Kirtland Bulk Fuels Facility Plume: Benefits of CSM-Driven Remediation

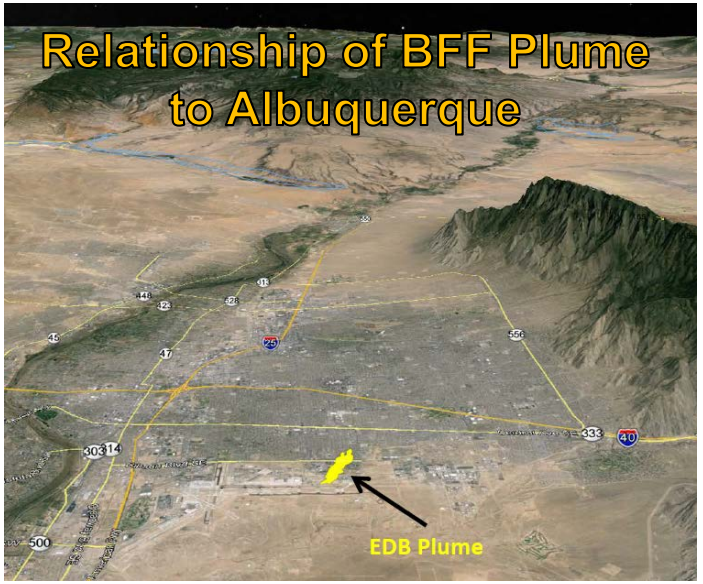
Kent Glover and John Gillespie
AFCEC Environmental Directorate
Technical Support Division

November, 2019

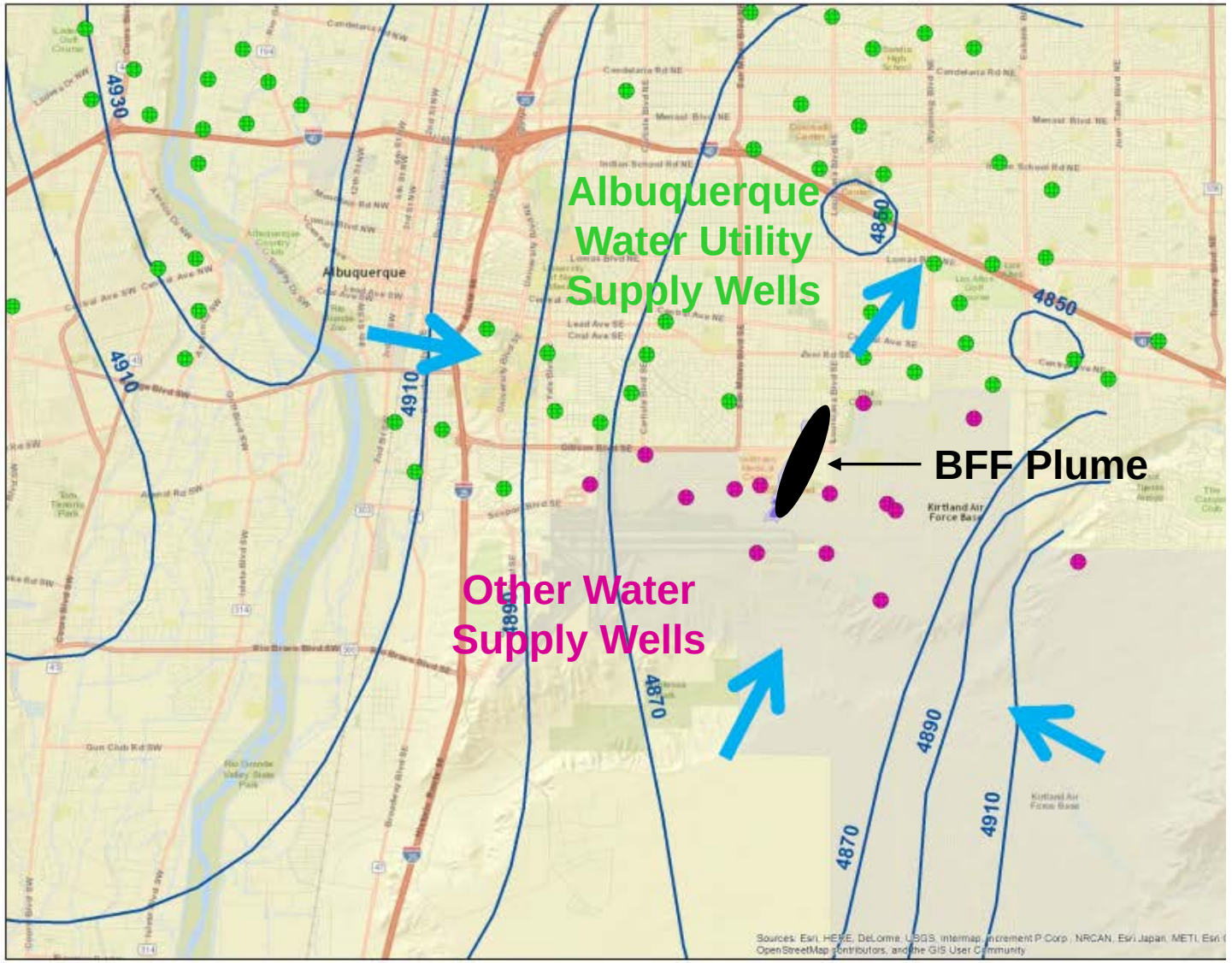
Kirtland Bulk Fuels Facility (BFF)

- Groundwater plume appeared to be migrating toward drinking water supply wells
  - Cleanup has been a top AFCEC priority since 2010
- Remediation success has been driven by adaptive and iterative process
  - Refining the conceptual site model (CSM)
  - Selecting, designing and optimizing remediation systems
- Presentation objective

Demonstrate benefits of CSM-driven remediation at a challenging site

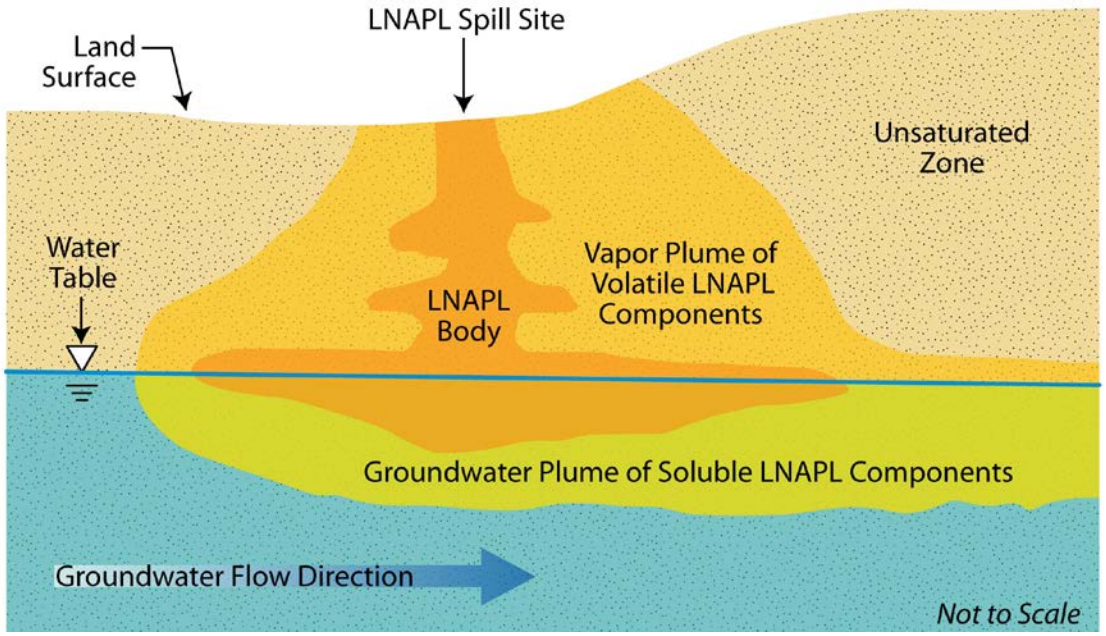


Relationship of BFF Plume to Regional Groundwater



Release History

- 1999 : Discovery
  - Jet fuel leak in subsurface piping
  - Large volume released over several decades
  - LNAPL and BTEX in upper half of 500 ft vadose zone

