# Rewriting the Playbook: Transforming Groundwater Remediation with Flux-Focused Models and Adaptive Strategies

**Reese AFB, Texas**

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**Panel 1: Groundwater RD/RA Case Studies**
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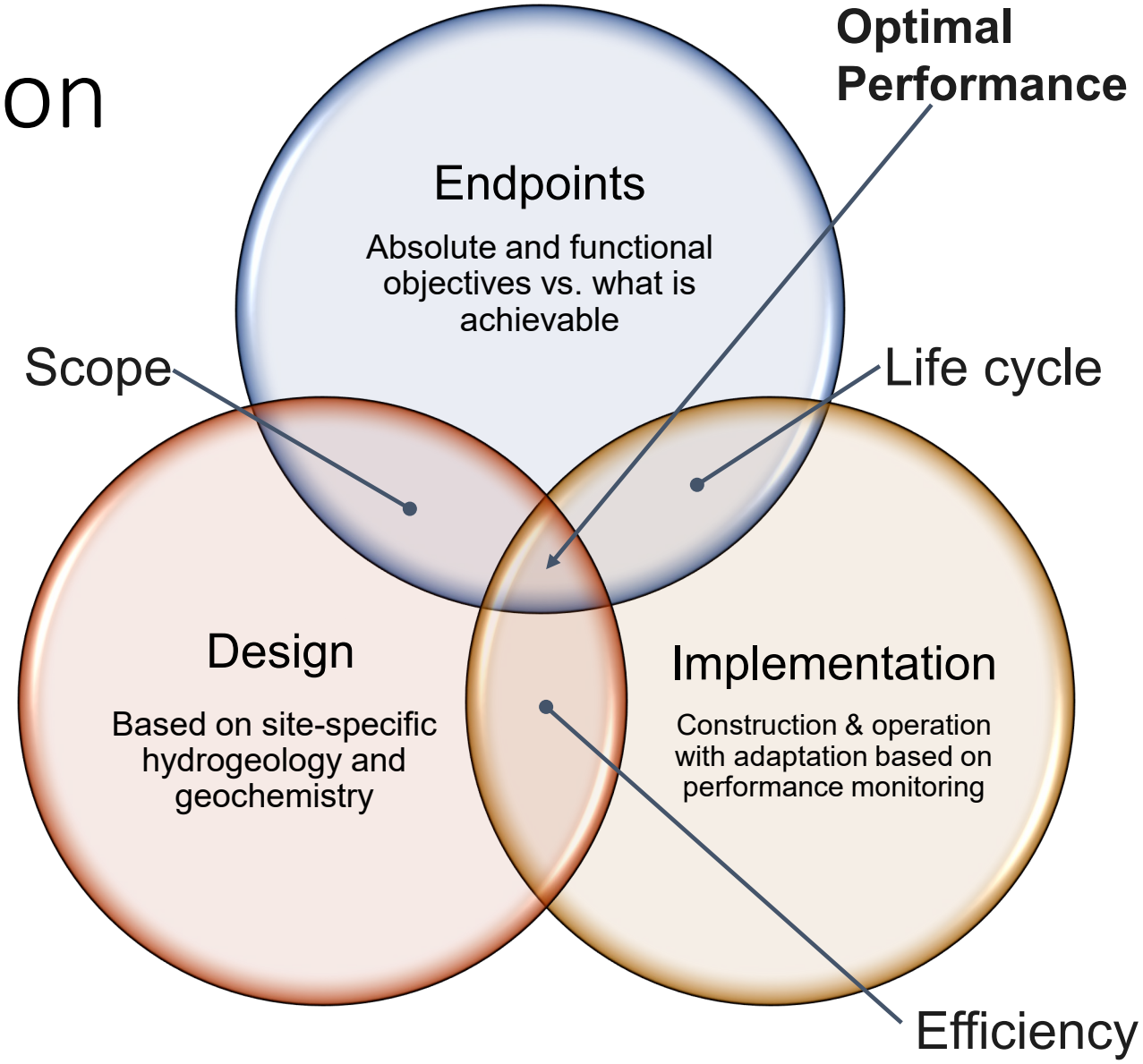
# Successful Remediation

- Successful outcomes are based on a combination of factors
  - Constraints
  - Data/Findings
  - Interpretation
  - Regulations
  - Risks
  - Technologies

