New Mexico Environment Department

2016 Strategic Plan

Kirtland Air Force Base Fuel Leak

DRAFT - open for public comment

Written comments due to NMED by close of business, January 15, 2016

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U.S. Army Corps of Engineers

U.S. Environmental Protection Agency

City of Albuquerque, Environmental Health Department

Albuquerque-Bernalillo County Water Utility Authority

New Mexico Bureau of Geology

U.S. Geological Survey

Official Draft; November 20, 2015

A Message from NMED Cabinet Secretary Ryan Flynn:

Cleaning up the Kirtland Air Force Base (AFB) fuel leak continues to be one of the highest priorities of the New Mexico Environment Department (NMED). During 2015 we successfully implemented the first phase of a pump and treat measure that will collapse and treat the ethylene dibromide (EDB) plume, preventing migration into water supply wells. With the planned activities in 2016 we will continue to work aggressively to prevent the leak from threatening the health and safety of Albuquerque's citizens. As Cabinet Secretary, I remain committed to working collaboratively with the Air Force, Albuquerque-Bernalillo County Water Utility Authority, City of Albuquerque, and U.S. Environmental Protection Agency to ensure Albuquerque's drinking water supply is not endangered by the fuel leak.

Over the past year, our project teams have accomplished the design of a plume collapse strategy resulting in the installation of three extraction wells, construction of a temporary and full-scale treatment system, and the start of treatment of EDB contaminated groundwater. NMED worked closely with technical working groups to identify and fill data gaps in the EDB plume extent and completed an important test to evaluate soil vapor rebound and biorespiration in the source area. I am very pleased with the amount of progress over the last 12 months and am confident we are headed in the right direction. Though I will not be satisfied until we have successfully cleaned up the entire leak, the strategies presented in this plan continue the positive progress to aggressively and effectively address the contamination.

This document describes remediation activities we expect the Air Force to complete in 2016 including:

- Installation of strategically placed groundwater monitoring wells.
- Installation and operation of up to 4 additional extraction wells and continued treatment of extracted groundwater to drinking water standards.
- Expansion of the full-scale treatment system to a treatment capacity of 800 gallons per minute.
- Implementation of multiple field-scale pilot tests that evaluate remediation technologies to clean up the light non-aqueous phase liquid (LNAPL).

We appreciate comments and constructive feedback and have posted the draft version of this document for your review. A final version will be published in January 2016, serving as a guide for the extensive work to be conducted in the coming year. We hope many of you will continue to participate in the public meetings, field trips, and other opportunities to stay informed and to make your voice heard as this important project progresses.

Sincerely ,

Ryan Flynn

Ryan Flynn, Secretary of Environment

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The New Mexico Environment Department (NMED) 2016 update to the Strategic Plan continues our roadmap for aggressively remediating soil and groundwater at the Kirtland Air Force Base fuel site throughout this year. The 2016 Strategic Plan summarizes accomplishments in 2015 and presents data-driven strategies for continued progress of our goal throughout 2016.

One Goal, Four Strategies

GOAL: Protect Albuquerque's aquifer and drinking water supply wells in the area of the fuel leak.

STRATEGIES TO ACHIVE THE GOAL:

1) **Implement a robust site monitoring and wellhead protection program.**
   Compliance monitoring (soil vapor and groundwater) for the RCRA permit, and monitoring of sentinel wells and water supply wells.

2) **Characterize and remediate LNAPL, impacted soil, and associated dissolved phases in source area.**
   Inclusive of soil vapor, soil, and submerged LNAPL contamination at the site.

3) **Collapse the dissolved EDB plume.**
   Collapse the dissolved-phase EDB plume and pull it back to the boundary of Kirtland AFB; will include additional treatment strategies during 2016.

4) **Meet or exceed all requirements for providing public information and involvement.**
   Our continued effort to increase transparency and exceed requirements for public information and involvement.

Details of these strategies are outlined in the following pages.

Dissolved EDB will not be allowed to impact any drinking water supply system at detectable concentrations.

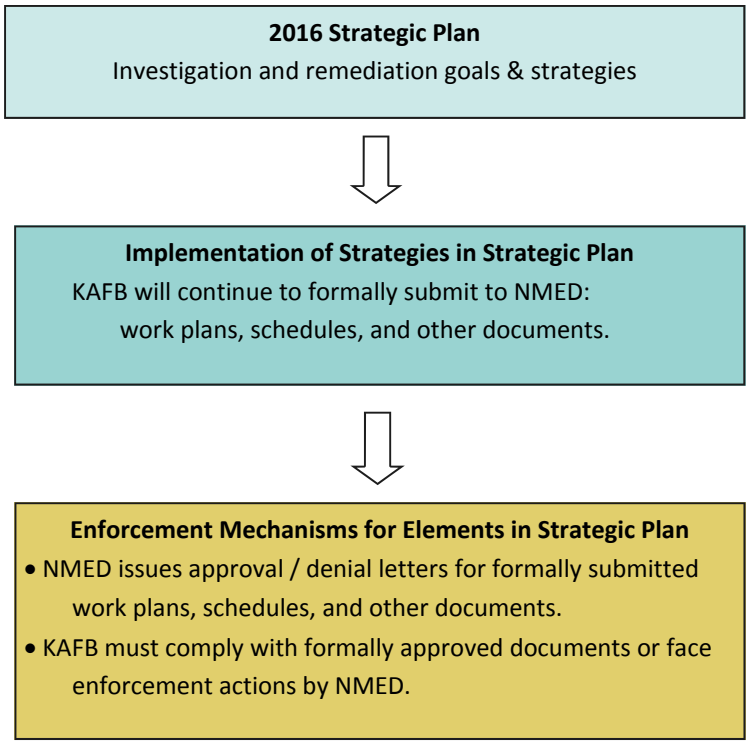
The NMED developed this Strategic Plan to provide a clear vision on how to continue to advance the fuel cleanup during 2016. The Strategic Plan continues to be a guide to the various strategies currently in place, being actively implemented, as well as strategies that have been identified by the technical working groups as viable measures to implement.

The strategic plan includes the following key sections:

- Projection Accomplishments in 2015
- Introduction
- Regulatory Framework
- General Project Timeline
- Discussion of the four strategies

What is the Strategic Plan?