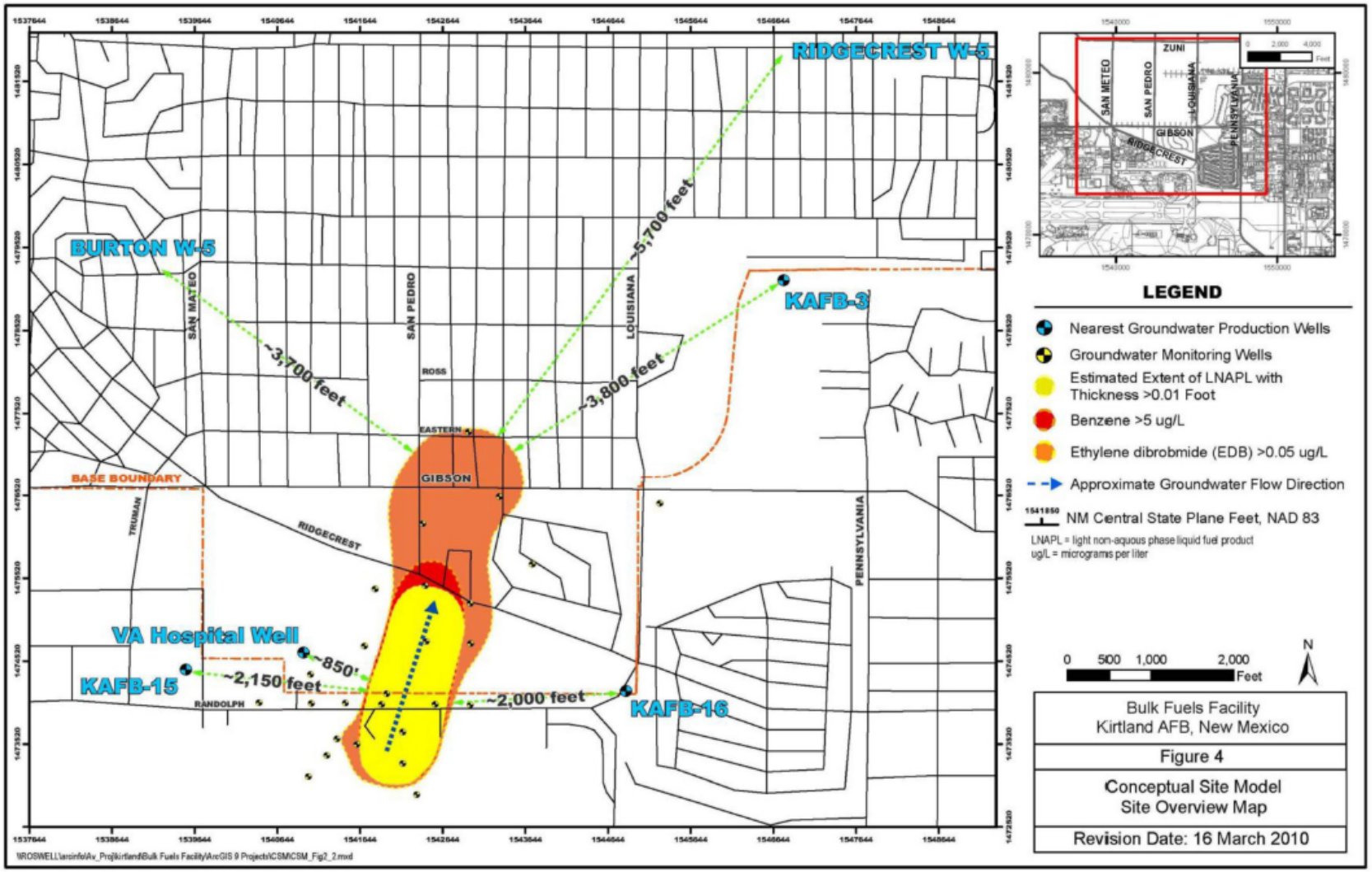


- 2001 : EDB, BTEX detected in groundwater
- 2007 : Free product discovered at water table
  - Offset from release site
- 2009 : Plume detected north of base boundary
  - LNAPL mapped in deep vadose zone

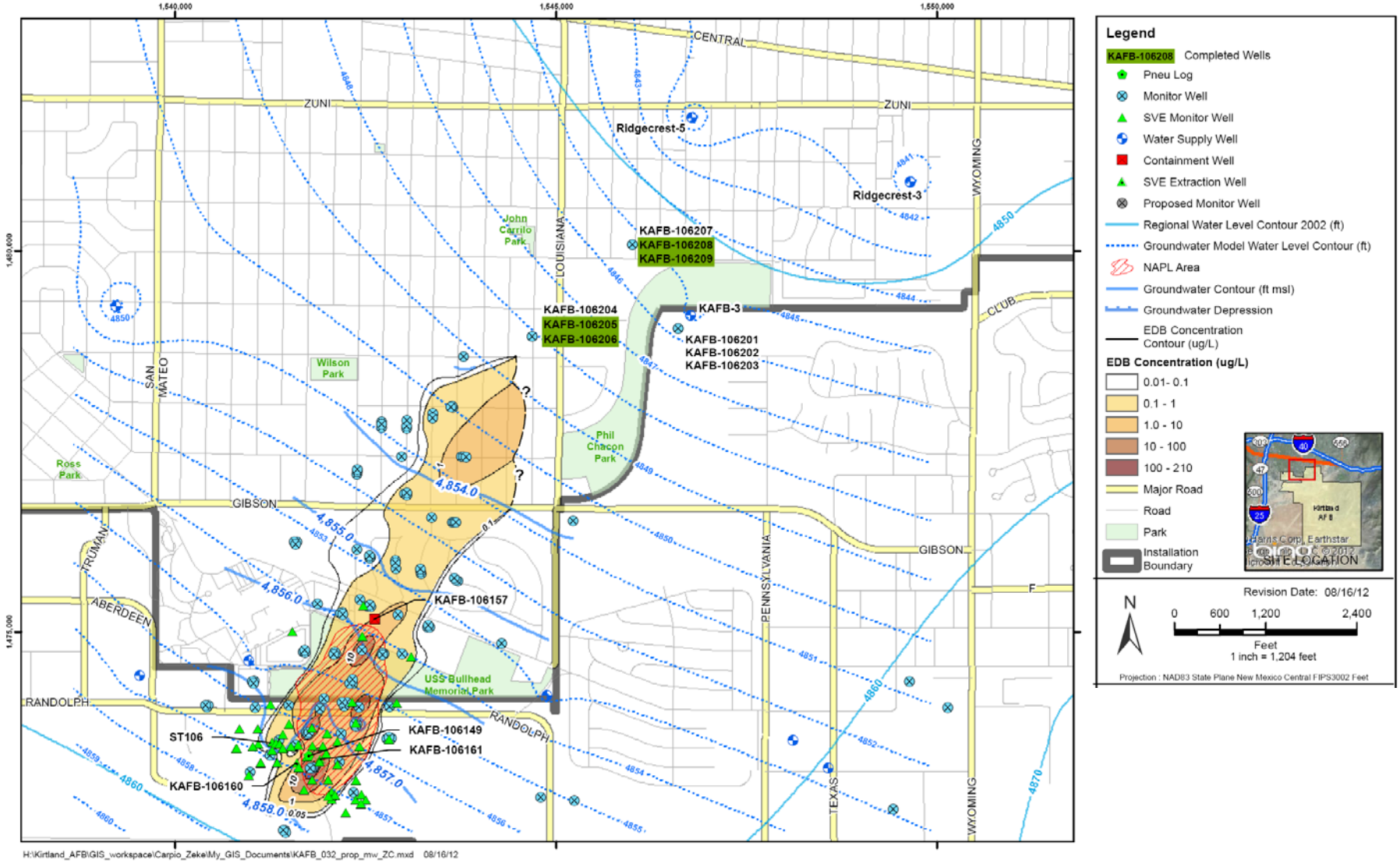
Remediation Challenges

- High visibility with public and Congress
  - Senior leadership committed high level of expertise, contract support and public outreach
  - Diverse stakeholders: AFCEC, NMED, USGS, Water Utility, EPA, Albuquerque, VA Hospital, Citizen Action Group
- Complex site characteristics
  - Deep vadose contamination: LNAPL and vapor phase
  - LNAPL at water table : ~500 ft below surface
  - Large EDB plume with very low MCL : 0.05µg/L
  - Off-base urban infrastructure
- Water table rising as regional water use changes
  - Disappearance of floating LNAPL in groundwater wells
  - Changes in groundwater flow direction

