New Mexico Environment Department
2018 Strategic Plan
For Kirtland Air Force Base
Aviation Fuel Cleanup

July 11, 2018

Sand and gravel deposited by the ancestral Rio Grande is the host material for a major aquifer in the Albuquerque area

Message from Secretary Tongate

Cleaning up the Kirtland Air Force Base (KAFB) fuel leak continues to be one of the highest priorities for the New Mexico Environment Department (NMED). Our team of federal, state and local experts, cooperating with community stakeholders, is successfully extracting groundwater contaminants in the area nearest to drinking water wells. More than 400 million gallons of contaminated groundwater have been extracted, treated to less than detectable concentrations, and either used to water the KAFB golf course, or injected back into the aquifer.

The rising water table, while beneficial for the long-term sustainability of Albuquerque's aquifer, has created challenges for this project that the team continues to adapt to. Data gaps will be filled by drilling new monitoring wells, and we are evaluating how the water level rise may affect the migration and cleanup of groundwater contaminants.

Interim corrective measures and pilot tests will continue during 2018. A bioremediation pilot project is underway to provide information on how groundwater bacteria can best be utilized to biodegrade fuel contaminants. Bioventing, a logical follow-up to the 12 years of soil vapor extraction conducted at the site, will deliver more oxygen to soil bacteria to enhance biodegradation of contaminants in the vadose zone above groundwater.

On behalf of the team, we are extremely grateful to members of the public who attend our meetings, technical "deep dives" and field trips. Special thanks to the neighborhoods for putting up with the noise and inconvenience of well drilling, sampling, and construction.

Site History

- **1951-53 –** Kirtland Air Force Base, Bulk Fuel Facility was constructed. Site operations included handling aviation gasoline which contained the additive ethylene dibromide (EDB).
- **1975 –** Handling of aviation gasoline ended; transition to jet propellant 4 (JP-4) which did not contain EDB.
- **1993 –** Primary fuel transitioned from JP-4 to JP-8 which also did not contain EDB.
- **1999 –** KAFB discovered fuel pipeline leaks, notified NMED, decommissioned pipelines, and initiated site investigations.
- **2001 –** KAFB notified NMED of fuel constituent detections in groundwater.
- **2003-15 –** Soil vapor extraction (SVE), combined with bioslurping, vacuumed and biodegraded ~750,000 gallons of fuel out of the source area.
- **2007 –** Light non-aqueous phase liquid (LNAPL) discovered in groundwater.
- **2008-11 –** Bioslurping (vacuuming LNAPL and soil vapor with circulation of air that facilitates fuel biodegradation) near the water table in the source area.
- **2009 –** Groundwater table began to rise because of decreased pumping of municipal water wells. Water conservation and use of river water drove reduced pumping.
- **2015 –** Groundwater cleanup began as interim corrective measure aiming to collapse EDB plume away from drinking water wells.
- **2016 –** Cone of depression observed around groundwater extraction wells.
- **2017 –** Capacity of groundwater treatment system doubled; 4th extraction well drilled.

Regulatory Basis

Drinking Water Protection

- Public water systems, such as the Albuquerque Bernalillo County Water Utility Authority, KAFB, and the Veterans Administration Hospital, are required to deliver water to consumers that complies with federal Safe Drinking Water Act (SDWA) standards. NMED has been granted primacy by the U.S. Environmental Protection Agency (EPA) to administer the SDWA program.

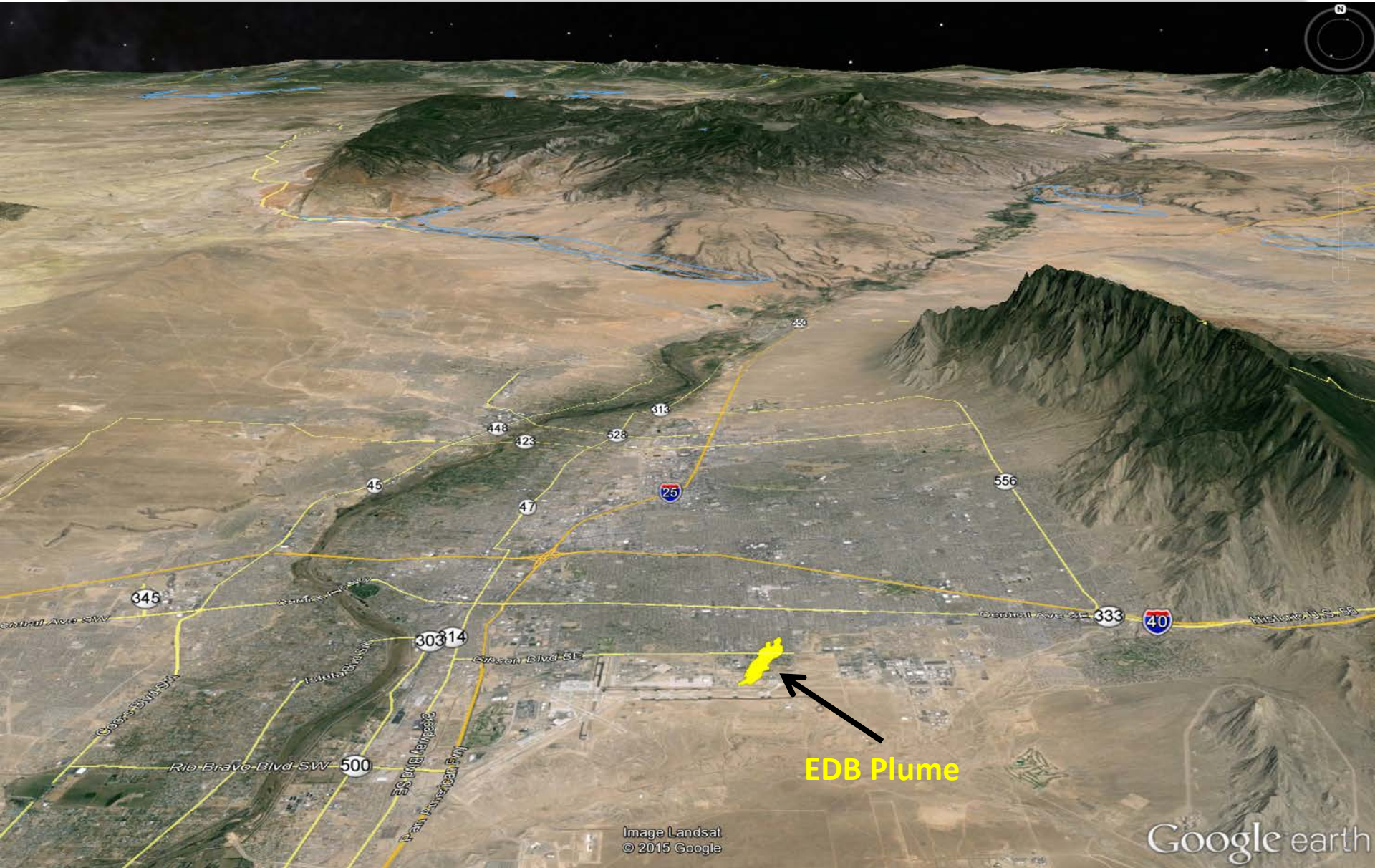
Cleanup of Fuel Contamination

- Investigation and cleanup of the fuel leak began in 1999 under the authority of N.M. Water Quality Control Commission (WQCC) groundwater regulations administered by NMED. In 2010, NMED transferred the fuel cleanup from WQCC to federal Resource Conservation and Recovery Act (RCRA) authority. KAFB must comply with the Corrective Action requirements of their RCRA permit. NMED also has been granted primacy by EPA to administer the RCRA program.