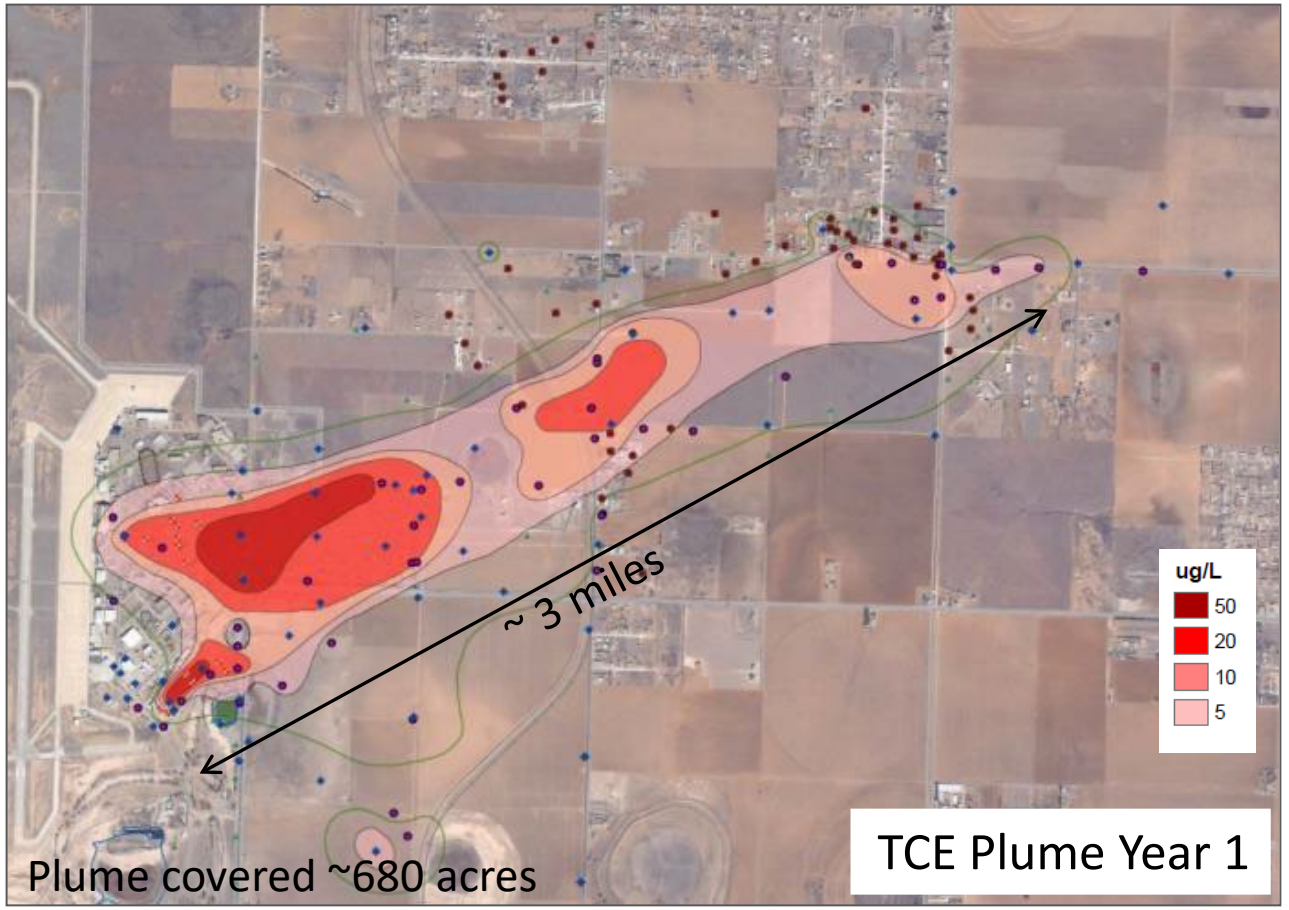


# Former Reese Air Force Base: Site Background

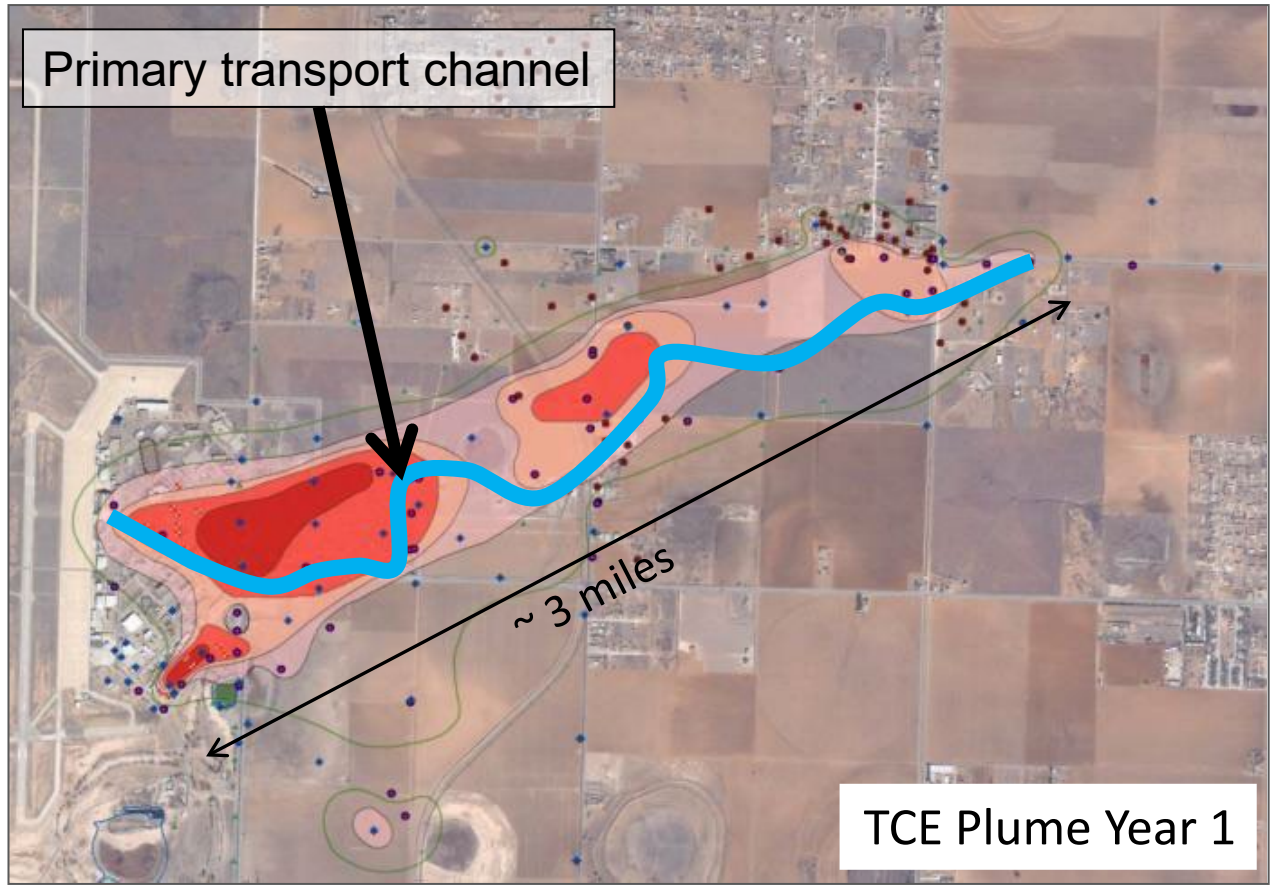
- Former AFB located in west Texas
- 3-mile TCE plume impacting local drinking water supplies
- 200 ft deep sandy aquifer, 50-75 ft saturated thickness
- Groundwater remediation (pump, treat and re-injection) operated for 15 years without much change in plume footprint
- Period of performance: 10 years
- Fixed price contract