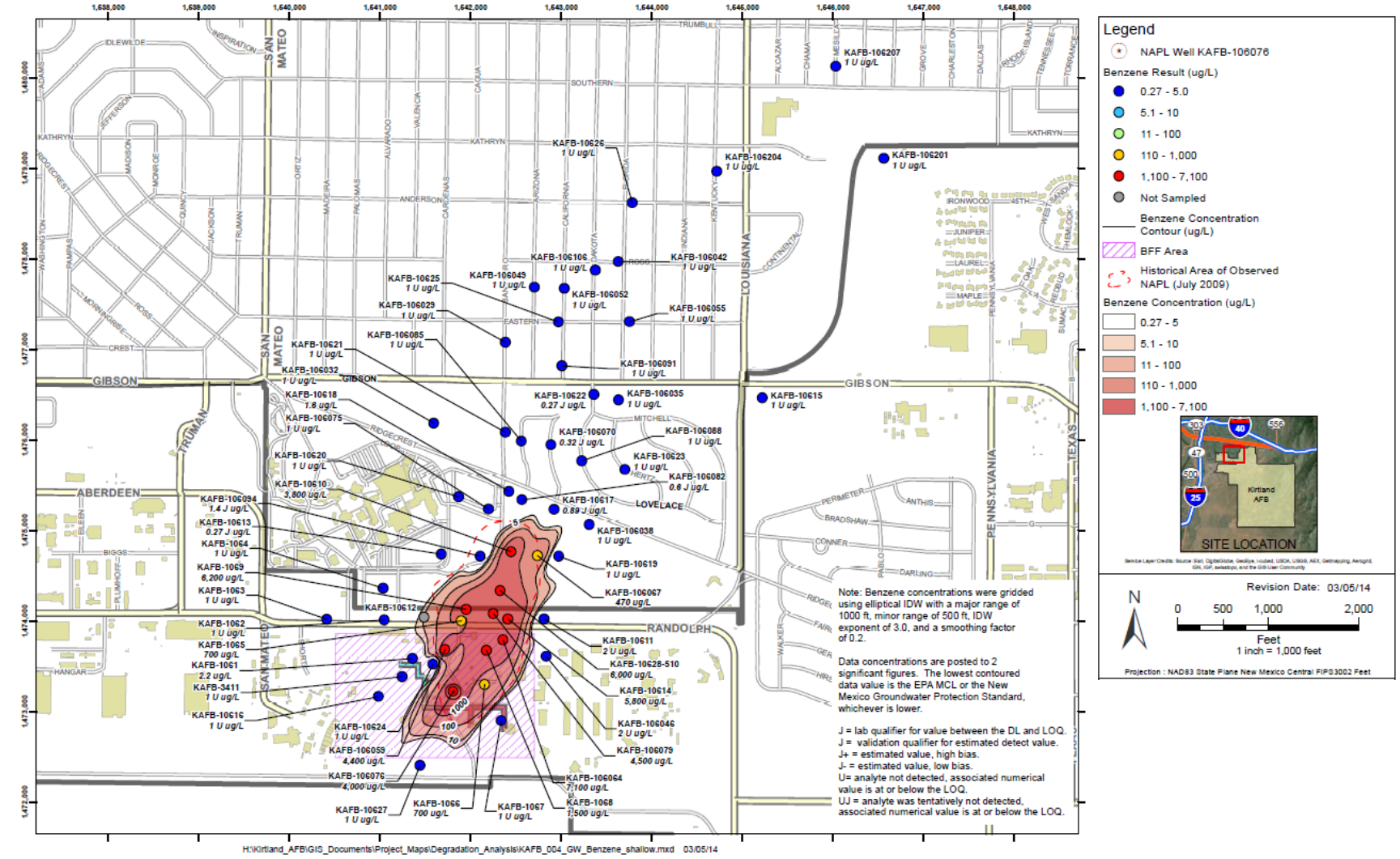
Plume Description: 2010



EDB Plume Chasing: 2012



Stable Benzene Plume Reflects LNAPL Footprint



Leadership Direction

- 2010 : Remediation objectives
  - Ensure drinking water is never contaminated
  - Develop contingency plans with sentinel well clusters for public water supply
  - Stop/collapse ethylene dibromide (EDB) plume
  - Remediate contaminants of concern in accordance with RCRA permit

- 2014 : Establish technical working groups (TWG)
  - Technical experts and site managers/regulators (AFCEC, NMED, Water Utility, EPA, USGS, Albuquerque, VA Hospital)
  - Forum for frequent and transparent collaboration and accountability
  - Evaluate progress on interim measures and work through technical issues

TWG Startup

- Guiding principles
  - Use best available science and data to inform decisions
  - Employ creative technical solutions to address problems
  - Collaborate and engage stakeholders in decisions
  - Ensure meaningful compliance with regulations and permits
- TWG implemented an adaptive and iterative process
  - Improve and refine the CSM
  - Select, design and optimize remediation systems
  - Frequent all-day meetings with action items
  - Small-group spinoffs for data evaluation
- Adaptive approach
  - Emphasize incremental improvements to CSM and remedy
  - 70% solutions, data-driven decisions, collaborative work plans