- KAFB obtained authorization from NMED for the discharge of treated groundwater to the KAFB golf course (for use as irrigation water) and by injection into well KAFB-7 (for aquifer recharge). A WQCC Underground Injection Control (UIC) permit, a provision of the SDWA program, was required for discharge into well KAFB-7. The Class V UIC Permit contains additional safeguards and monitoring requirements beyond those contained in KAFB's RCRA permit.

Conceptual Site Model Animation

https://www.env.nm.gov/NMED/Issues/KirtlandFuelPlume/KAFBProjectImages.html



2018 Strategic Plan

<u>Goal</u>: Protect Albuquerque's aquifer and drinking water supply wells in the area of the fuel leak

<u>Strategies to Achieve the Goal</u>

In 2018, NMED and the Air Force will continue to:

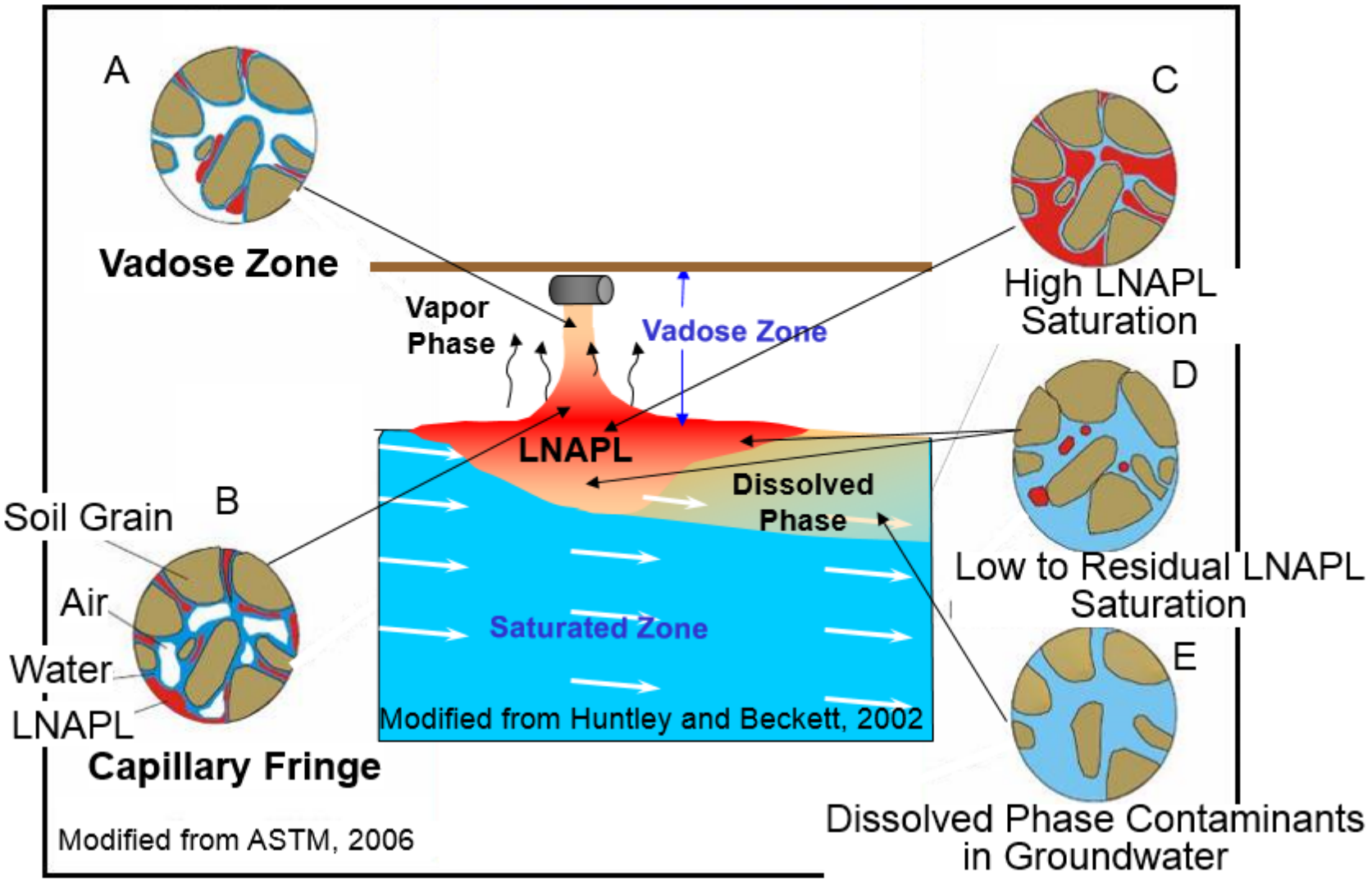
1. **Implement a robust site monitoring and wellhead protection program**
2. **Update the Conceptual Site Model, as necessary, to describe physical, chemical and biological processes that affect the migration and fate of fuel contamination in soil, soil vapor and groundwater**
3. **Using information gained in Strategies 1 and 2, deploy multiple engineered technologies, both simultaneously and sequentially as interim corrective measures, to mitigate soil, soil vapor and groundwater contamination**
4. **Meet or exceed all requirements for providing public information and involvement**

Strategy 1 – Implement Robust Site Monitoring and Wellhead Protection

- No detections of EDB in drinking water wells or sentinel wells
- Cone of depression persists in groundwater extraction area
- Rigorous EDB plume capture analysis will be performed
- Soil coring will fill data gaps on residual LNAPL
- Evaluate changes to groundwater flow direction and contaminant migration
- Data gaps caused by water level rise are being filled by:
  - Drilling new monitoring wells
  - Monitoring previously dry soil-vapor wells that now contain groundwater

KAFB fuel contaminants will not be allowed to adversely impact any community drinking water wells

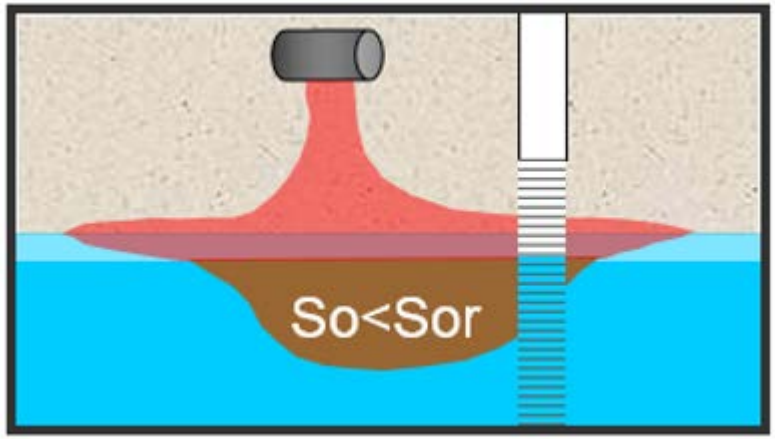
1. Example of LNAPL in the Subsurface



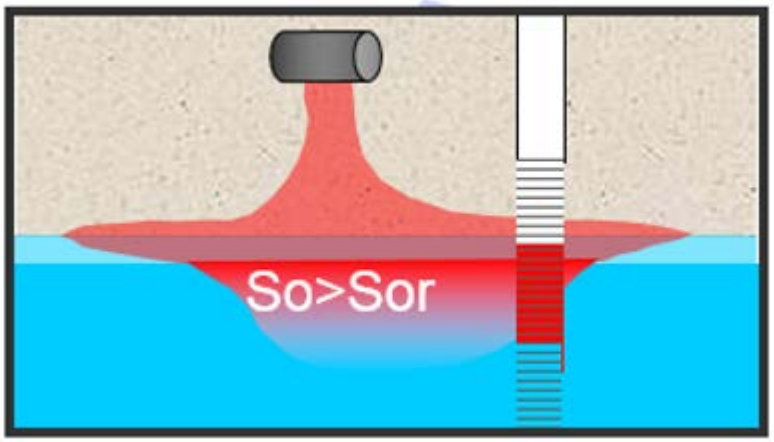
1. LNAPL Saturation

LNAPL Saturation (So) = percent of soil pore space occupied by LNAPL (oil)

Residual LNAPL Saturation (Sor) = LNAPL that will not freely drain from the soil into a monitoring well



LNAPL saturation less than residual saturation
LNAPL does not flow into well



LNAPL saturation greater than residual saturation
LNAPL flows into well

Residual LNAPL at the KAFB site provides an ongoing source of dissolved groundwater contaminants, and characterization is a major data gap that will be addressed during 2018.