The 2016 Strategic Plan is not an element required by the Resource Conservation and Recovery Act (RCRA) process; we developed it as a reference and planning document. It is not an enforceable document under RCRA or any other regulatory authority. The strategies presented in the 2016 Strategic Plan are accomplished by the Air Force submitting regulatory documents for NMED approval. The following figure shows the relationship between the regulatory framework and the Strategic Plan.



Increasing transparency and public involvement was a primary goal in 2015. The NMED values public involvement and comments. A draft of the 2016 Strategic Plan is currently posted for public review. Comments and suggestions will be reviewed for incorporation into the final document to be released in January 2016. A draft Strategic Plan for calendar year 2017 will be issued in December 2016.

Project Accomplishments in 2015

In 2015, NMED and the Air Force closed data gaps in the northeastern extent of the EDB plume, began collapsing the EDB plume, and conducted laboratory and field studies to identify technologies to remediate the source area. Specifically, the following work was completed in 2015:

Site Monitoring and Wellhead Protection (Strategy 1)

- ✓ Drilled and sampled 19 new groundwater monitoring wells and closed the northeastern extent of the EDB plume and defined the bottom of the plume.
- ✓ Monthly testing of drinking water wells continued to show no detectable fuel contaminants.
- ✓ Optimization of quarterly sampling and reporting.
- ✓ Completed a synoptic water level measurement event across Kirtland AFB, the first of its kind.
- ✓ Created a revised, stand-alone Executive Summary document for the quarterly monitoring reports.

Source Area Remediation (Strategy 2)

- ✓ Completed the soil vapor rebound and biorespiration testing.
- ✓ Developed a list of potentially suitable technologies for LNAPL interim measure.
- ✓ Continued soil vapor extraction, removing approximately 770,000 gallons of fuel.

Groundwater Remediation (Strategy 3)

- ✓ Installed first extraction well and began collapsing the EDB plume on June 6, 2015.
- ✓ A temporary treatment system was constructed and produces water with no detectable EDB.
- ✓ Treated water used for irrigation at the Kirtland AFB Golf Course.
- ✓ Performed aquifer testing and computer modeling.
- ✓ Two additional groundwater extraction wells and construction of a full-scale treatment system is on schedule for completion by December 31, 2015.
- ✓ Evaluated multiple beneficial use options for treated groundwater, including aquifer recharge by infiltration galleries and injection well.
- ✓ Created an independent panel of experts to review potential remediation technologies for LNAPL.
- ✓ Completed microcosm laboratory testing of biodegradation of EDB and benzene.



Public Outreach and Participation (Strategy 4):

- ✓ NMED and Kirtland AFB held 3 joint public meetings in March, July, and November.
- ✓ Conducted two public field trips in April and October.
- ✓ Participation in 10 presentations to Neighborhood Associations, university seminars, and professional societies.
- ✓ Hosted a booth at the International District Fair in September to allow direct access to NMED and Air Force experts.
- ✓ Kirtland AFB Initiated public surveys and interviews for updates to the community relations plan and to gauge interest in a possible a Restoration Advisory Board.
- ✓ A Self-Guided Geologic Field Trip Guidebook will be published by December 2015.


Photo credit: Reed, Ollie. *ABQ native leading fuel spill cleanup.* 2015. Albuquerque, NM. *Albuquerque Journal.* April 28, 2015.

Leakage of aviation gasoline and jet fuel from the Kirtland AFB bulk fuel facility (BFF) migrated through ~500 feet of soil (vadose zone), and into the underlying aquifer.

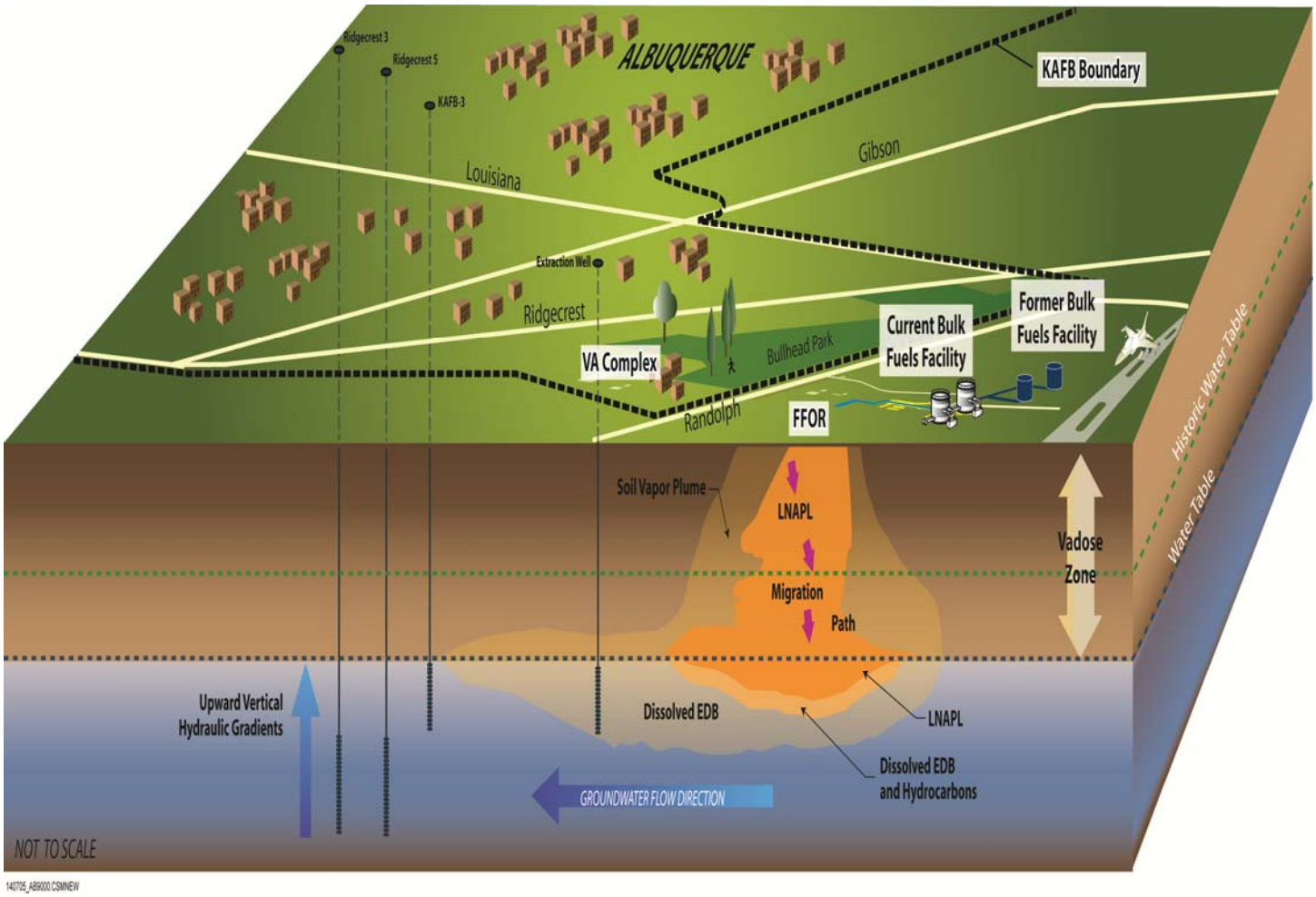
During migration, the LNAPL partitioned into dissolved, vapor, and adsorbed phases.