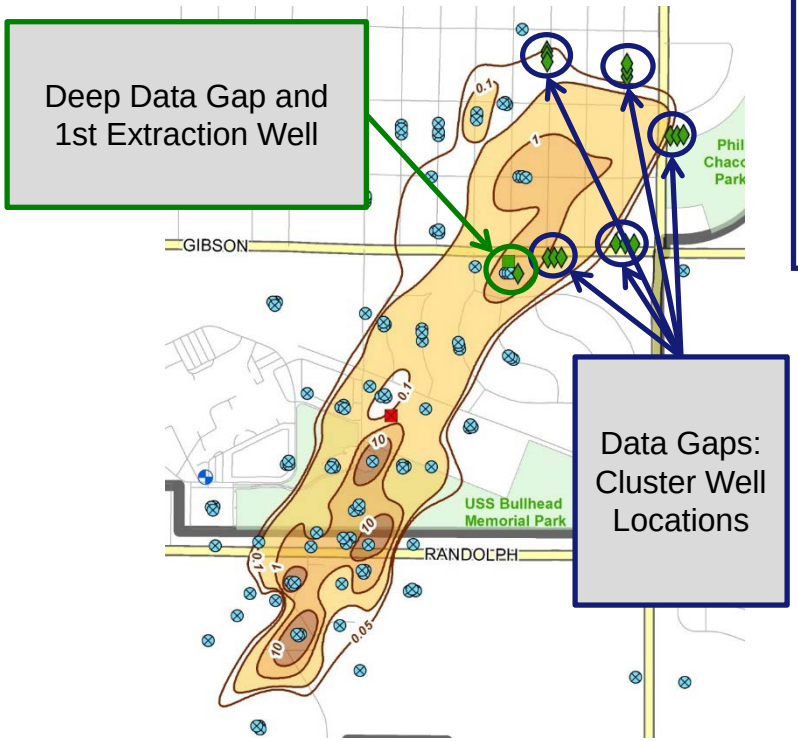
TWG Initial Approach to EDB Plume

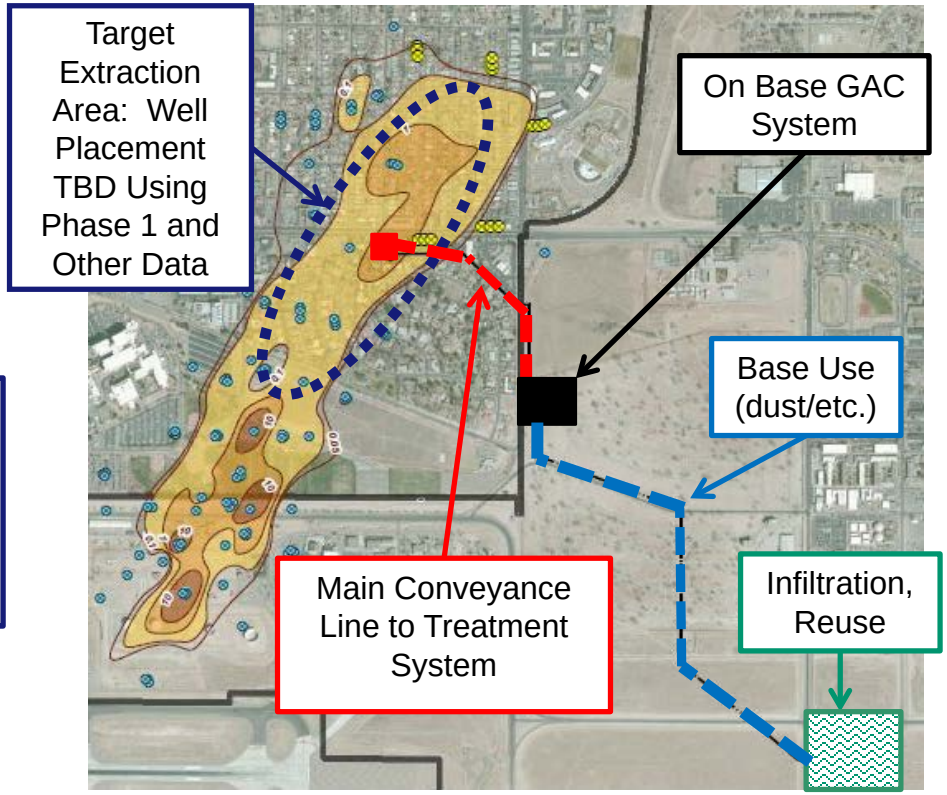
Phase 1

- Interim measure P&T (~100 gpm)
- Characterize plume extent

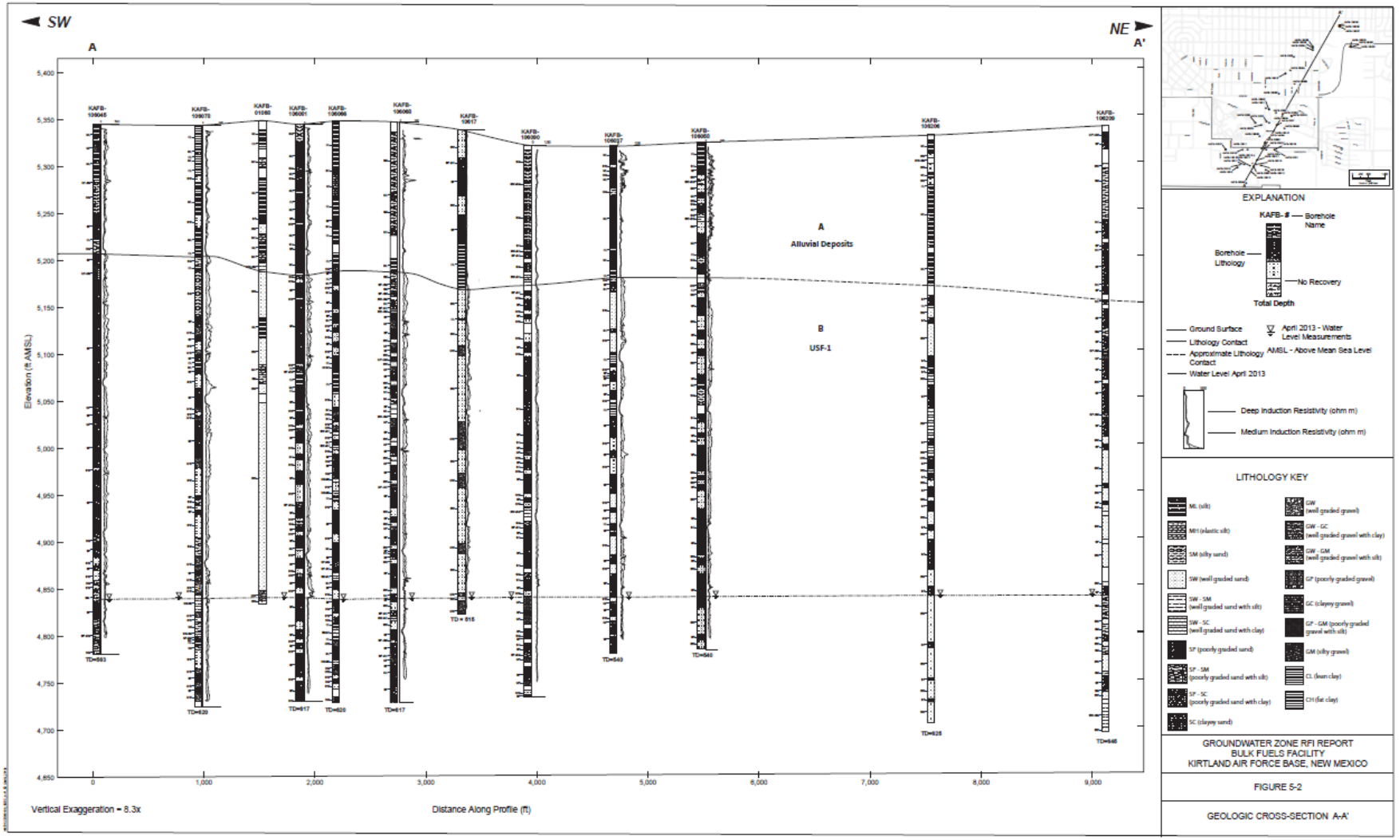
Phases 2 and 3

- Expand P&T system: 5-7 extraction wells (600-800 gpm)
- System optimization to contain and collapse plume



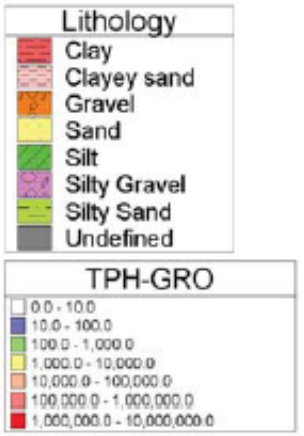


Large Geological Database but Little Analysis Prior to TWG

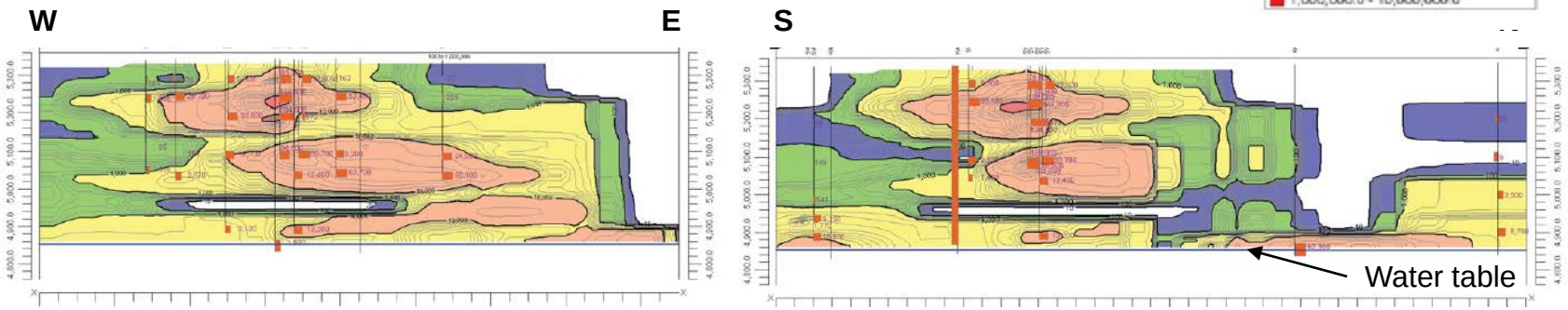


CSM Evolution: Hydrogeological Framework: 2010

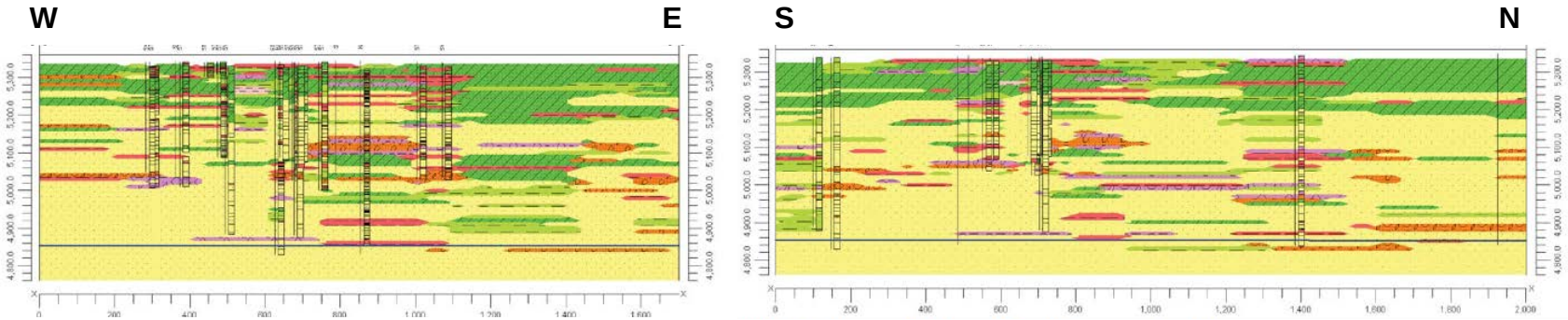
- Geological architecture unrelated to depositional or structural geology
- Weak relationship of plume configuration to potential migration pathways