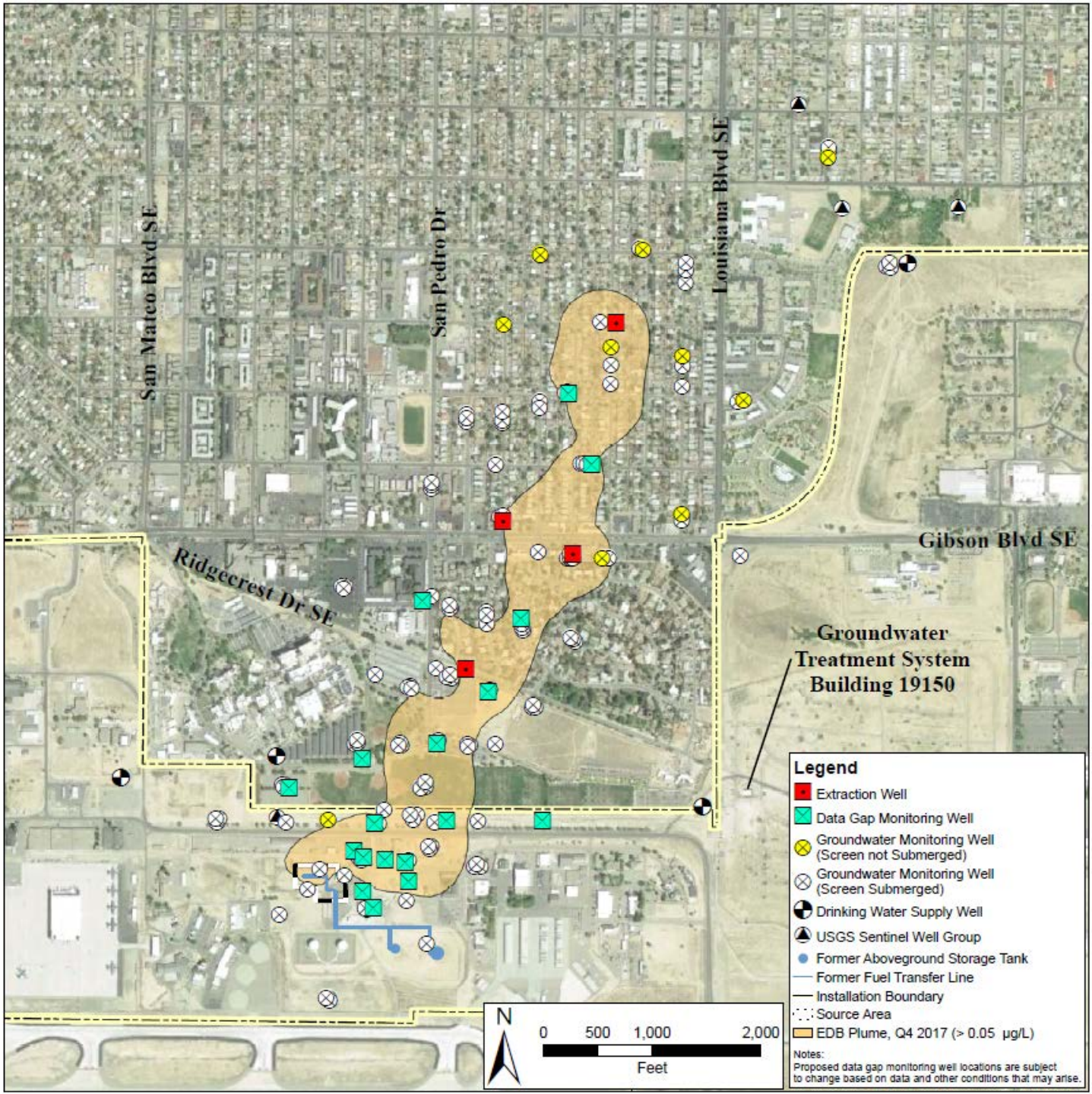
1. At Least 18 (up to 26) New Wells to Fill Data Gaps

Six monitoring wells will be drilled.

Five, and possibly up to 8, LNAPL coreholes will be completed as monitoring wells.

At least seven, and likely up to 12, previously dry soil-vapor or groundwater wells now have water due to rising water table (using these existing wells will save up to $5.25 million in drilling costs) and will be added to monitoring network.

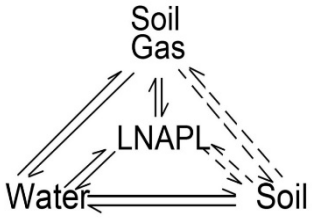
Use of existing wells to fill data gaps reduces cost to taxpayers!



Strategy 2 – Update Conceptual Site Model

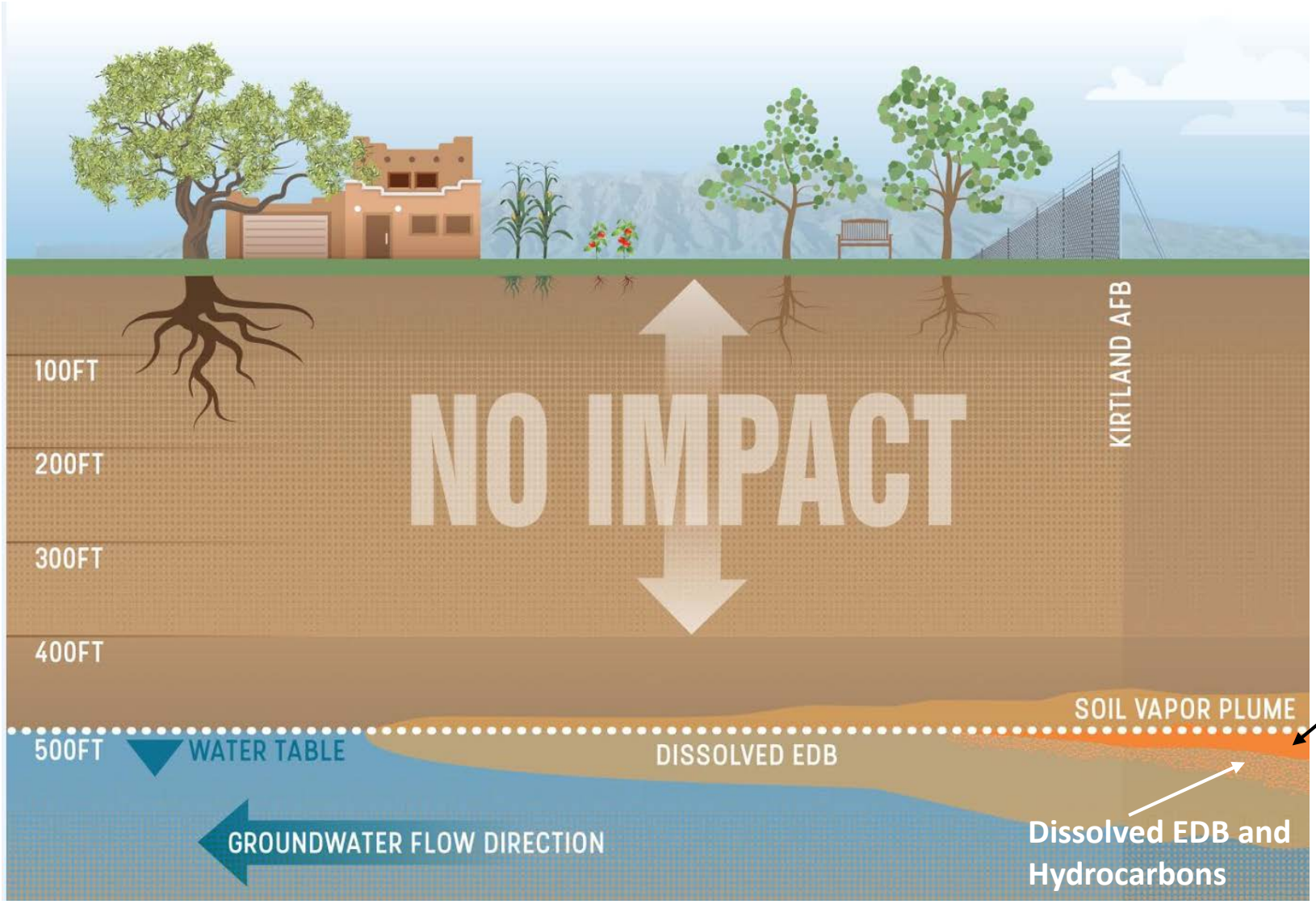
- Define effect of water table fluctuations on locations and amounts of residual LNAPL
- Identify natural degradation processes and potential opportunities for enhancement through engineered cleanup technologies