Initially, the LNAPL floated on the groundwater surface. Beginning in 2009, the water table began to rise and the LNAPL became submerged and trapped within the groundwater. This "drowned" LNAPL continues to release dissolved EDB and other contaminants into the groundwater.

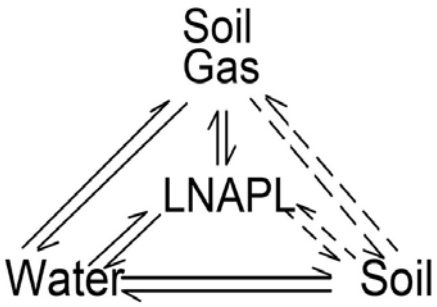
Benzene and other hydrocarbons are readily biodegraded by native groundwater bacteria. EDB is biodegrading only in the presence of biodegrading hydrocarbons. Once the EDB has migrated beyond the area of hydrocarbon contamination, there is currently no evidence of EDB biodegradation. Understanding the biodegradation of EDB in groundwater is currently an area of interest for technical working groups at this site.

The aquifer contains naturally occurring upward vertical hydraulic gradients. These upward gradients mean that deep groundwater, such as in the zones tapped by drinking water wells, moves upwards into shallower aquifer zones. The upward gradients work in favor of helping to prevent the fuel contamination from moving downward, and offer some protection of the drinking water wells.

Conceptual Diagram of the Kirtland AFB Fuel Leak



The conceptual diagram illustrates the current understanding of how fuel migrated through the soil in the vadose zone down to the groundwater. At the Kirtland AFB BFF leak site fuel is found in the four phases:



- LNAPL residual fuel;
- Soil vapor (lighter fuel constituents as vapor in soil);
- Adsorbed contaminants (fuel constituents attached to soil particles); and
- Dissolved contaminants (fuel constituents in groundwater).

Fuel originally floated on the water table but has, over time, become submerged as regional groundwater levels rise. The LNAPL migration path through the subsurface was influenced by the local geology, the properties of the compound and soil, and the height of the water table over time. This conceptual site model continues to be evaluated as data is collected and data gaps are closed.

Multiple measures have been implemented in the source area to remove mass of fuel contamination. Almost 5,000 tons of soil contaminated with fuel constituents has been removed through three separate excavation events between 2000 and 2014. Soil vapor extraction (SVE) was initiated in 2003 and has vacuumed approximately 570,000 gallons from soil in the source area. The operation of SVE also facilitated biodegradation of an additional 200,000 gallons of fuel for a total of 770,000 gallons of fuel.

The groundwater pump and treat system was designed to:

⇒ Stop migration of EDB towards drinking water wells;
⇒ Extract and treat EDB contaminated groundwater; and
⇒ Collapse the EDB plume back towards the Kirtland AFB boundary.

References for additional technical information are attached in Appendix A.

The NMED has regulatory authority to administer the federal Safe Drinking Water Act (SDWA) program and the RCRA hazardous waste program. In addition to the SWDA and RCRA, site characterization and remediation actions must comply with other applicable laws and regulations such as the NM Water Quality Control Commission (WQCC) Regulations, New Mexico Air Quality Standards, and Office of the State Engineer Regulations. As such, permits are required from NMED, the Office of the State Engineer, and Albuquerque Environmental Health Department depending on the specific planned activity.

Regulatory documents submitted to the NMED by the Air Force are posted to the project websites and are available to the public (Appendix B).

Safe Drinking Water Act

One of NMED's SWDA responsibilities is to require that public water systems supply drinking water to consumers that complies with the EPA Primary (human health based) Maximum Contaminant Levels (MCLs).

Constituent	Primary MCL* (µg/L)
Ethylene dibromide (EDB)	0.05
Benzene	5
Toluene	1,000
Ethylbenzene	700
Xylenes (total)	10,000