TPH in Source Area



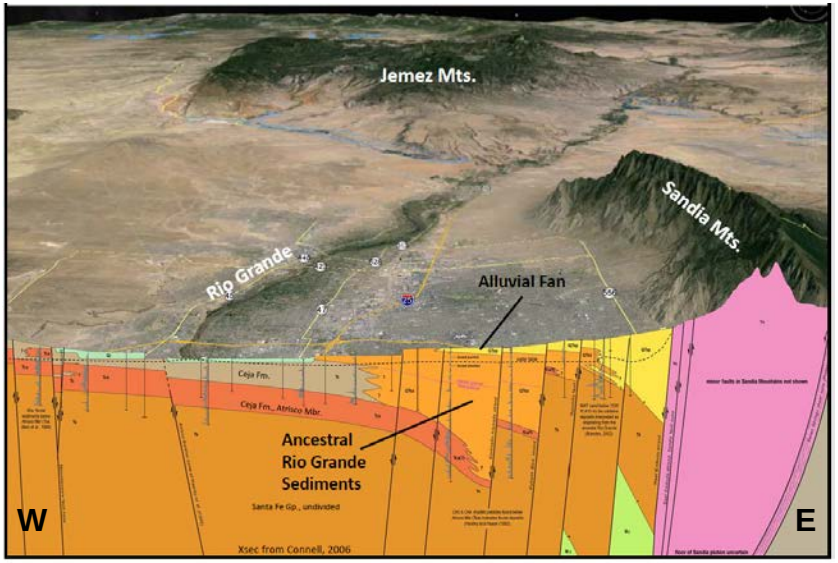
Lithology in Source Area



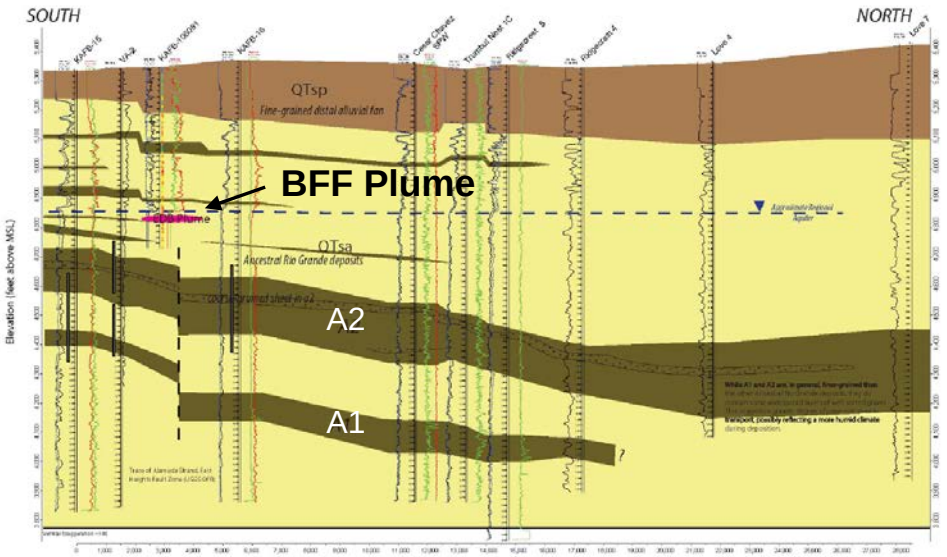
CSM Evolution: 2014 Sequence Stratigraphy

- Hydrogeological framework refined with sequence stratigraphic model
- 2013 hydrogeological & geophysical data base
  - 35 vadose zone locations with 5 depth intervals per location
  - 177 groundwater wells at three depth intervals