Contaminant partitioning between LNAPL, water, soil gas and soil (adsorbed) phases



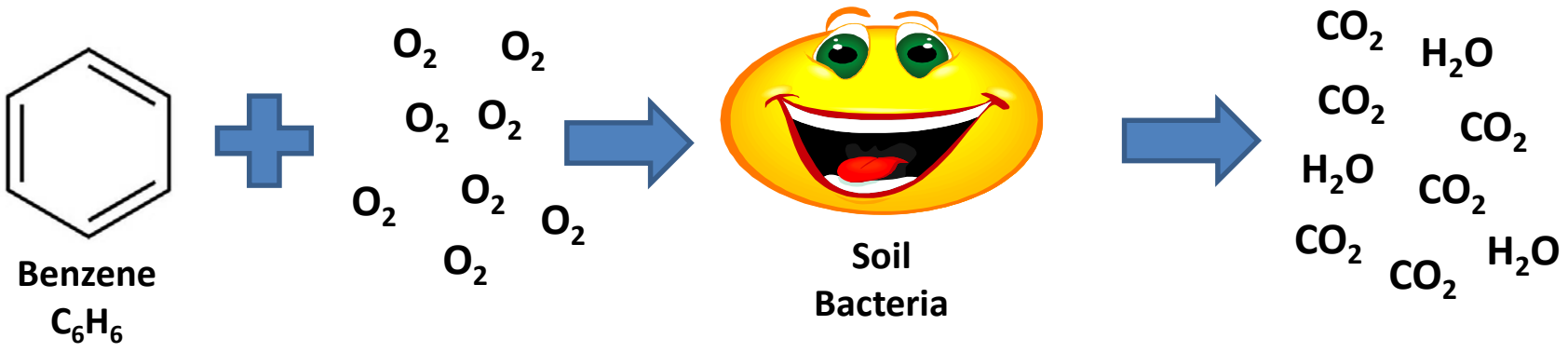
Conceptual Site Model Before Interim Corrective Measures

2. It is safe to drink city water, grow gardens and fruit trees, and enjoy back yards and parks.



2. Hydrocarbon Biodegradation

Soil and groundwater bacteria can oxidize petroleum hydrocarbons, such as benzene, into carbon dioxide and water. Naturally occurring biodegradation process can sometimes be enhanced, for example, by delivering additional oxygen to soil bacteria during bioventing.



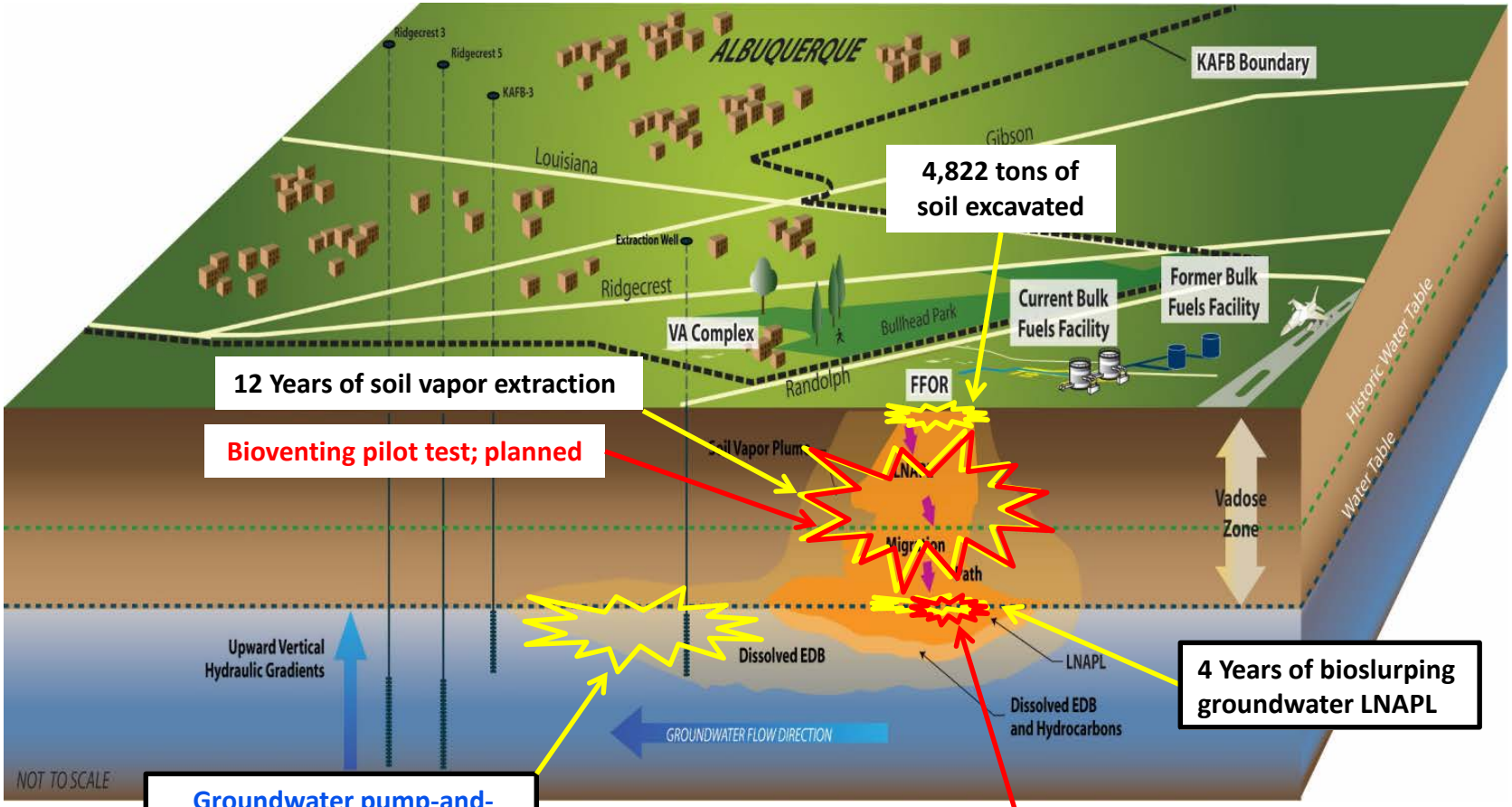
$$C_6H_6 + 7.5\ O_2 \rightarrow 6CO_2 + 3H_2O$$