# Objectives

- Complete remediation of TCE below MCL of 5 µg/L
- Key challenge was interpreting the plume
- Early interpretations and remedial efforts were built on oversimplified CSMs and used average conditions
- Remedy performance/LTM was based on 20% of available wells after many years of P&T operation
- Unclear where the high permeability flow pathways were
- Limited progress with existing system



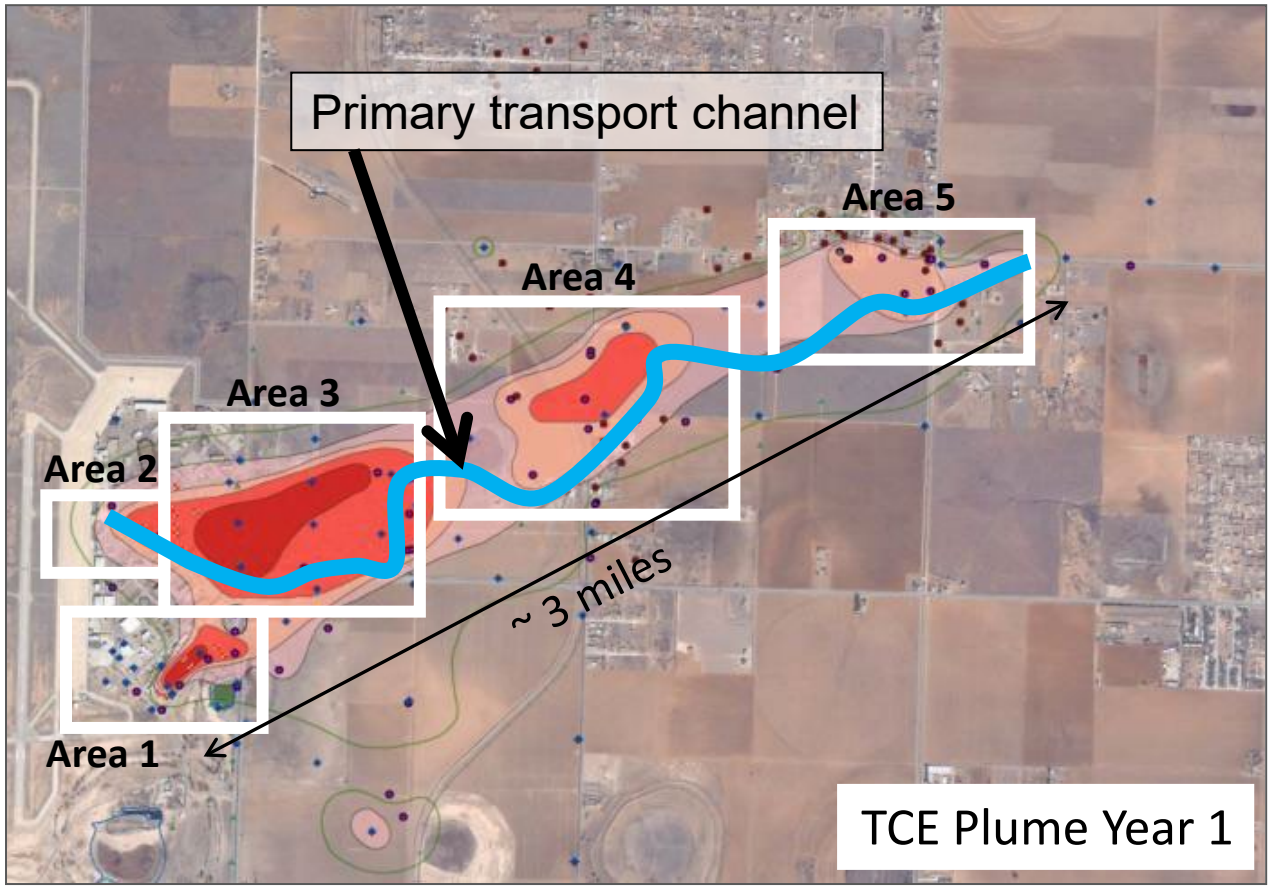
# Identified Primary Transport/Flux Pathway