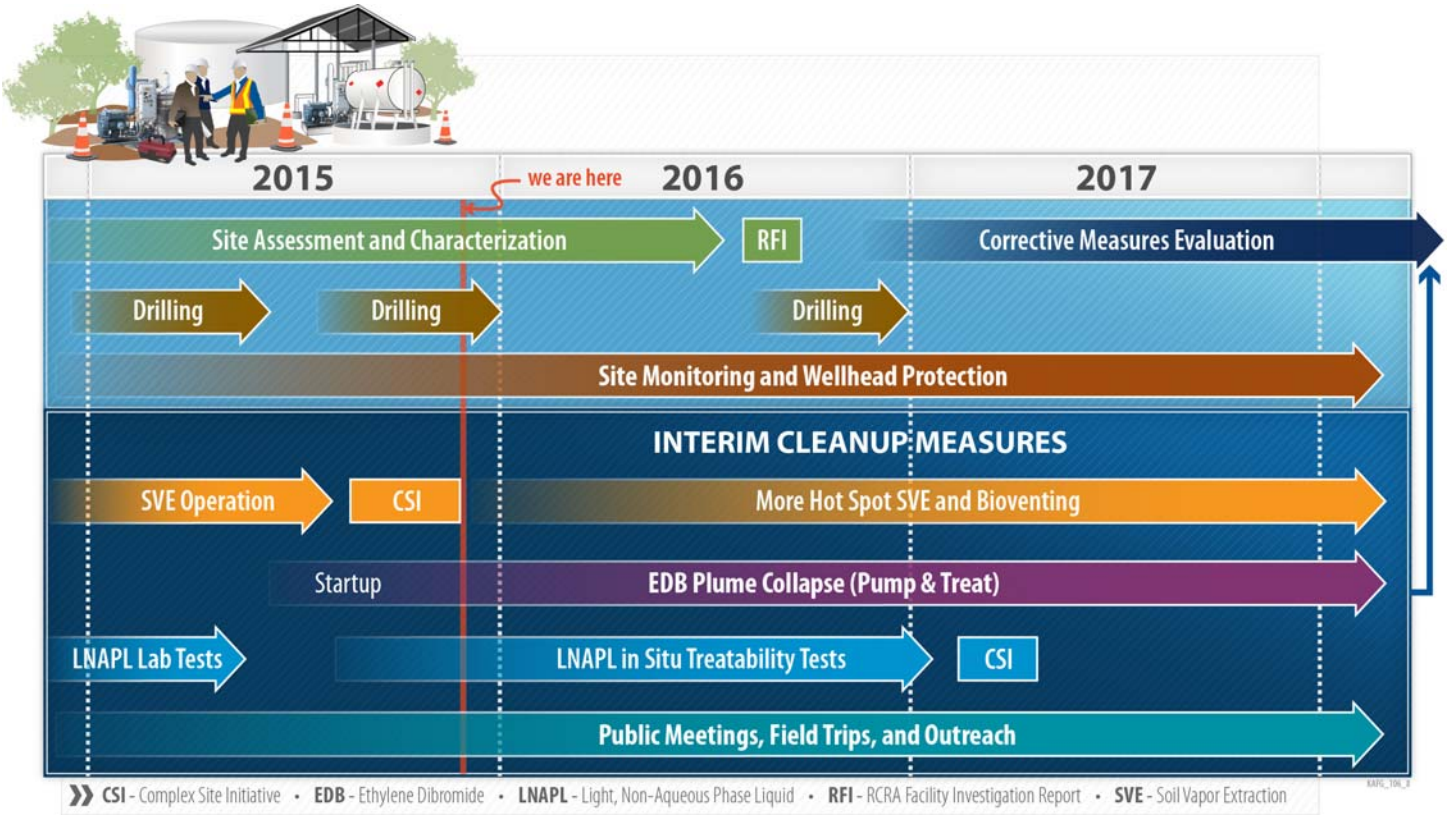
*EPA MCLs have been adopted by NMED as part of our regulatory authority (http://water.epa.gov/drink/contaminants/

Resource Conservation and Recovery Act

Site investigation and cleanup activities of the jet fuel leak at Kirtland AFB follows a specific regulatory process known as Corrective Action. This process is spelled out in state and federal regulations, as well as in provisions in Part 6 of the Kirtland AFB Hazardous Waste Treatment Facility Operating Permit (RCRA permit). The RCRA process will end when cleanup (corrective action complete) is achieved.

The timeline below highlights the site investigation and interim measure activities planned through 2017.

Project Timeline through 2017



The Kirtland AFB RCRA permit provides for using interim measures in order to reduce or prevent migration of hazardous constituents that have, or may result in, an unacceptable human or environmental exposure while long-term corrective action remedies are being evaluated and implemented. Interim measures for the Kirtland AFB BFF leak site are focused on two areas: source area (Strategy 2) and groundwater (Strategy 3).

Site assessment and characterization activities are ongoing and, upon completion, RCRA Facilities Investigation (RFI) reports will be submitted to NMED. Data collected during the implementation of interim measures, including EDB plume collapse and source area treatment, will be incorporated into the RFI reports. A risk assessment will be part of the RFI. The RFI reports, after approval by NMED, will be used to support the Corrective Measures Evaluation (CME) and the selection of the final remedy or remedies.

General timeline of current and expected project activities:

Winter 2015/ Spring 2016	Strategy 1: Site Monitoring and Wellhead Protection • Continue monthly sampling of drinking water supply wells. • Continue quarterly sampling of sentinel wells. • Continue periodic sampling of soil vapor and groundwater monitoring wells. • Develop sentinel well indicator parameters and action levels. Strategy 2: Source Area Remediation • Conduct Complex Site Initiative (CSI) Meetings. • Submit work plan(s) for coring and analysis at locations within the source area and at the plume edge to characterize the presence and nature of LNAPL. • Begin field-scale pilot test for an anaerobic treatability study. • Submit work plan for bioventing pilot test. Strategy 3: Groundwater Remediation • Complete construction of conveyance lines and full-scale treatment system; begin operation. • Conduct aquifer tests for the two additional extraction wells. • Develop of plan for non-potable, beneficial-reuse of treated water based on the results of percolation testing and pilot test data from injection at well KAFB 7. • Continue on-going groundwater modeling of plume collapse to determine location and number of additional extraction wells. Strategy 4: Public Participation and Outreach • Conduct public surveys and interviews and update and implement the community involvement plan to incorporate input and opinions received. • Finalize 2016 Strategic Plan, incorporating public comments received. • Host Spring 2016 field trip. • Host Spring Public Meeting and Poster Session. • Continue to present project updates at the invitation of community groups and other organizations.
Summer 2016	Strategy 1: Site Monitoring and Wellhead Protection • Continue monthly sampling of drinking water supply wells. • Continue quarterly sampling of sentinel wells. • Continue periodic sampling of soil vapor and groundwater monitoring wells. • Evaluate further optimization monitoring frequency and analytes in both groundwater and soil vapor. Strategy 2: Source Area Remediation • Submit work plans for an air sparge pilot test.