Aerobic Benzene Biodegradation

Strategy 3 – Deploy Multiple Engineered Cleanup Technologies, Simultaneously and Sequentially, as Interim Corrective Measures

During 2018:

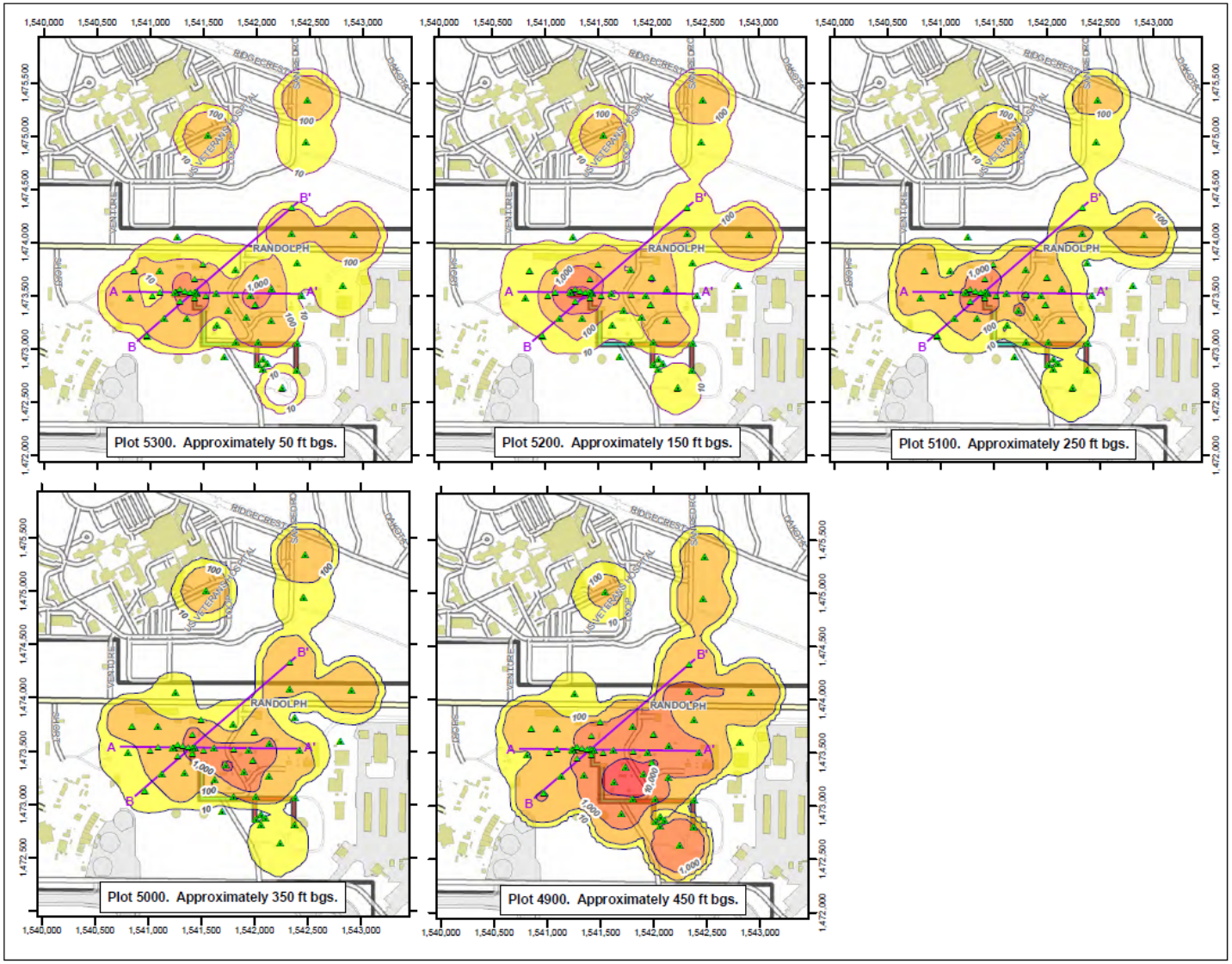
- **Efforts to collapse the EDB groundwater plume with pump-and-treat technology will continue; and**
- **Pilot tests for enhanced in-situ anaerobic groundwater biodegradation, and soil bioventing will be conducted.**



3. Soil Vapor Extraction (SVE) and Biospurping

- 12 years of SVE vacuumed and biodegraded fuel out of spaces between soil particles in the source area
- 3 years of bioslurping removed and biodegraded fuel from the water table zone in the source area
- The combined removal and biodegradation of approximately 750,000 gallons of fuel has significantly decreased soil vapor contaminant concentrations in the source area
- Based on this success, the SVE was shut down in 2015 to perform rebound and bio-respiration testing which confirmed that soil bacteria continue to biodegrade fuel contaminants
- A bioventing pilot test (interim measure) is a logical next step

3. Total VOC Soil Vapor, June 2011



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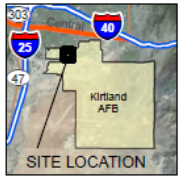
Legend

- SVE Extraction Well
- SVE Cluster
- Cross-Section Line
- VOC Concentration Contour (ppmv)

VOC Concentration (ppmv)

- 10 - 99
- 100 - 999
- 1,000 - 9999
- ≥ 10,000
- Installation Boundary
- Aboveground Fuel Transfer Lines
- Underground Fuel Transfer Lines
- Structure
- Runway
- Highway
- Major Road
- Road

Note:
The vadose zone VOC plume was gridded in three dimensions using inverse distance weighting in RockWorks and then concentration plan-view maps were "cut" at respective elevations. Ground elevations range from 5314 to 5364 ft above mean sea level across the ST-106/SS-111 investigation area.