- Extensive data evaluation across the site to determine where primary transport pathways were and where mass remained
- Reviewed well logs
- Reviewed pumping performance
- Focused efforts on high mass flux zones

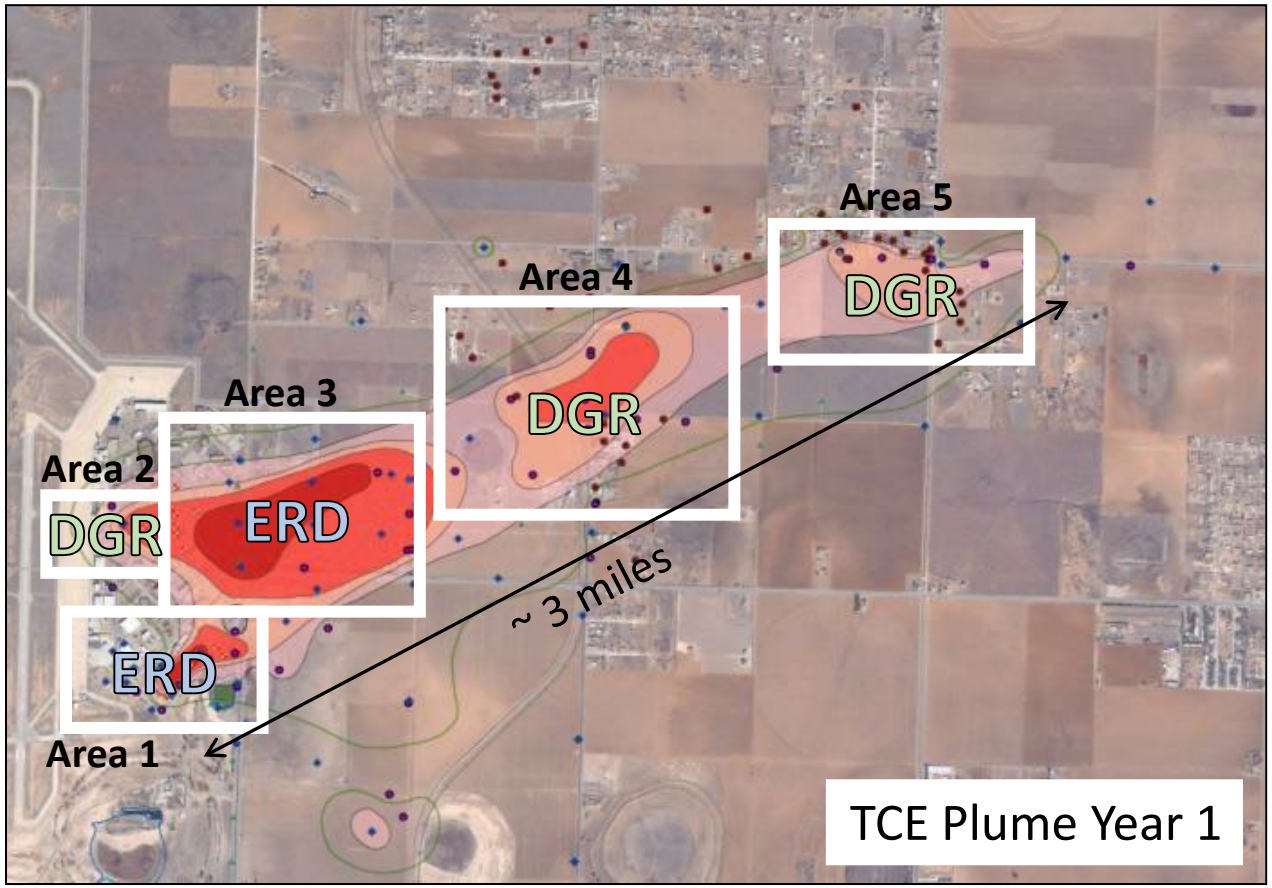
# Plume Approach

- Divided plume into 5 areas
- Individual CSMs for each
- Remedial strategies created for each area to accommodate:
  - Large plume size (3 miles long by 1 mile wide)
  - Plume age
  - Cleanup timeframe available
  - Site access, pipe routing, electrical connections



