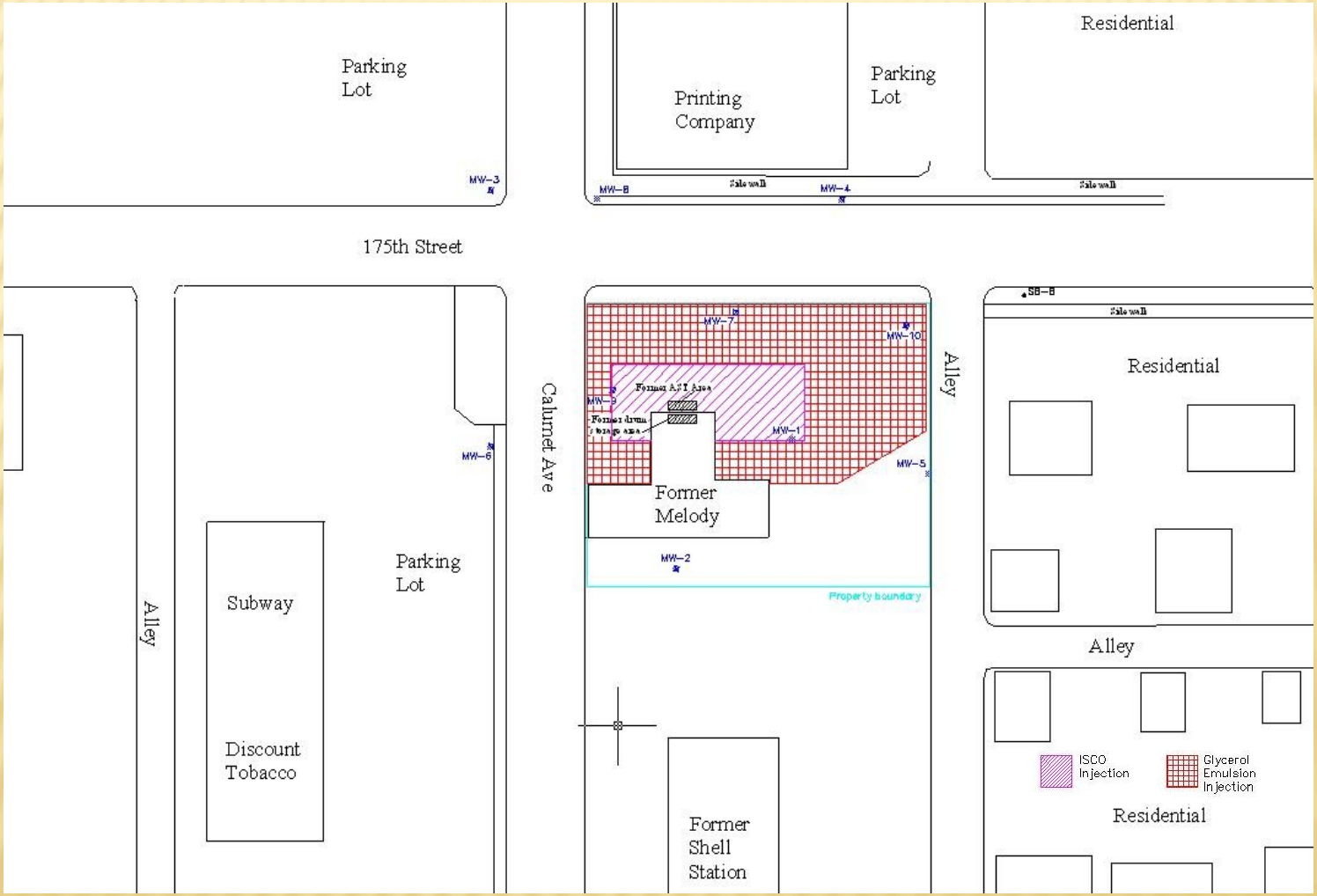
SITE PLAN 4



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GEOLOGY

- Surficial sand extending to 7 feet depth at one site up to 35 feet at the deepest site
- Clay aquitard underlying the sand unit
- Limited unsaturated soil impact observed
- Ideal geology for maximum contact between injected material and dissolved phase contaminants
- Clean quartz sand allowed spread of ISCO

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ROTATION IMPLEMENTATION

- Injection equipment was rotated between the four sites
- ISCO was pulsed between the sites over a 6 month period – 3 pulses per site
- 120 days for the aquifers to pseudo-equilibrate
- Electron donor rotation – 1 event per site
- Approximately 15 months elapsed from beginning to end of coupled injection of 4 sites