General Project Timeline and Schedule

Summer 2016	Strategy 3: Groundwater Remediation • Submit work plans for the expansion of the full-scale treatment system to a total treatment capacity of 800 gpm. • Submit work plans for the drilling and installation of up to 4 additional groundwater extraction wells south of Gibson to continue collapse of the EDB plume. • Submit work plans for the installation of data gap monitoring wells to continue the definition of EDB plume extent along the northwestern edge. • Complete design, construction, and permitting of infiltration system for treated ground water at Tijeras Arroyo (if determined to be a technically viable option for discharge of treated water). Strategy 4: Public Participation and Outreach • Host Summer Public Meeting and Poster Session. • Continue to present project updates at the invitation of community groups and other organizations.
Fall / Winter 2016	Strategy 1: Site Monitoring and Wellhead Protection • Continue monthly sampling of drinking water supply wells. • Continue quarterly sampling of sentinel wells. • Continue periodic sampling of soil vapor and groundwater monitoring wells. • Submit RCRA Facility Investigation Reports with risk assessment Strategy 2: Source Area Remediation • Conduct CSI meetings to review performance of pilot tests (bioventing, anaerobic treatability, and bioremediation sparge). Strategy 3: Groundwater Remediation • Complete expansion construction of the full-scale treatment system to increase the total treatment capacity to 800 gpm of extracted groundwater. • Complete drilling, installation, and conveyance piping for up to 4 additional groundwater extraction wells installed south of Gibson Boulevard. • Submit work plan and complete aquifer testing of the additional extraction wells (up to 4). Strategy 4: Public Participation and Outreach • Initiate update to the Strategic Plan and post for public comment. • Host Fall 2016 field trip. • Host Fall Public Meeting and Poster Session. • Continue to present project updates at the invitation of community groups and other organizations.

To track activities and progress during 2016, plan to attend public meetings, sign up for the NMED email list serve (link on website), and check project websites:

New Mexico Environment Department

⇒ www.env.nm.gov/NMED/Issues/KirtlandFuelPlume

Kirtland Air Force Base

⇒ http://www.kirtlandjetfuelremediation.com

STRATEGY 1

Implement a robust soil, groundwater, and wellhead monitoring program.

2016 Strategy

As fuel plume cleanup proceeds, the following plan is being implemented:

⇒ Continue to test for fuel contaminants at drinking water wellheads monthly (current regulatory requirements are for testing every 3 years).

⇒ Continue to test sentinel wells quarterly to provide early detection of any contaminant migration towards the drinking water wells.

⇒ Continue routine monitoring of soil and groundwater in compliance with the RCRA permit.

⇒ Complete quarterly sampling of influent water at the treatment system and of treated discharge water for compliance with NMED Ground Water Quality Bureau discharge permit.

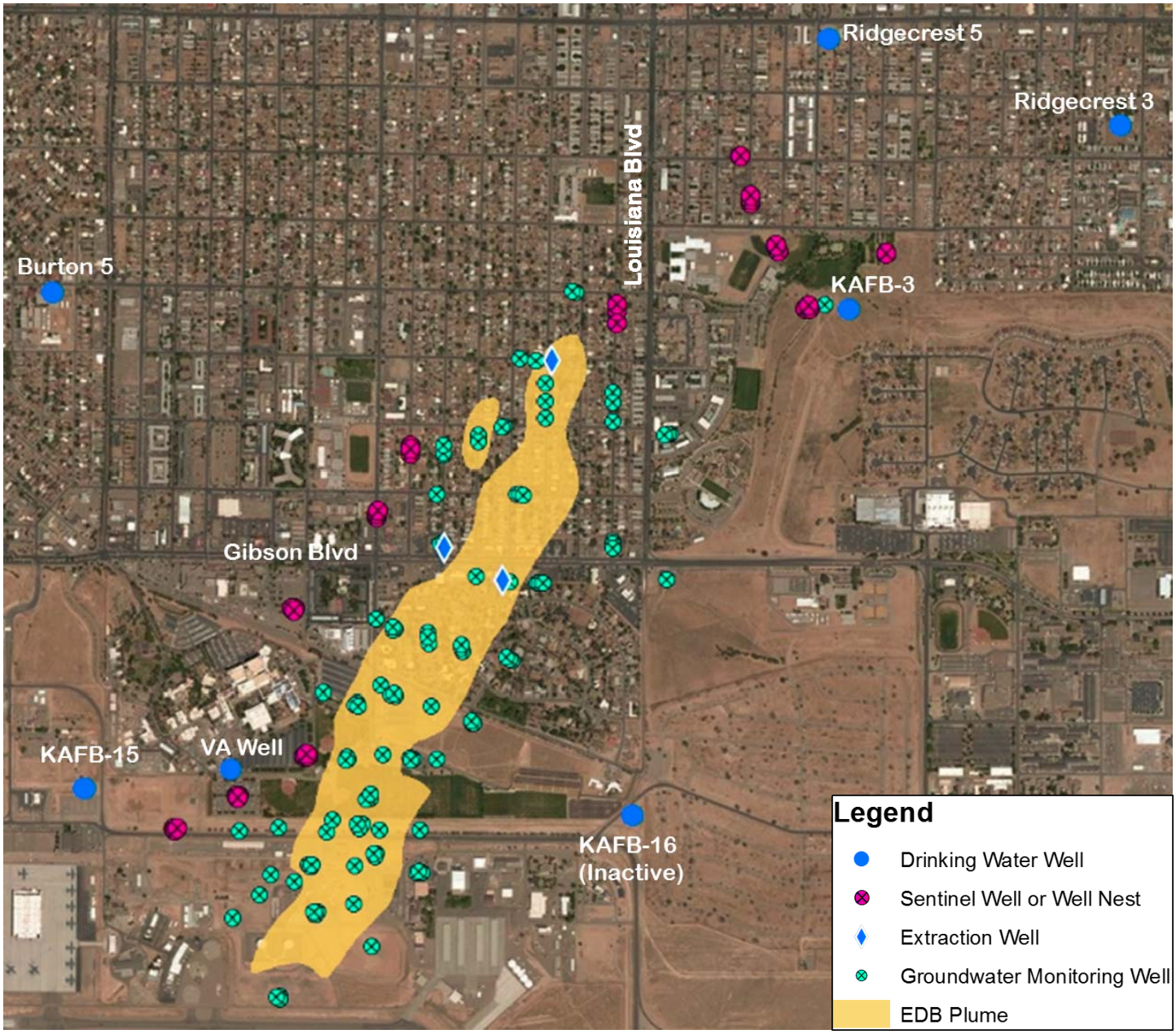
⇒ Further optimization of soil and groundwater monitoring sampling network and frequency.