# Remedial Strategy

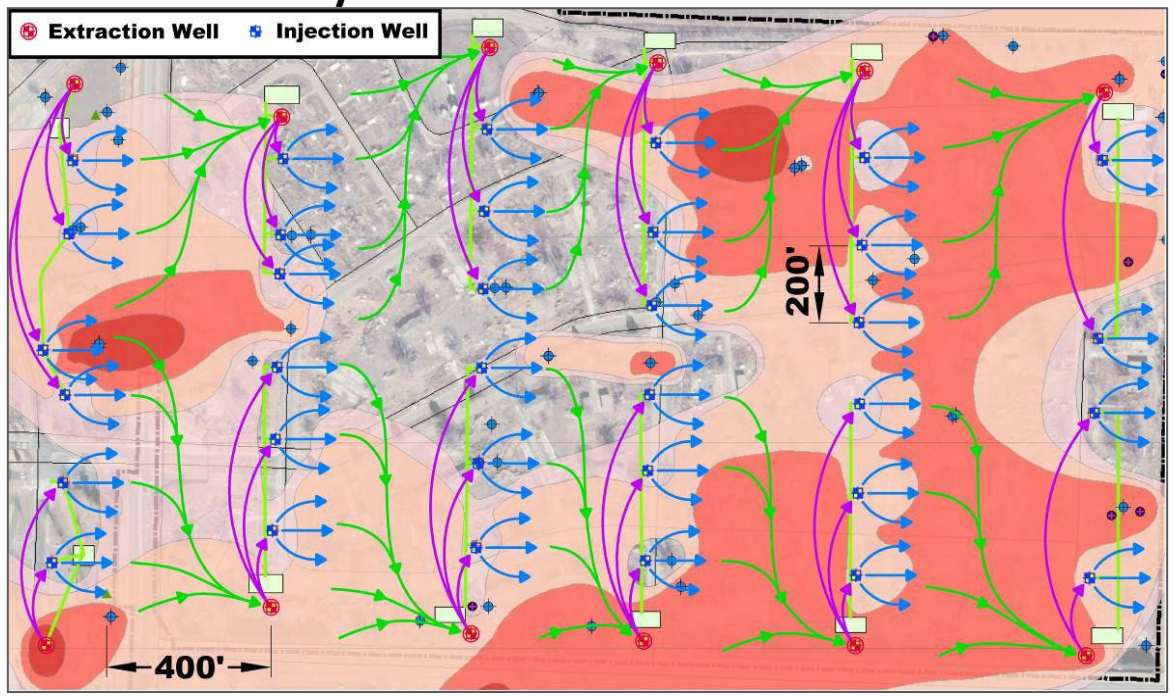
- Project team adopted a **flux-centric** framework
  - Highest flux tends to be in primary flow paths
  - Greatest return on remedial investment will be achieved by aggressively focusing on mass flux
- Selected a combined remedy including Enhanced Reductive Dechlorination (ERD) and Dynamic Groundwater Recirculation (DGR)
- ERD began Year 1, DGR followed
- Remedial approaches were adaptively managed as site conditions were better understood