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RESULTS

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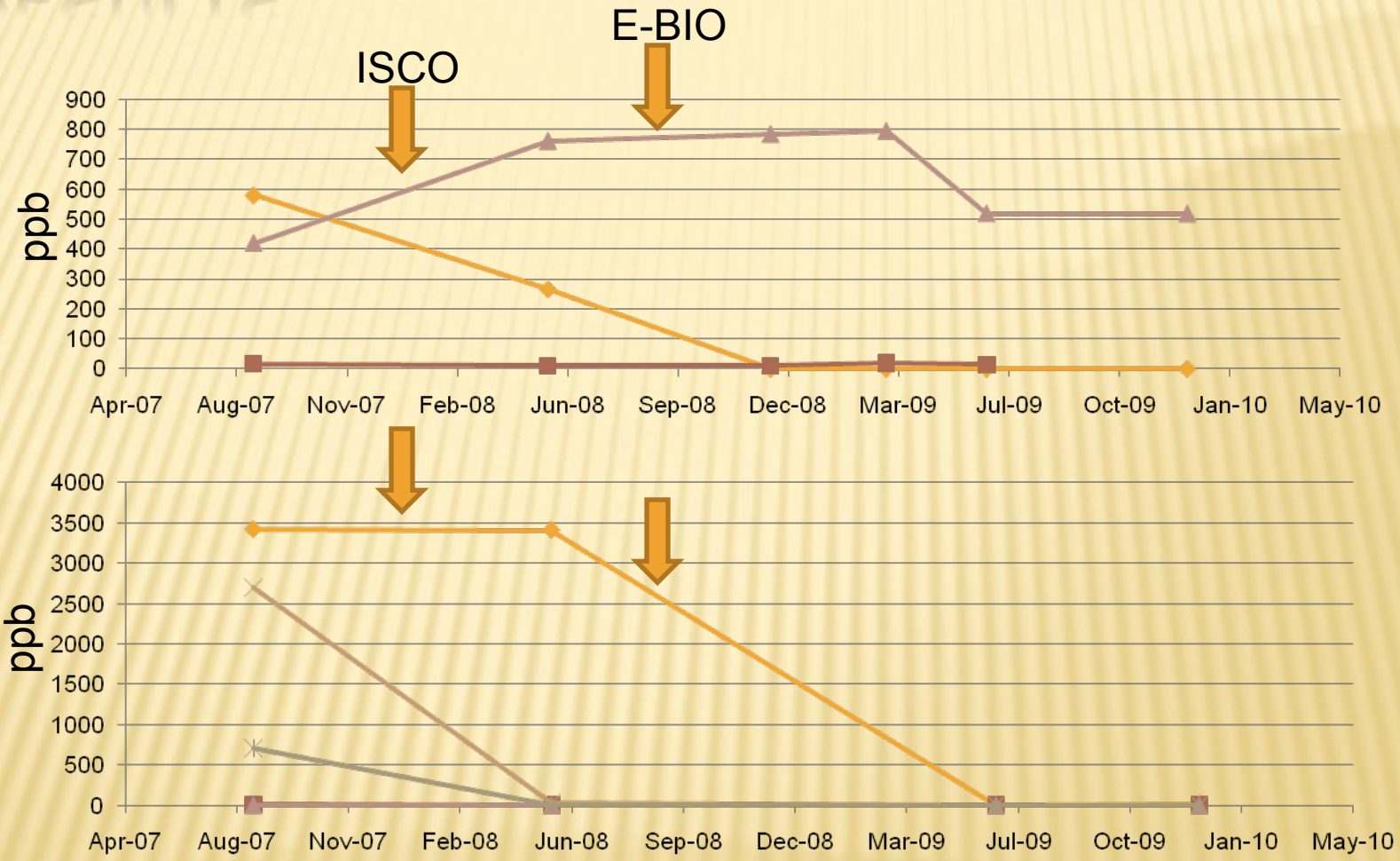
RESULTS