Any remaining data gaps in the definition of LNAPL nature and extent as well as the dissolved-phase plume will be identified in order to complete the conceptual site model and to continue to inform the design of a robust interim measure. The NMED will oversee the following actions to identify and address data gaps:

- Drill, install, and sample up to 2 data gap groundwater monitoring wells near the northwestern edge of the plume to define the horizontal and vertical extent of EDB.
- Evaluation of concentration gradients and trend analyses.
- Evaluation of mass distribution of EDB in the groundwater.
- Evaluation of data to determine the need for additional soil vapor

The figure below illustrates the known extent of EDB in shallow groundwater relative to sentinel and water supply wells. Sentinel wells provide a mechanism for early detection of contamination migration, ensuring our ability to protect water supply wells.

EDB in Shallow Groundwater at Kirtland AFB



Performance Measures and Timeline

The success of Strategy 1 will be measured by:

- Continued non-detectable test results in all sentinel wells and drinking water wells.
- Continued compliance with WQCC and RCRA permit monitoring requirements.
- Implementation of further optimization of the soil vapor and groundwater monitoring network and frequency.
- Submittal of RCRA Facility Investigation Report with risk assessment.

If contaminants are detected in any of the sentinel or drinking water wells, there will be increased monitoring and/or intervention.

STRATEGY 2

Remediate LNAPL, impacted soil, and associated dissolved phases in source area.

2016 Strategy

Through continued collaboration with stakeholders and the technical working groups, develop data quality objectives for LNAPL in both the soil (vadose zone) and dissolved phases. Identify and fill data gaps in order to complete the conceptual site model for LNAPL distribution and nature in the vadose zone (soil), as well as the nature of its presence on and in the saturated zone. Conduct pilot tests of remediation technologies to evaluate performance and effectiveness of LNAPL treatment in the vadose zone and groundwater. Develop a robust interim measure treatment system based on evaluation of data collected during site investigation, implementation of pilot tests, and monitoring.

Characterization of LNAPL

The results of the 2015 soil vapor hydrocarbon rebound and biorespiration testing demonstrated that the nature and extent of LNAPL in the subsurface remains a data gap in the conceptual site model. The NMED will oversee the following actions to identify and address data gaps:

- Collect continuous cores within the source area and along the plume edge for analysis. Targeted analyses will include geotechnical, geochemical, and microbiological methods.
- Evaluation of concentration gradients and trend analyses within the vadose zone and at the water table.
- Develop data quality objectives for LNAPL in the vadose zone and dissolved phases.

Interim Measures

In April 2015, soil vapor extraction was stopped to complete soil vapor rebound and biorespiration testing in order to identify areas of residual contamination and to evaluate the biodegradation capacity of the vadose zone. The results of those tests indicate there are zones of residual contamination in the soil that are candidates for field-scale pilot tests that would evaluate remediation technologies as interim measures.

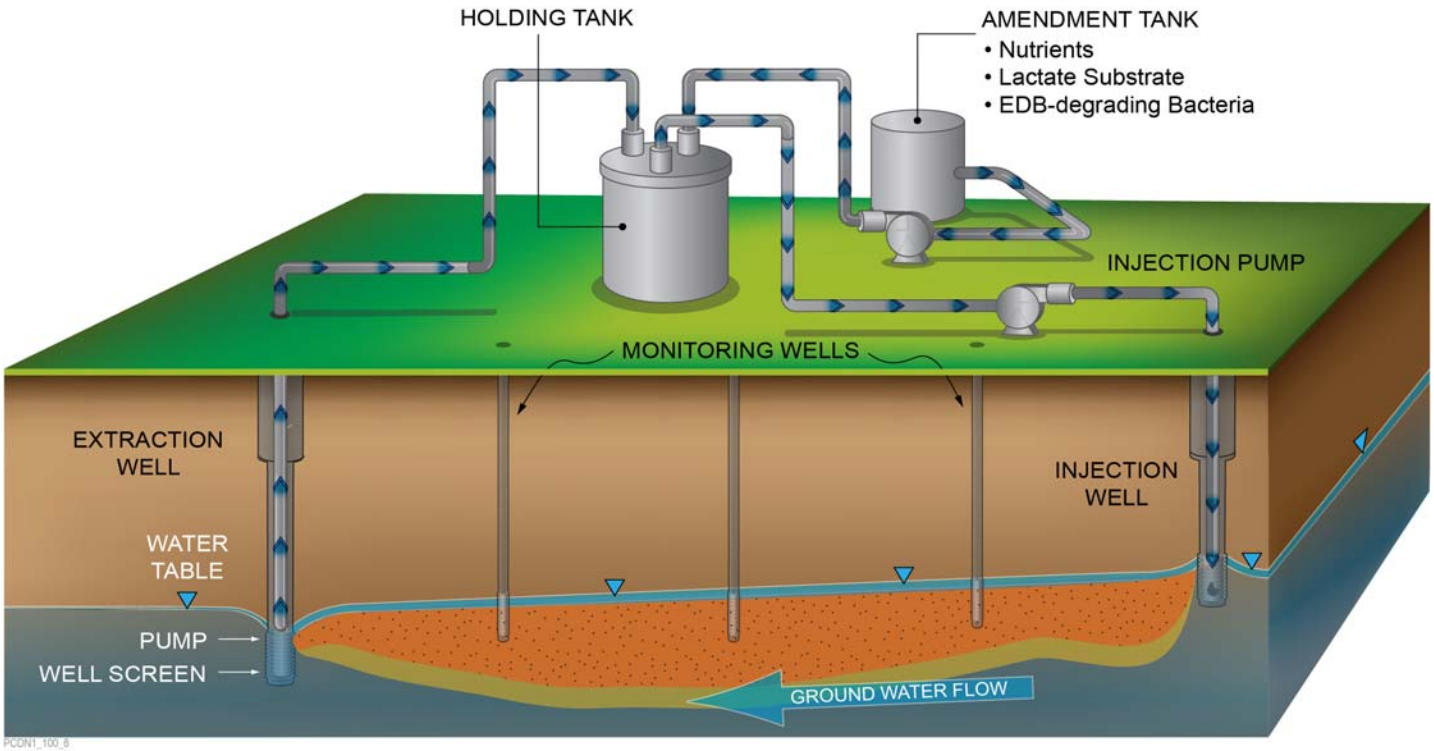
Scaled-up laboratory and field pilot tests will be conducted for critical evaluation of remediation technologies that are deemed to be potentially feasible. NMED will oversee evaluations performed by the Air Force and their contractors to explore the feasibility and effectiveness of a variety of remediation technologies:

- Anaerobic bioremediation recirculation (introducing amendments to stimulate native aquifer bacteria to enhance biodegradation of contaminants);
- Bioventing (introduction of low air flow rates into the subsurface to provide enough oxygen to sustain microbial activity); and
- Bioremediation sparging (blowing air into the groundwater to push contaminants into vapor and enhance biodegradation in both the vadose zone and groundwater).