# ERD Remedy

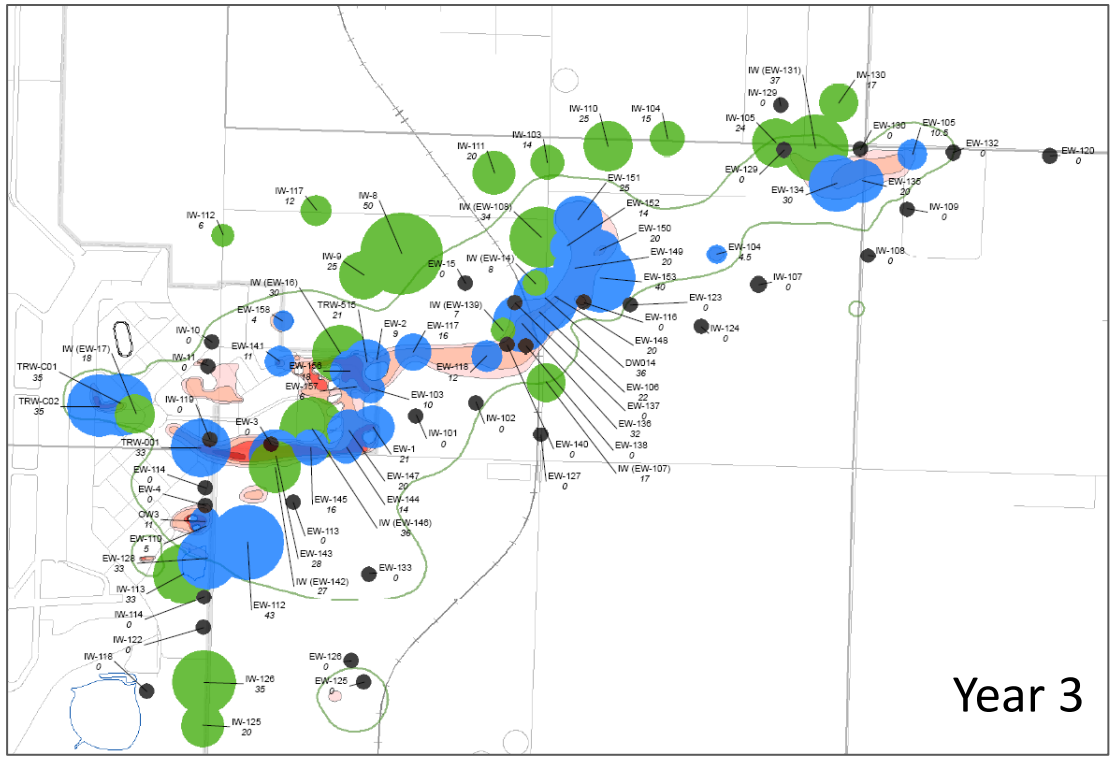
- *Objective:* Enhance natural aquifer geochemistry to facilitate the dechlorination of VOCs (TCE)
- Electron donors such as dilute carbohydrates (ethanol, molasses) delivered to the subsurface using *continuous recirculation*
- Delivery of the electron donor is key to successful implementation of ERD

**Area 3 – Well Layout and Flow**



# DGR Remedy

- *Objective:* Maintain increased mass recovery rates by continuously optimizing extraction and re-injection locations
- Increases number of aquifer pore flushes resulting in shortened cleanup times
- Focused on highest flux zones to maximize TCE mass recovery
- Requires diligent review of extraction and injection rates and concentration trends
- Reduced total flow rate from ~650 gpm to ~300 gpm AND achieved 10X increase in TCE mass recovery rate with higher degree of plume capture




Active Extraction (circle size varies with flow rate)

Active Injection (circle size varies with flow rate)

# Optimized Remedial Strategy

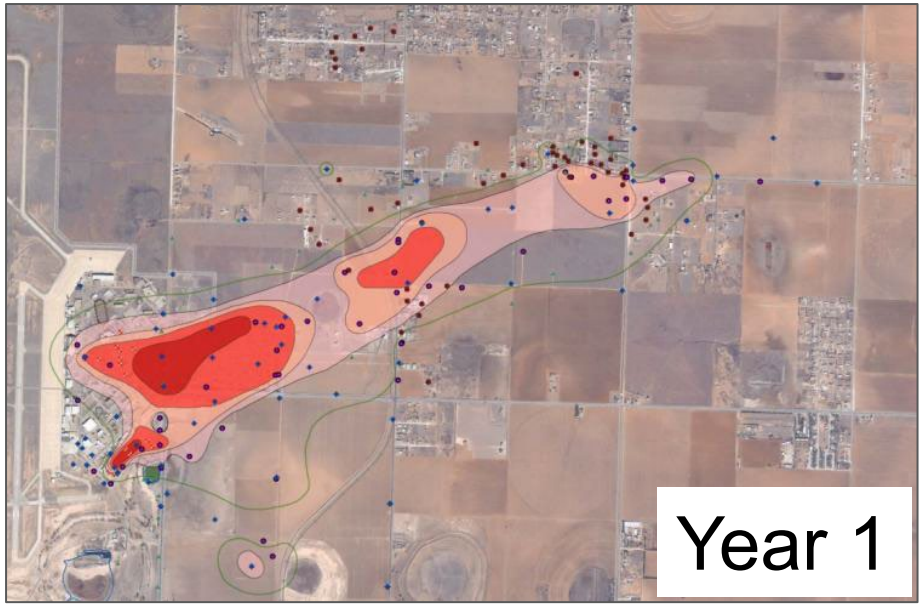
- Although ERD was successful in treating VOC impacts, both ERD areas were converted to DGR in Year 6 (continued to operate/recirculate but without the addition of carbon substrate)
- Objective was to reach cleanup goals faster and more efficiently
- ERD transects provided high degree of lateral coverage, therefore well layout could be used
- Extracted water on periphery, treated with GAC, then re-injected clean water in interior