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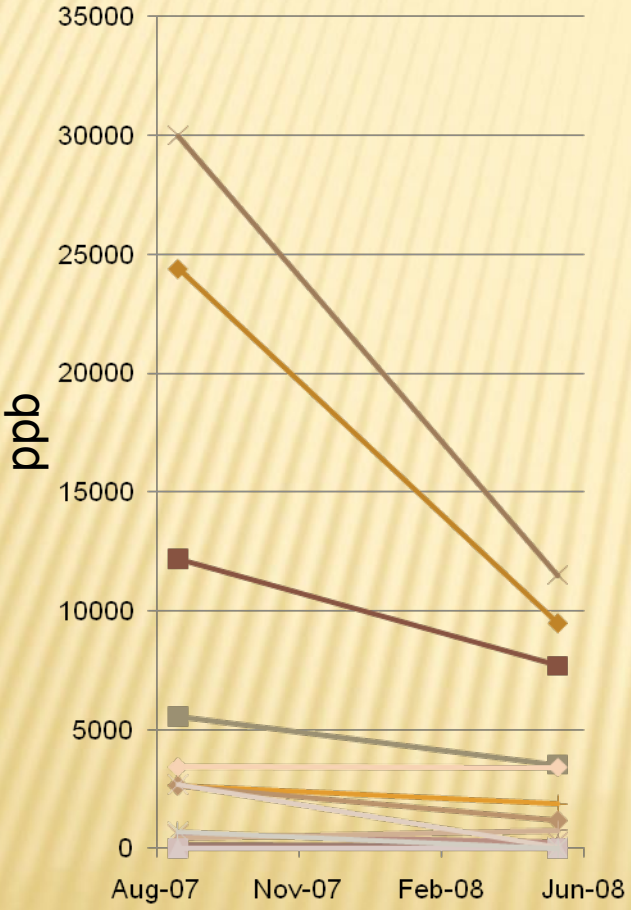
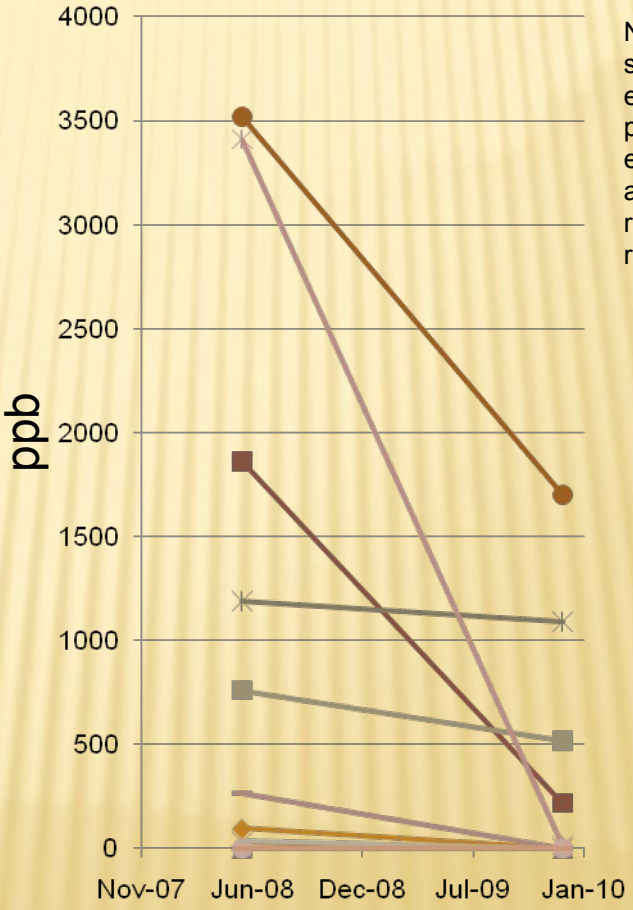
TECHNOLOGY EFFECTIVENESS

Baseline to Post-ISCO



Post-ISCO to Post-Bio (1 yr)



Note: Three samples exceeding 4000 ppb were excluded to attain better resolution for the remainder

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DISCUSSION OF GEOCHEMISTRY

- Dehalococcoides testing
  - Significant microbes present prior to remediation
  - No changes to net microbe count after ISCO
  - Microbe count increased after glycol treatment
- Geochemical Parameters
  - REDOX parameters behaved predictably in response to the treatments.

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OVERALL RESULTS

- Site 1: ISCO 57%, ISCO+E-Bio 65%, Starting PCE Average 16,577 ppb
- Site 2: ISCO 40%, ISCO+E-Bio 72%, Starting PCE Average 2,184 ppb
- Site 3: ISCO -2%, ISCO+E-Bio 48%, Starting PCE Average 339 ppb
- Site 4: ISCO 49%, ISCO+E-Bio 99.8%, Starting PCE Average 1,369 ppb
- ISCO most cost-effective in initial PCE reduction at sites with higher concentrations, multiple injection events may be needed.
- E-Bio most cost-effective at sites with lower concentrations

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CONCLUSIONS

- Coupled technologies created positive results at each site and provided data needed for future work
- Assess (likely) needed amendments and long term strategy to closure/goal
- NOT the preferred method to remediation
- BUT acceptable risk to stakeholders
- Two sites have been sold for redevelopment (with vapor barriers), one sale is pending, and one site remains unsold with decreasing impact
- Further coupled technology pilot testing to be completed soon

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QUESTIONS?

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