Regional Perspective



Sub-Regional Cross Section Through BFF plume



CSM Evolution: 2014 Plume-Scale Stratigraphy

Permeable Channel Orientation, and Size Vary with Depositional History

Alluvial Fan Sediments

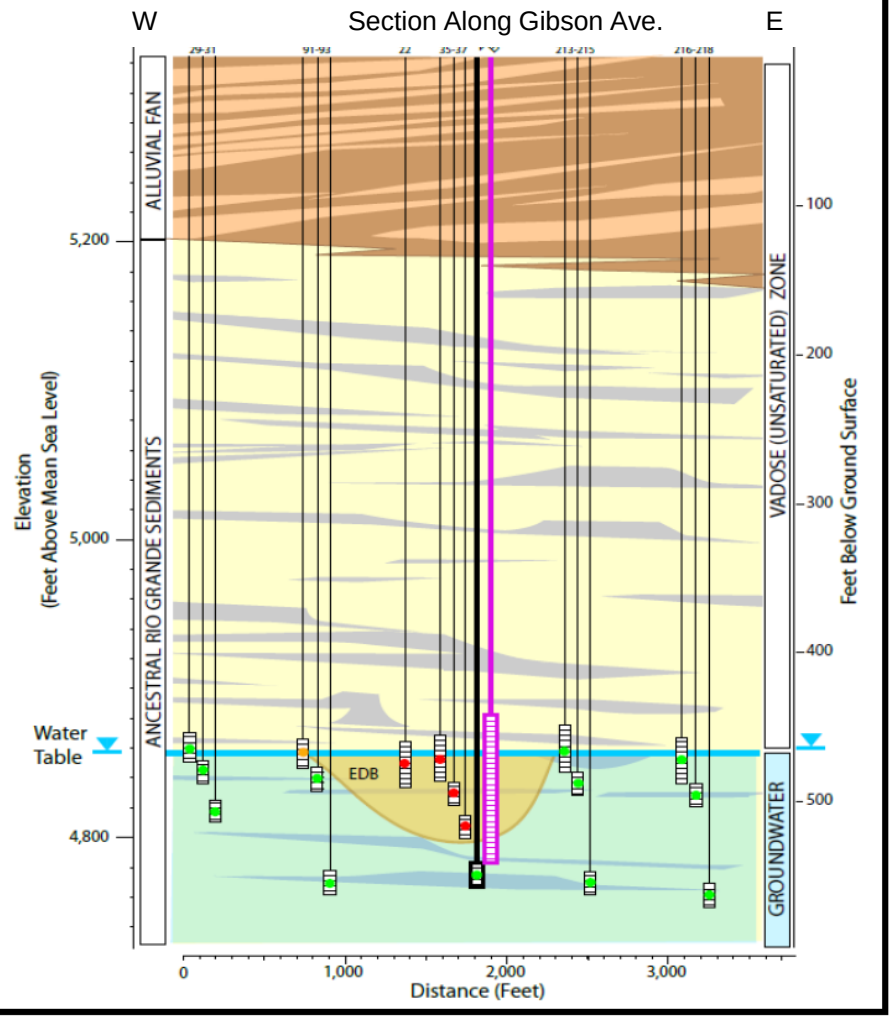
- High Permeability
- Low Permeability

Ancestral Rio Grande Sediments

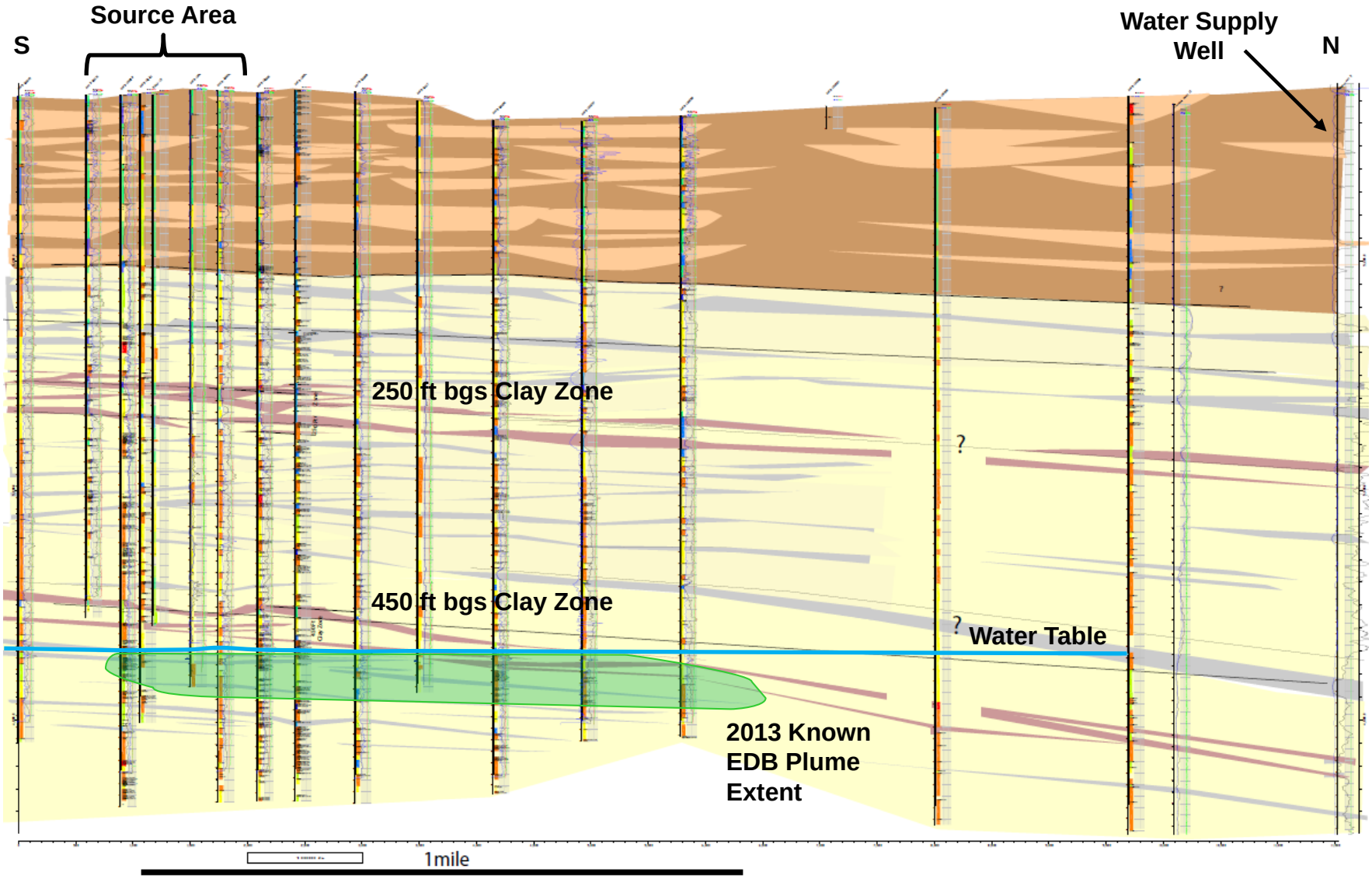
- High Permeability
- Low Permeability

EDB

- Non-Detect
- Detection, Below MCL
- Detection Above MCL

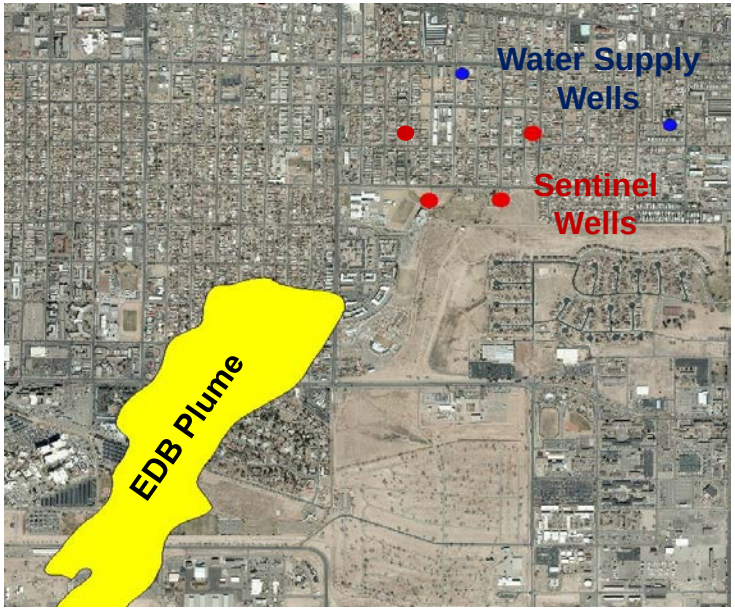


CSM Evolution: Cross Section along Plume Axis

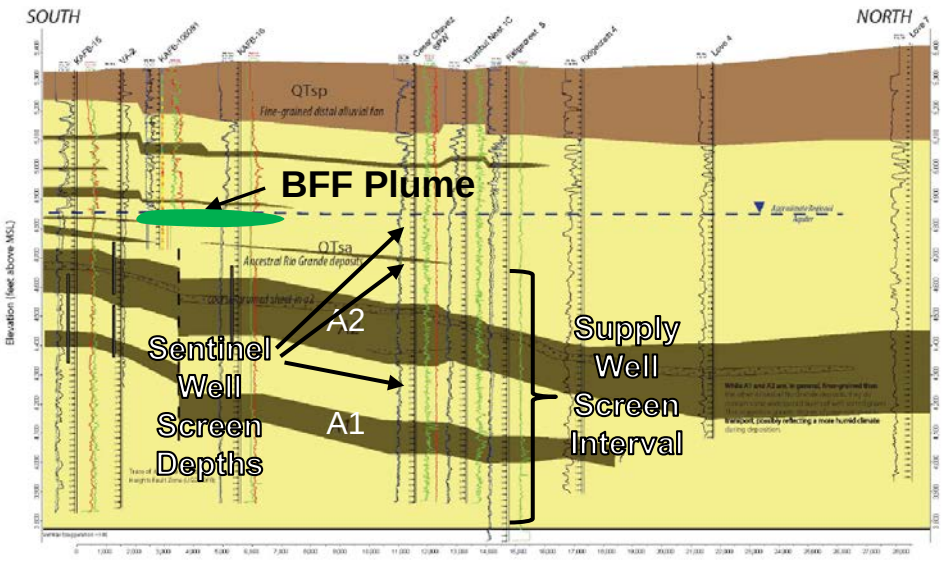


Use of CSM for Sentinel Well Placement

- Sentinel wells give early warning to trigger contingency
- Water supply wells screens at greater depths than plume
- Three screen intervals per sentinel location
  - Water table
  - Above A2 confining unit
  - Below A2 unit



Sub-Regional Cross Section

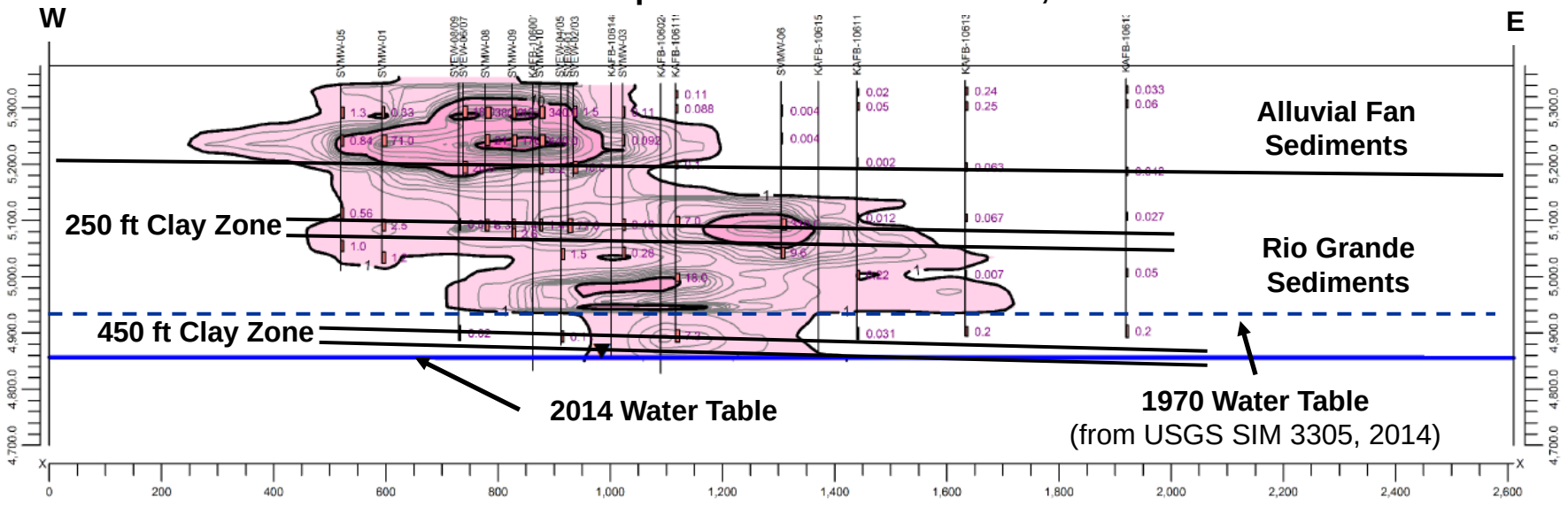


Use of CSM in Vadose Zone Remediation

- Relate LNAPL migration and stratigraphy
- Expand SVE footprint to hot spots
- Perform SVE pilot tests
  - Optimize extraction and treatment
- Collect/evaluate soil cores