Revision Date: 09/08/11

N

0 500 1,000 2,000

Feet

1 inch = 1,000 feet

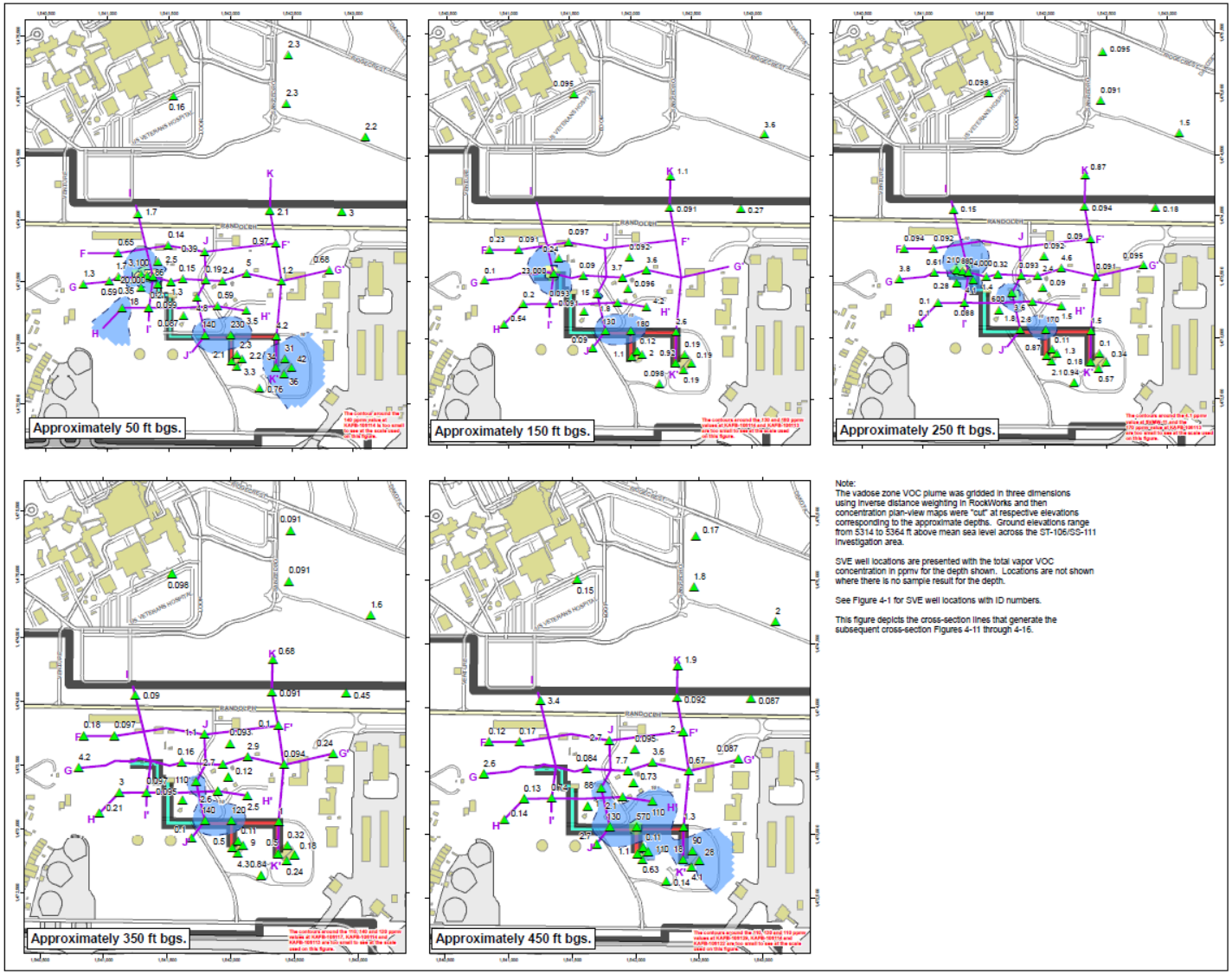
Projection : NAD83 State Plane New Mexico Central FIPS3002 Feet

2011 QUARTERLY REPORT 02
BULK FUELS FACILITY
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 4-8

LAB TOTAL VOC VAPOR PLUME FOOTPRINTS BY ELEVATION JUNE 2011

3. Total VOC Soil Vapor, Sept. 2014



Note:
The vadose zone VOC plume was gridded in three dimensions using Inverse distance weighting in RockWorks and then concentration plan-view maps were "cut" at respective elevations corresponding to the approximate depths. Ground elevations range from 5314 to 5364 ft above mean sea level across the ST-106/SS-111 investigation area.

SVE well locations are presented with the total vapor VOC concentration in ppmv for the depth shown. Locations are not shown where there is no sample result for the depth.

See Figure 4-1 for SVE well locations with ID numbers.

This figure depicts the cross-section lines that generate the subsequent cross-section Figures 4-11 through 4-16.

Legend

- SVE/SVM Well with Vapor VOC Concentration (ppmv)
- Fence Diagram Line
- VOC Concentration Contour (ppmv)

VOC Concentration (ppmv)

- 10 - 100
- 100 - 1,000
- 1,000 - 10,000
- 10,000 - 30,000

Revision Date: 12/17/14

N

0 400 800 1,600

Feet

1 inch = 415 feet

Projection : NAD83 State Plane New Mexico Central FIPS3002 Feet

THIRD QUARTER 2014
BULK FUELS FACILITY
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 4-9

TOTAL VOC VAPOR PLUME FOOTPRINTS BY DEPTH AND CROSS-SECTION LINES SEPTEMBER 2014

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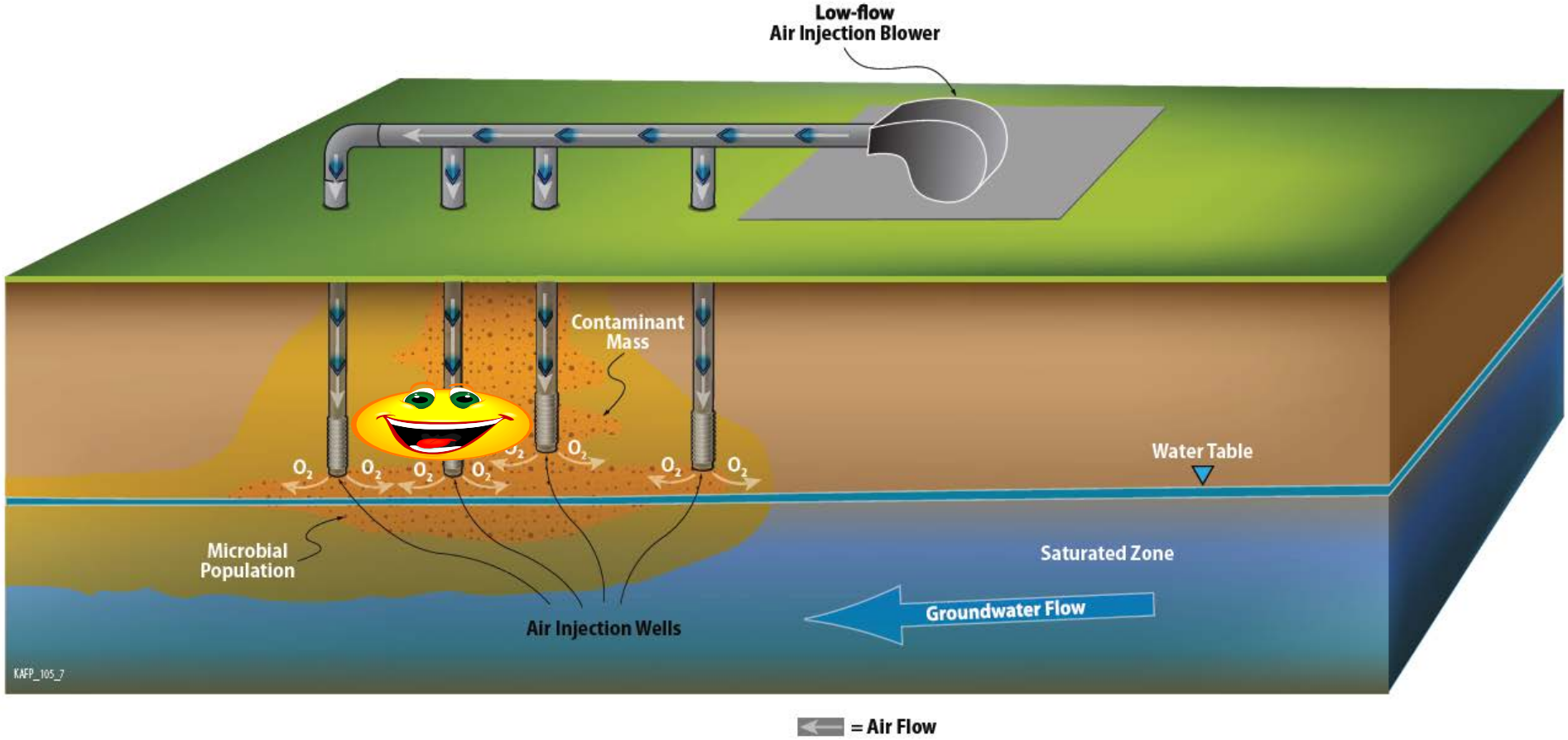
3. Bioventing