Strategy 2: Source Area Remediation

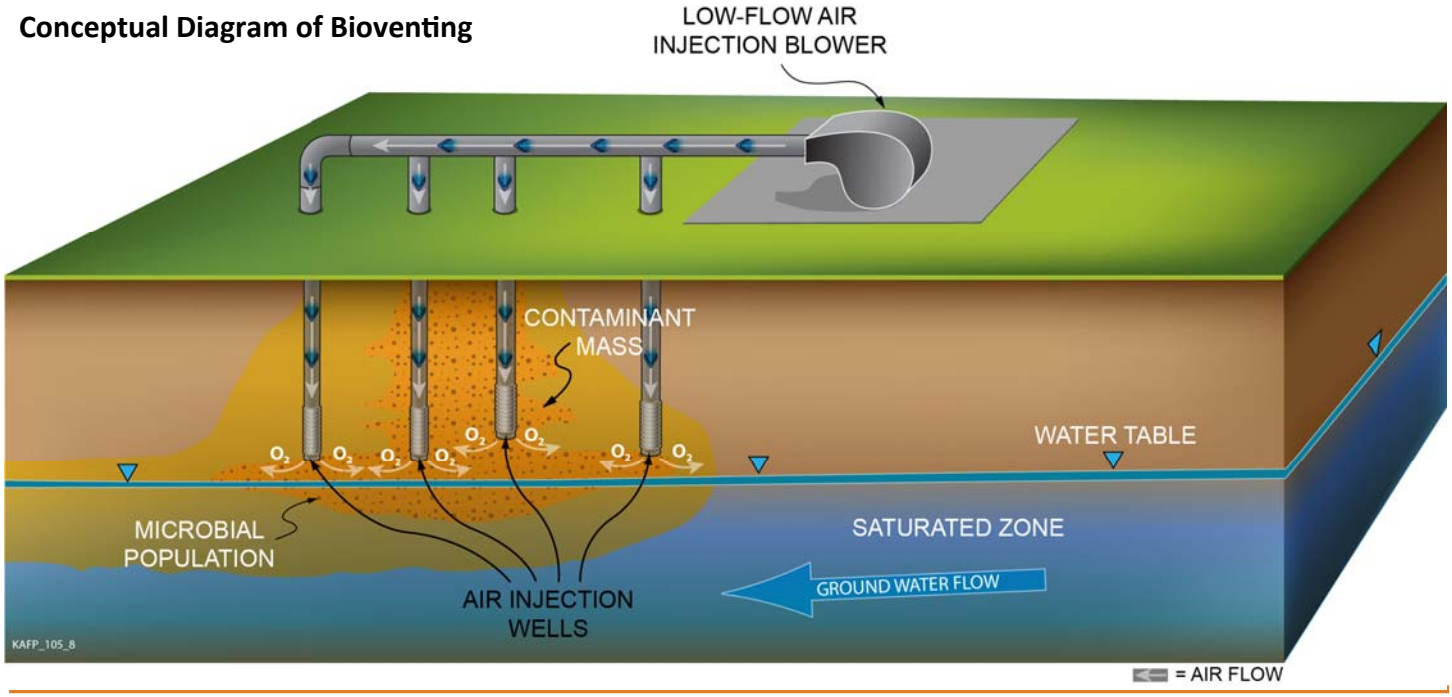
In 2015, the technical working groups generated a list of potential remediation technologies for evaluation as interim measures. This list will continue to be discussed and revised as pilot tests are conducted and as data is collected. A work plan for an anaerobic bioremediation recirculation pilot test is expected to be submitted to the NMED in Winter 2015 with the pilot test beginning operation in Summer 2016. This pilot test involves the mixing of amendments into the groundwater in order to stimulate natural bacteria so that they can do a better job of biodegrading contaminants (see figure below).

Conceptual Diagram of Bioremediation Recirculation



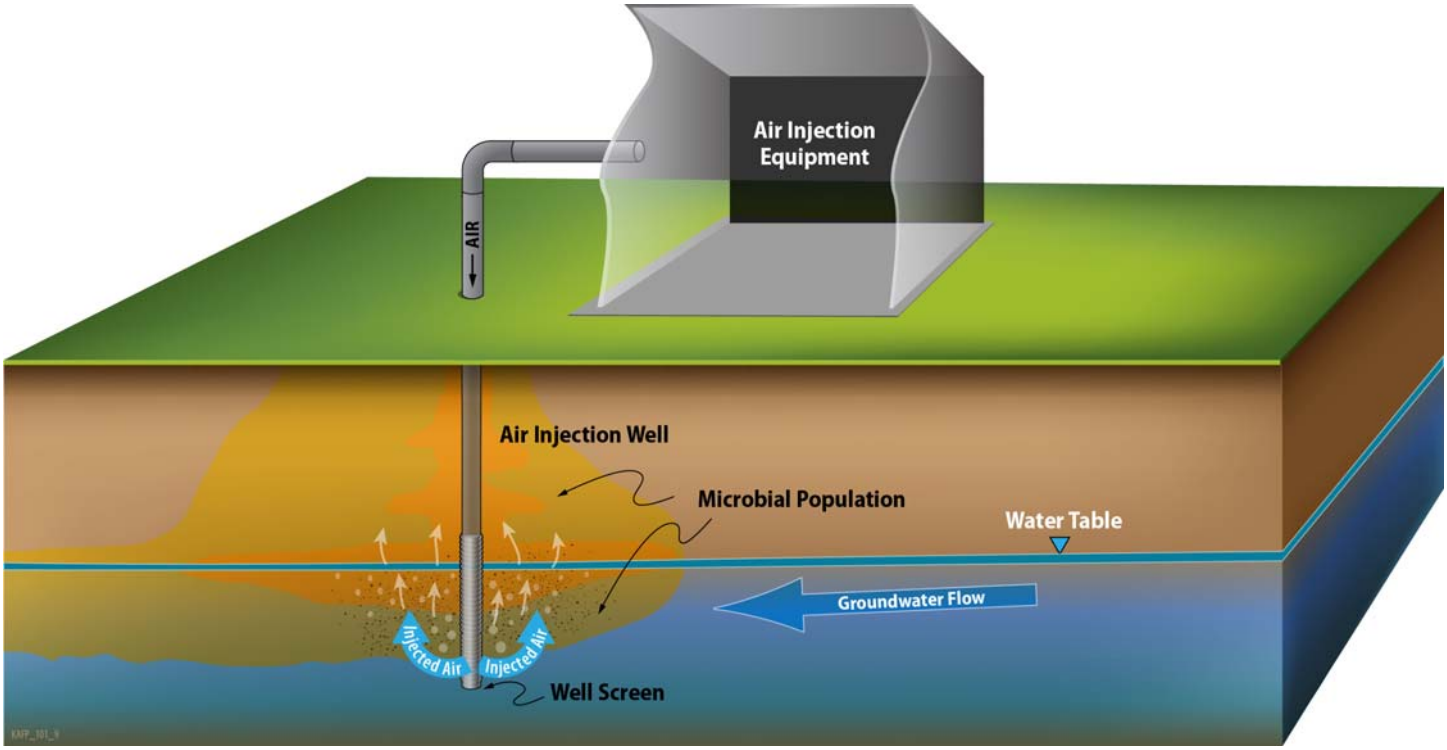
Bioventing is another interim measure being considered for source area remediation. This technology is the process of stimulating the natural in situ biodegradation of contaminants in soil by providing air or oxygen to existing soil microorganisms (see figure below).