Extraction rate increased from 50 to 1,800 cfm

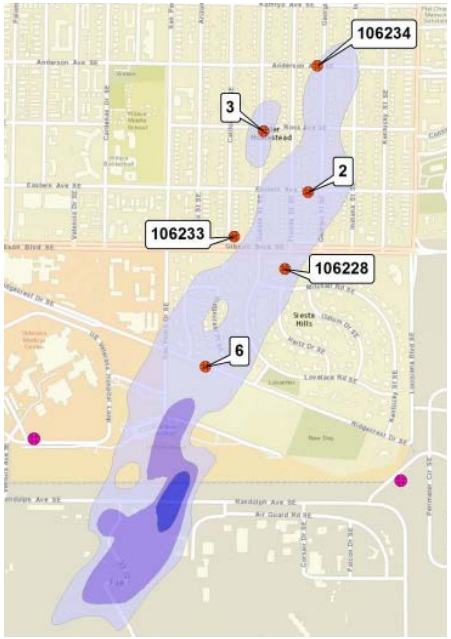
Benzene Vapor Profile in Source Area, 2013



Use of CSM in Distal Plume Remediation

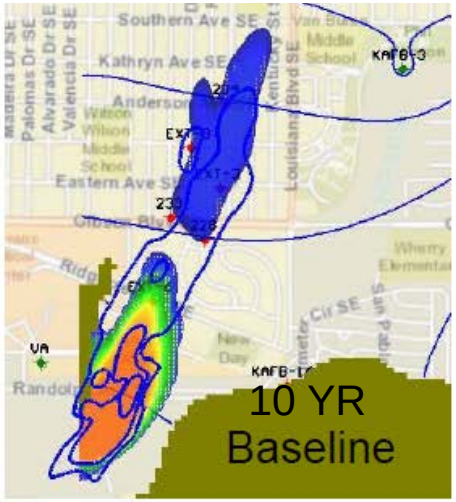
- Key Considerations in P&T system design
  - Flow & transport model recalibrated to address 450 ft bgs clay zone
  - Distribution & orientation of channel deposits
  - Urban infrastructure
- Stepwise approach as each pumping well was brought on line
  - Allowed feedback loop to refine CSM and optimize design of later wells
  - Example: Design alternatives for 4th and 5th extraction wells

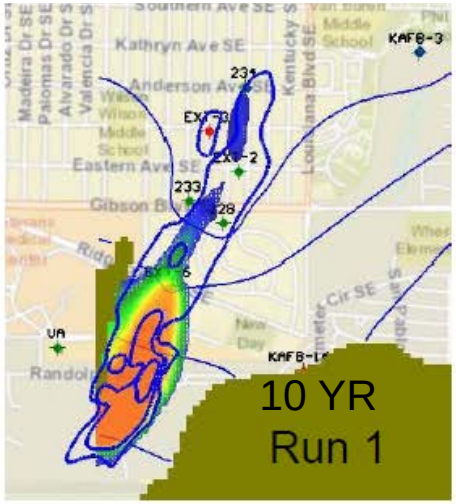
		Pumping Rate (gpm)			
Well	Approximate Saturated Screen (ft)	Baseline	Run 1	Run 2	Run 3
KAFB-106228	80	0	-150	-150	-150
KAFB-106233	80	0	-150	-150	-150
KAFB-106234	80	0	-150	-150	-200
EXT-2	80	0	-150	0	0
EXT-3	80	0	0	0	0
EXT-6	80	0	-75	-75	-75
KAFB-7	465	-300	675	525	575



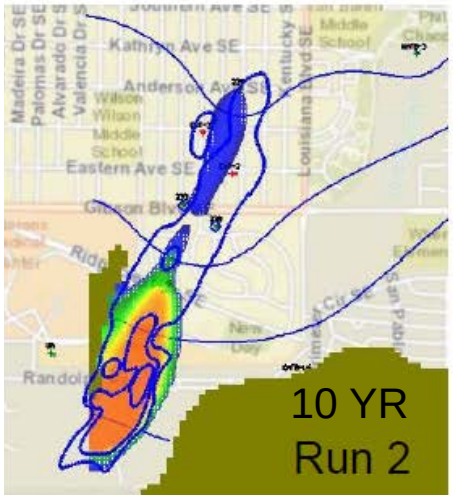
Projected EDB Clean Up for Design Alternatives

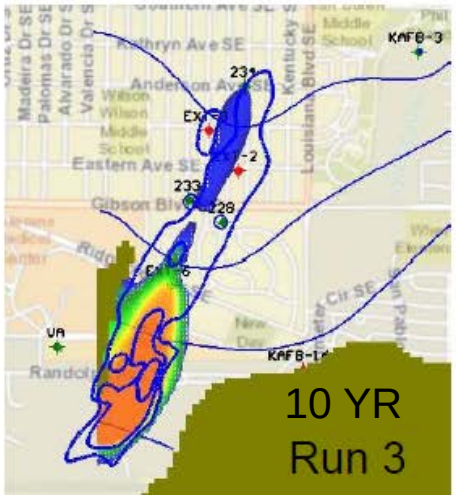
Upper part of plume controls cleanup north of Gibson Blvd

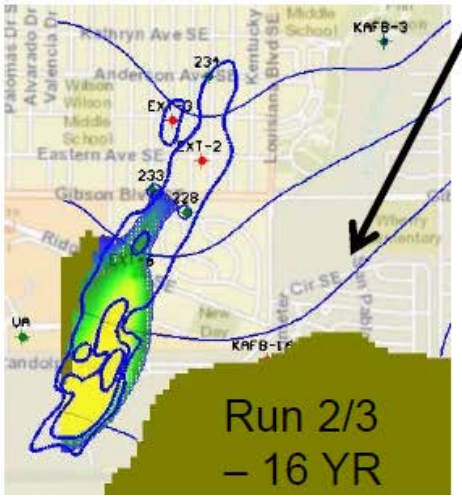




Max. time to clean up EDB north of Gibson.



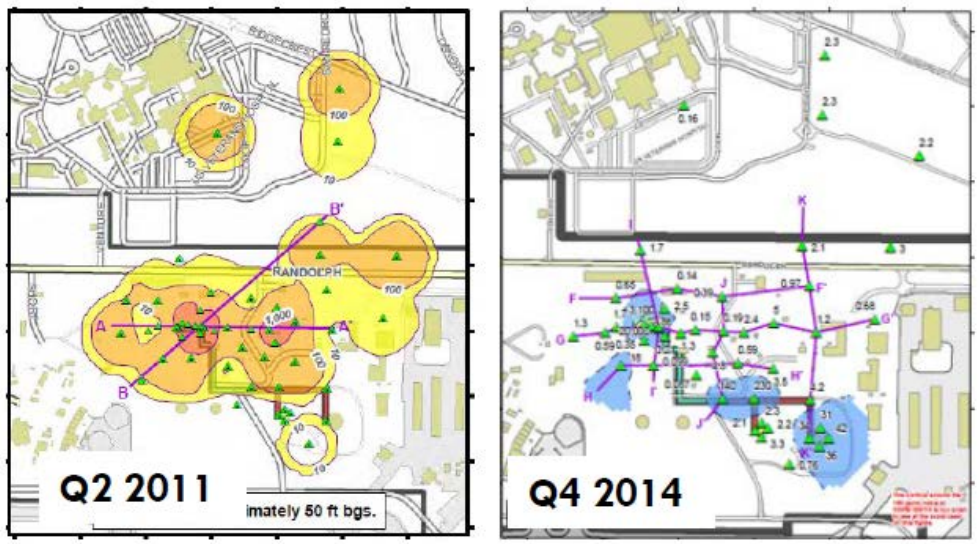


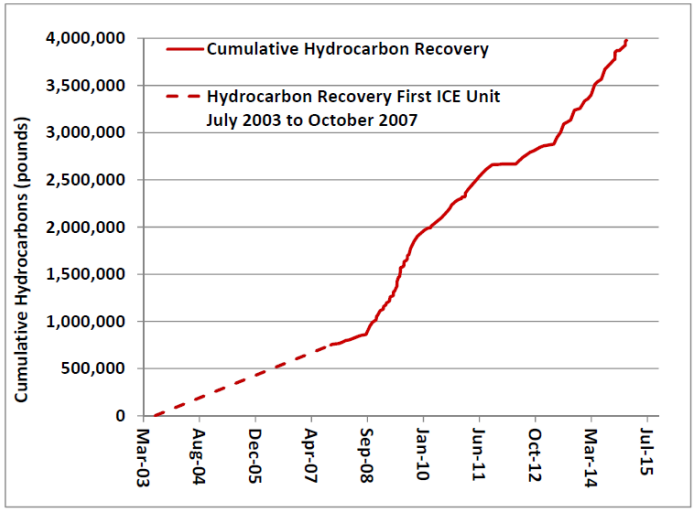


Result of Vadose Remediation

- Soil removal: 5,000 tons
- SVE removed 780,000 gal fuel
  - SVE shutdown: 2015
  - Soil-gas rebound testing
  - Coring of select locations
  - In situ respiration monitoring