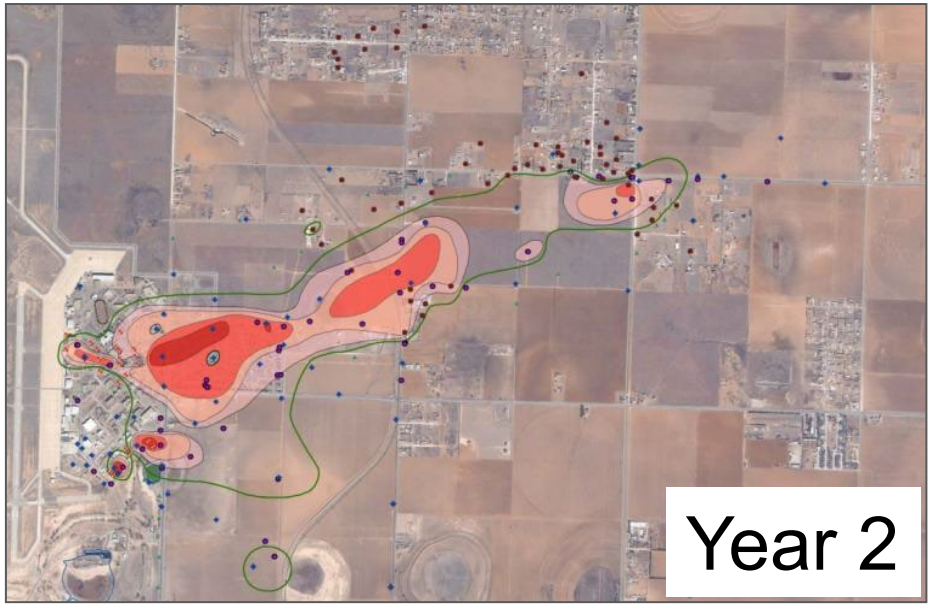
Trailer with GAC Vessels

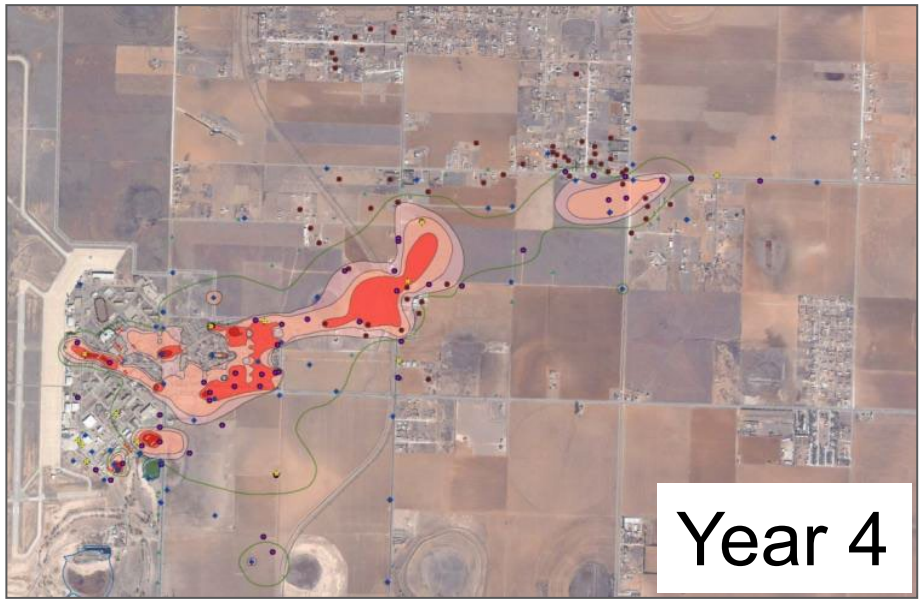
Typical Trailer Manifold System

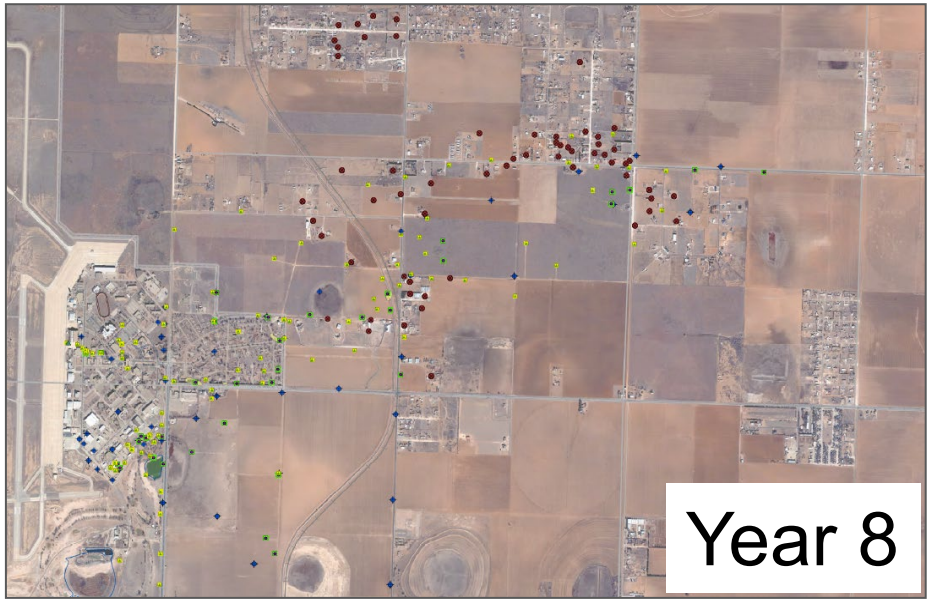

Typical Trailer to EQ Tank

# Plume Evolution



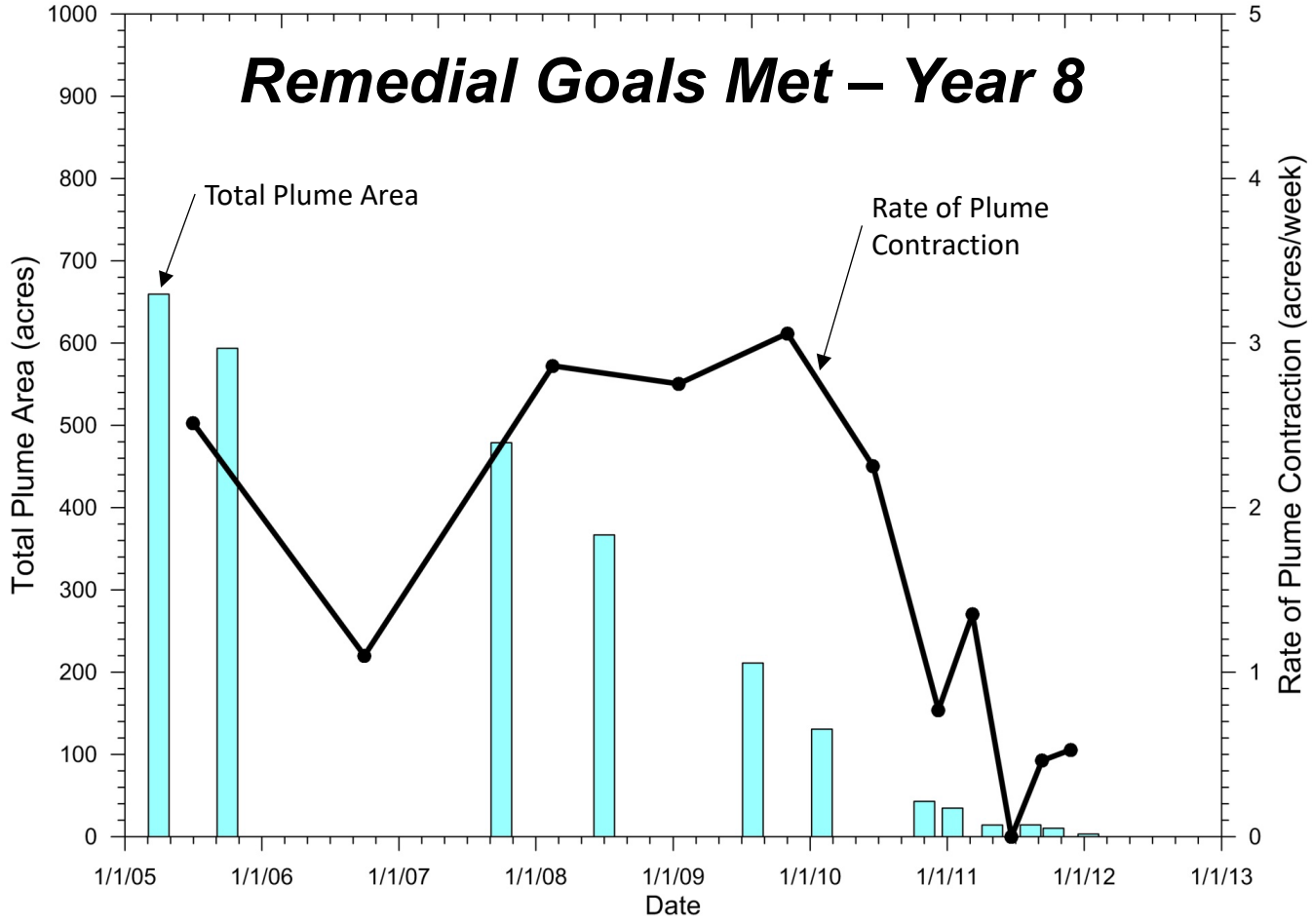



# Performance Assessment

- Complete TCE plume reduction in less than a decade, far ahead of previous 50-year projections
- Remedy optimization led to significant cost savings



# Summary

- Understanding the hydrostratigraphic CSM is critical and should be continuously challenged as new data becomes available
- A flux-centric approach focuses on high flux zones/primary transport pathways where mass remains
- Plume reduction objective requires maximizing mass removal rates throughout remedy operation; flux metrics should guide major decisions
- Project structure and remedial approach must be adaptable and flexible
- Multi-disciplinary approach for successful implementation of combined remedies

# Thank you!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