Bioventing is a logical follow up to SVE and bioslurping. Air will be blown into the soil to deliver oxygen and moisture to naturally occurring bacteria and enhance their ability to biodegrade petroleum hydrocarbons

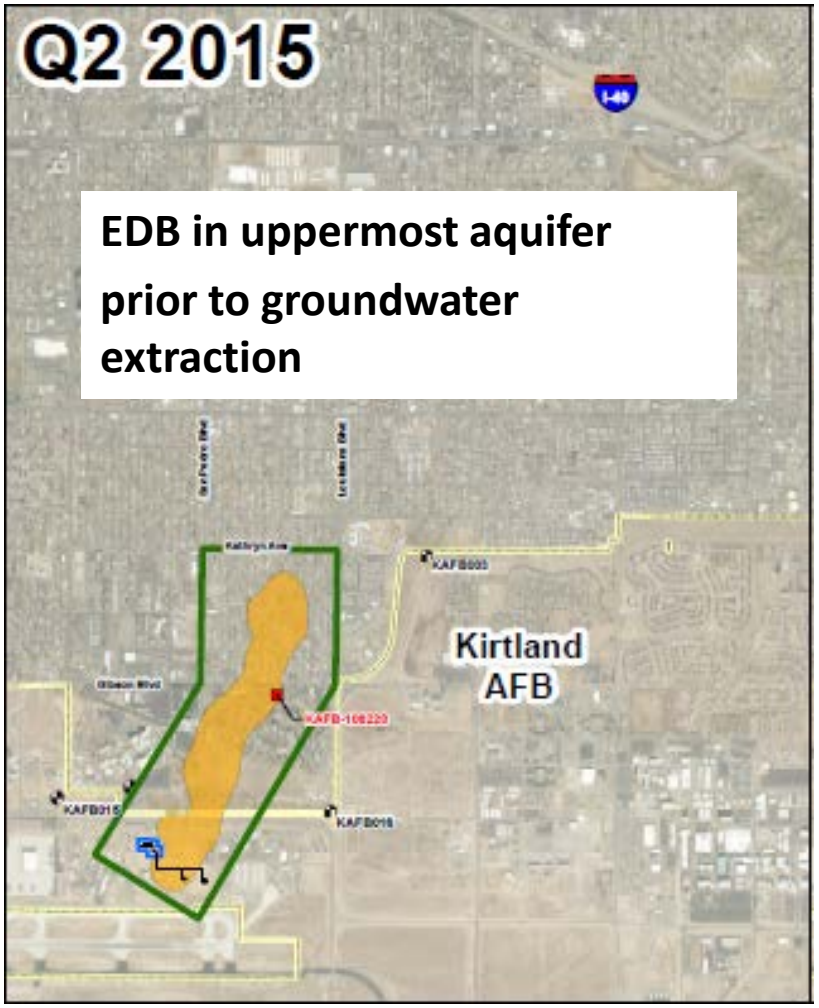


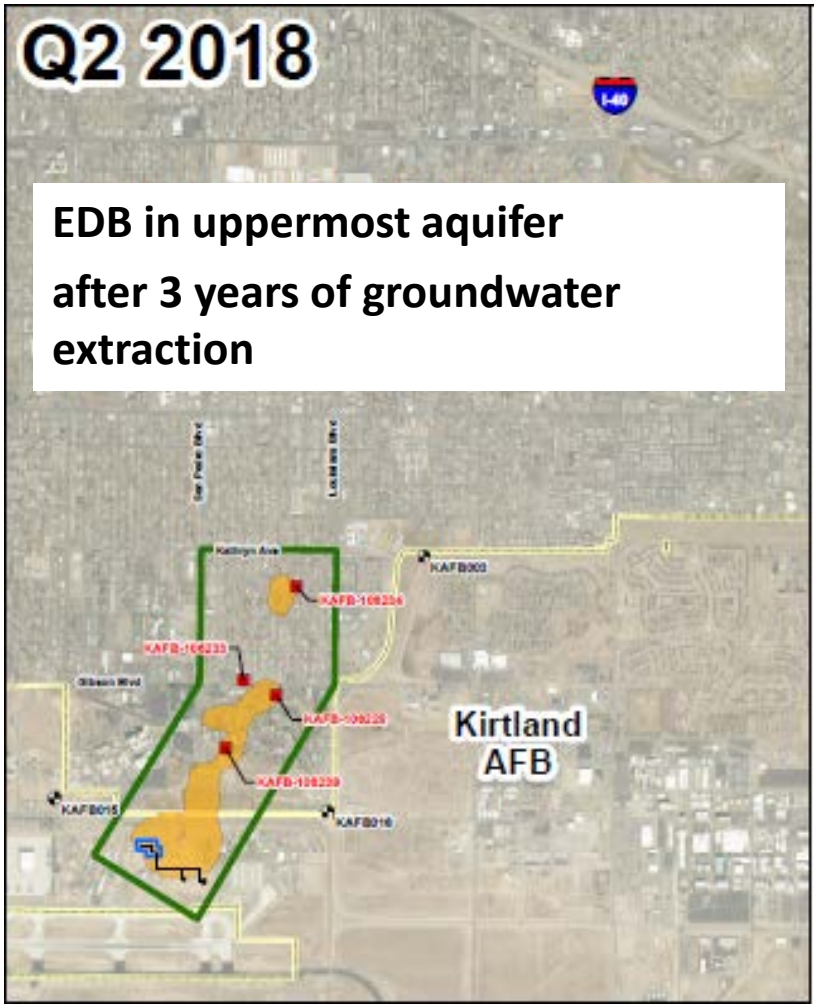
3. Collapse the EDB Plume

Groundwater Extraction and Treatment System:

- **Pump contaminated groundwater from extraction wells, treat water to remove contaminants, use treated water for KAFB golf course irrigation and aquifer recharge**
- **Four extraction wells have been installed to date**
- **Analyze plume capture, optimize system operation, add extraction wells if necessary**
- **Monitor for evidence of decreasing contaminant levels and plume collapse**