Total VOCs at 50 ft





- Rebound and coring identified remaining hot spots
- Respiration monitoring results
  - Correlate with hydrocarbon presence
  - Low respiration rates suggest minimal biodegradation
  - Water content not optimal

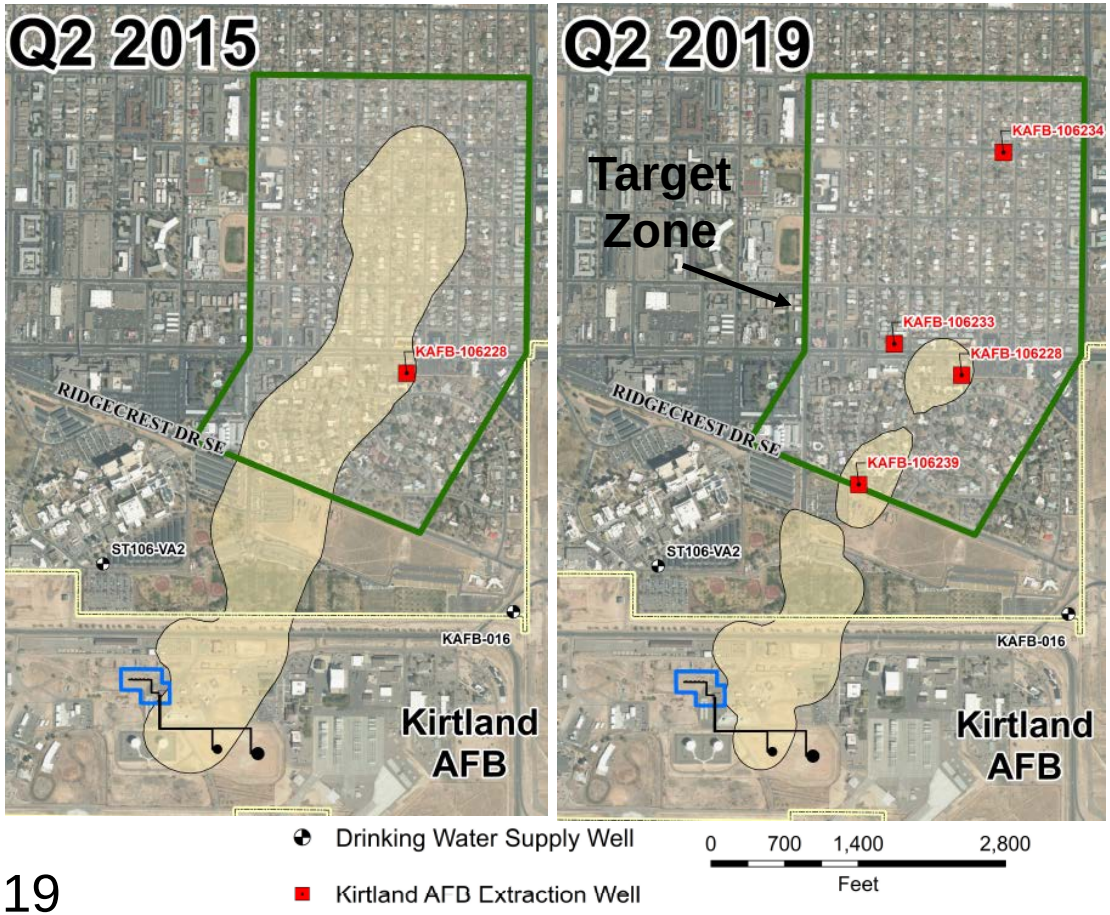
Result of Distal Plume Remediation

Extraction Well	Start Date
1	June 2015
2	Dec 2016
3	Apr 2017
4	Feb 2018

Water treatment

- Four 20,000 lb GAC units
- 601.5 Mgal though Mar 2019
- 13 g EDB

Footprint of Shallow Plume



- Cleanup of middle & lower parts of plume completed

Result: Public and Stakeholder Acknowledgement of Success

- Increased public awareness and involvement
  - Proactive & transparent communication
  - Public meetings, poster sessions, deep dives & field trips
  - Direct public access to technical experts
- Improved public relations
  - Dramatic changes from confrontation to seeking clarification of complex technical topics

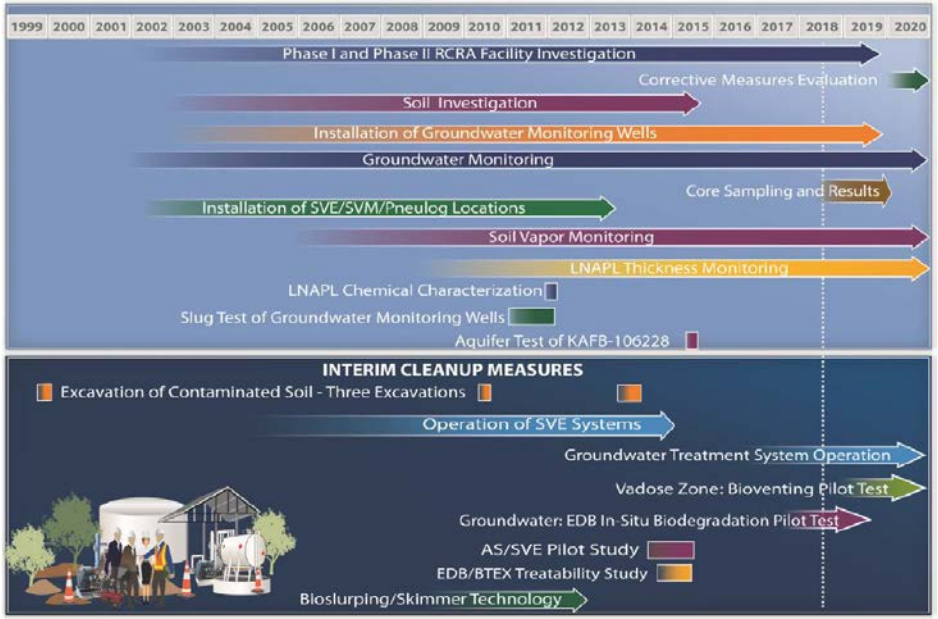
Editorials

Editorial: KAFB, NM have cleanup flowing in right direction

By Albuquerque Journal Editorial Board
Tuesday, July 19th, 2016 at 12:02am

Current Focus of Kirtland TWG

- Goal: Transition to long-term remedy
- Vadose zone: bioventing pilots to promote microbial degradation
  - Raise moisture content
  - Deliver oxygen



- Saturated zone EDB: In situ biodegradation pilot
  - Baseline, recirculation tracer test, passive monitoring (2017)
  - Biostimulation: two designs (2018-2019)
  - Additional passive monitoring (on-going)

Conclusions

- Meeting Kirtland BFF challenges requires rapid deployment of multiple remedial technologies in a complex setting
- Cleanup success driven by an adaptive remedial approach with strong links to an evolving CSM
- A functioning interagency TWG has been key to success
  - Adaptive, transparent and collaborative
  - Data-driven decision process
  - 70% solutions
  - Stepwise design/operation with CSM feedback loops
- Benefits of CSM-driven remediation
  - Builds stakeholder support to remediation approach
  - Shortens time to meet performance objectives
  - Builds confidence among leadership of all agencies and stakeholders

Kent Glover (Kent.Glover@us.af.mil)

John Gillespie (John.Gillespie.3@us.af.mil)

AFCEC/CZTE

2261 Hughes Ave, Ste 155

JBSA Lackland AFB, TX 78236-9853

"For media inquiries, please contact the Air Force Installation and Mission Support Center public affairs office email: AFIMSC.pa.workflow@us.af.mil

or call (866) 725-7617