3. Strong Evidence of EDB Plume Collapse



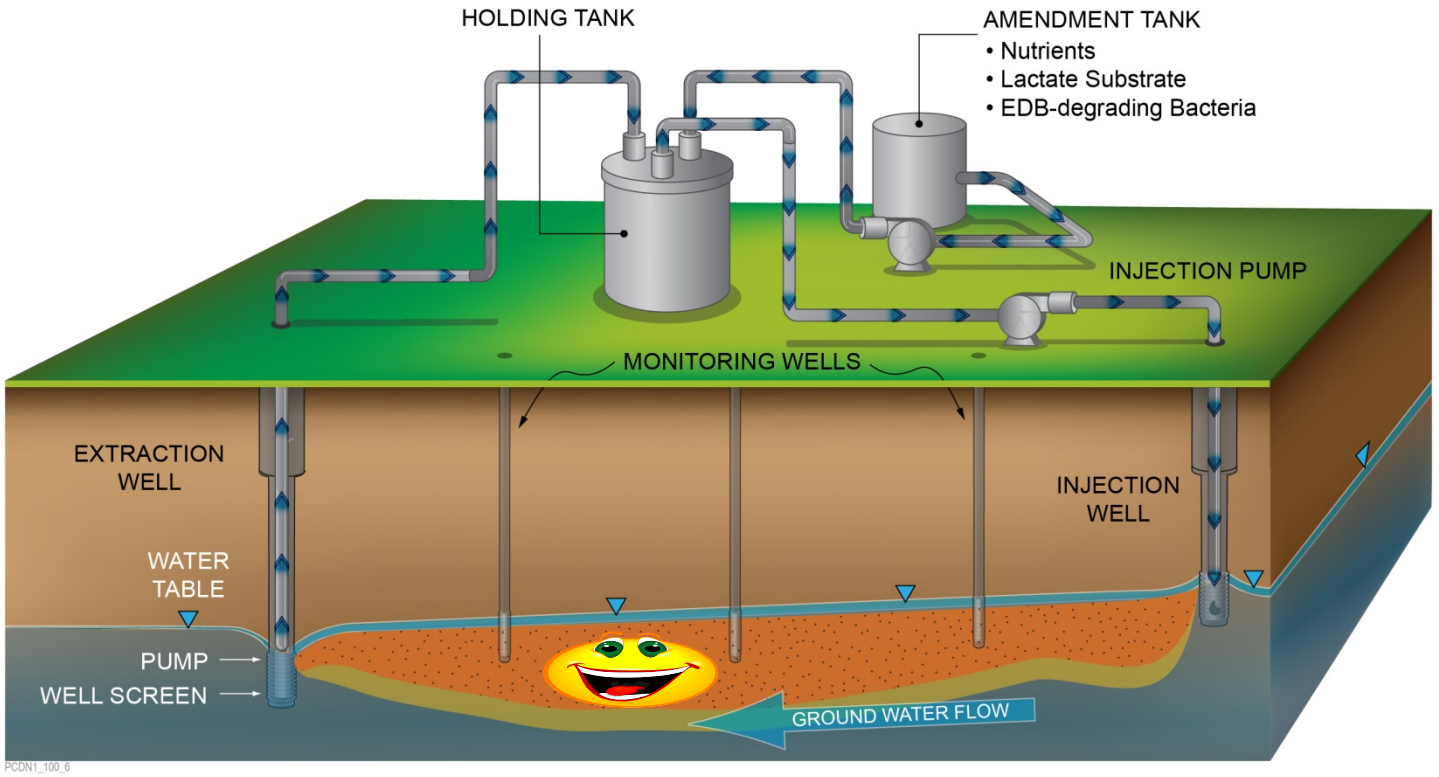


The Q2 2018 EDB footprint in the groundwater extraction area has varied, but is presently the smallest it has been since extraction began in 2015. The most likely explanation for this is that the extraction system is beginning to collapse the plume.

3. Anaerobic Biodegradation Pilot Test

Groundwater Recirculation

- **Pump groundwater and add amendments in phases**
- **Inject amended water up-gradient to create a recirculation cell**
- **Supports anaerobic degradation of EDB**



3. Anaerobic Biodegradation Pilot Test

- **Phase 1 – Baseline definition, tracer test circulation, passive monitoring (completed)**
- **Phase 2 – Bio-stimulation by adding nutrients and lactate (commenced December 2017)**
- **Phase 3 – Bio-augmentation by adding bacteria such as dehalococcoides (may not be necessary based on successful bio-stimulation)**
- **Phase 4 – Long-Term Passive Monitoring**

Strategy 4 - Public Outreach Schedule

The Air Force and NMED are conducting public outreach and involvement activities related to investigation and cleanup of the KAFB aviation fuel contamination in accordance with the public notice and community relations requirements of the WQCC and RCRA Permits.

Additionally, NMED will prepare and implement a Public Involvement Plan pursuant to NMED Policy 07-13, https://www.env.nm.gov/wp-content/uploads/2018/02/NMED-Policy-and-Procedure-07-13.pdf.

Date	Description
March 21, 2018	ABCWUA Governing Board Meeting, project update
March 22, 2018	Regular Public Meeting with Technical Poster Session
March 24, 2018	Groundwater Treatment System Open House
July 12, 2018	Regular Public Meeting with Technical Poster Session
July 31, 2018	Draft NMED Public Involvement Plan to be issued for public comment
October 12, 2018	ABCWUA Water Protection Advisory Board
October 17, 2018	63rd Annual New Mexico Water Conference
November 15, 2018	Regular Public Meeting with Technical Poster Session

NMED and the U.S. Air Force welcome invitations from neighborhood associations, civic organizations, environmental groups, and local government agencies.

4. Outreach with Public Schools

NMED will engage middle school, high school and college students with the project by:

1. **Making presentations to schools and colleges;**

2. **Encouraging and assisting students with the creation of original papers, slide presentations, physical models, digital animations, poetry, and musical compositions based on protecting the environment;**

3. **Providing opportunities for students to present their original work at public meetings.**

Outreach will include all students who are interested in environmental protection.

4. Public Involvement Plan (PIP)

- **NMED will develop a Public Involvement Plan (PIP) to ensure that public participation opportunities related to NMED activities and proceedings on the KAFB fuel cleanup project are in accordance with Title VI of the Civil Rights Act of 1964, 42 U.S.C. § § 2000d to 2000d-7, and the EPA regulations at 40 C.F.R. Parts 5 and 7.**

- **NMED will issue a draft PIP by July 31, 2018 for a 30 day public comment period.**

Site Activity Timeline

1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020

- Phase I and Phase II RCRA Facility Investigation
- Corrective Measures Evaluation
- Soil Investigation
- Installation of Groundwater Monitoring Wells
- Groundwater Monitoring
- Core Sampling and Results
- Installation of SVE/SVM/Pneulog Locations
- Soil Vapor Monitoring
- LNAPL Thickness Monitoring
- LNAPL Chemical Characterization
- Slug Test of Groundwater Monitoring Wells
- Aquifer Test of KAFB-106228

INTERIM CLEANUP MEASURES

- Excavation of Contaminated Soil - Three Excavations
- Operation of SVE Systems
- Groundwater Treatment System Operation
- Vadose Zone: Bioventing Pilot Test
- Groundwater: EDB In-Situ Biodegradation Pilot Test
- AS/SVE Pilot Study
- EDB/BTEX Treatability Study
- Bioslurping/Skimmer Technology

AS - Air Sparge • BTEX - Benzene, Toluene, Ethylbenzene and Xylenes • EDB - Ethylene Dibromide • LNAPL - Light Non-Aqueous Phase Liquid • RFI - RCRA Facility Investigation • SVE - Soil Vapor Extraction • SVM - Soil Vapor Monitoring

4. 2018 to 2020 Activities

2018

- **In-situ bioremediation pilot test is underway**
- **Drilling to fill groundwater and LNAPL data gaps is underway**
- **Public Involvement Plan will be published for public comment, then finalized with edits/additions based on public input**
- **Risk Assessment will be finalized**
- **Phase 1 RFI report will be submitted**
- **Bioventing pilot test will be commenced**
- **Plume capture analyses will be performed by USAF and NMED**

2019

- **Site investigations and pilot tests will be completed**
- **Phase 2 RFI report will be submitted**

2020

- **Corrective Measures Evaluation will begin**

About NMED's Strategic Plan

- **NMED's annual Strategic Plans are not regulatory documents, but serve to communicate goals and strategies with the public.**
- **NMED's Strategic Plans summarize the detailed, and often highly-technical, regulatory permits, workplans, engineering specifications, schedules, and approval letters that can be accessed from the NMED Hazardous Waste Bureau website: https://www.env.nm.gov/hazardous-waste/kafb/#KAFBBulkFuelsFacSpill.**
- **NMED's Strategic Plans for 2015, 2016, 2017 and 2018 are available online: https://www.env.nm.gov/kafbfuelplume/kafb-fuel-plume-documents/**
- **Kirtland Air Force Base jet fuel remediation website: https://www.kirtlandjetfuelremediation.com/**
- **Drinking Water Watch contains information and drinking water test results for public water systems in New Mexico, including Albuquerque Bernalillo County Water Utility Authority, Kirtland Air Force Base, and Veterans Administration Hospital: https://dww.water.net.env.nm.gov/NMDWW/**
- **NMED does not discriminate on the basis of race, color, national origin, disability, age or sex in the administration of its programs or activities.**