Conceptual Diagram of Bioventing



The soil vapor hydrocarbon rebound and biorespiration test data also supports the design and construction of a bioremediation sparging pilot test utilizing an existing soil vapor extraction well to target residual contamination at depth. The bioremediation sparge technology involves the injection of air into the groundwater, near the surface, creating a zone of aeration. As the groundwater is aerated, contamination is driven into the vapor phase. This remediation technology can also enhance biodegradation of contaminant, both below and above the water table.

Conceptual Diagram of Bioremediation Sparging



Final Corrective Measure Evaluation, Selection, and Implementation

- In accordance with the requirements of RCRA, interim measure performance data (e.g. bioventing mass removal) and other information will be evaluated to select and implement final corrective measure(s) for source area remediation. This may include a combination of different treatments.
- Establish metrics to determine when source area remediation is complete.
- Establish soil vapor cleanup concentrations that will be protective of groundwater.
- Operation, maintenance, and optimization of the remediation system until metrics approved by NMED are met.

Performance Measures and Timeline

The success of Strategy 2 will be measured by:

- Completion of coring and analyses by Winter 2015/Spring 2016 to characterize the nature and extent of the LNAPL;
- Preparations of work plans by Winter 2015 and Spring 2016 for field-scale anaerobic biodegradation recirculation, bioventing, and bioremediation sparging pilot tests; and
- Implementation of field-scale anaerobic biodegradation recirculation, bioventing, and air sparging pilot tests.

STRATEGY 3

Collapse and treat the dissolved EDB plume.

2016 Strategy

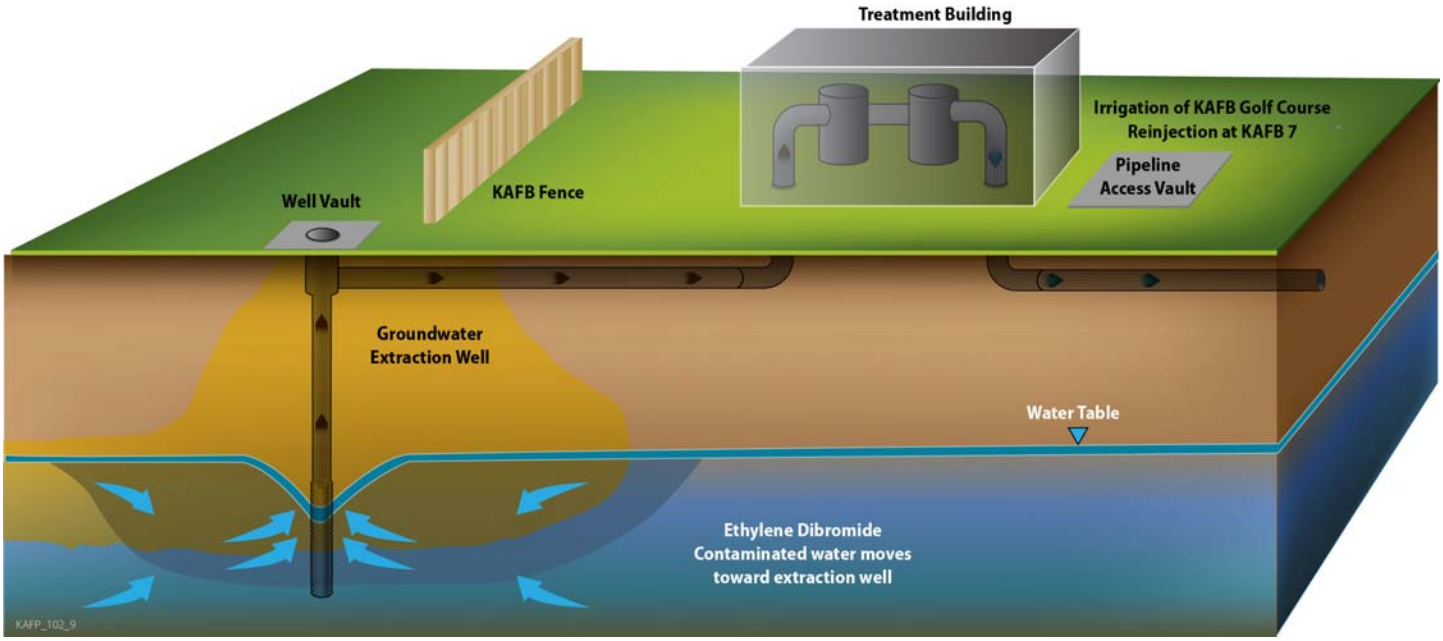
Develop a robust monitoring and pump and treat system to:

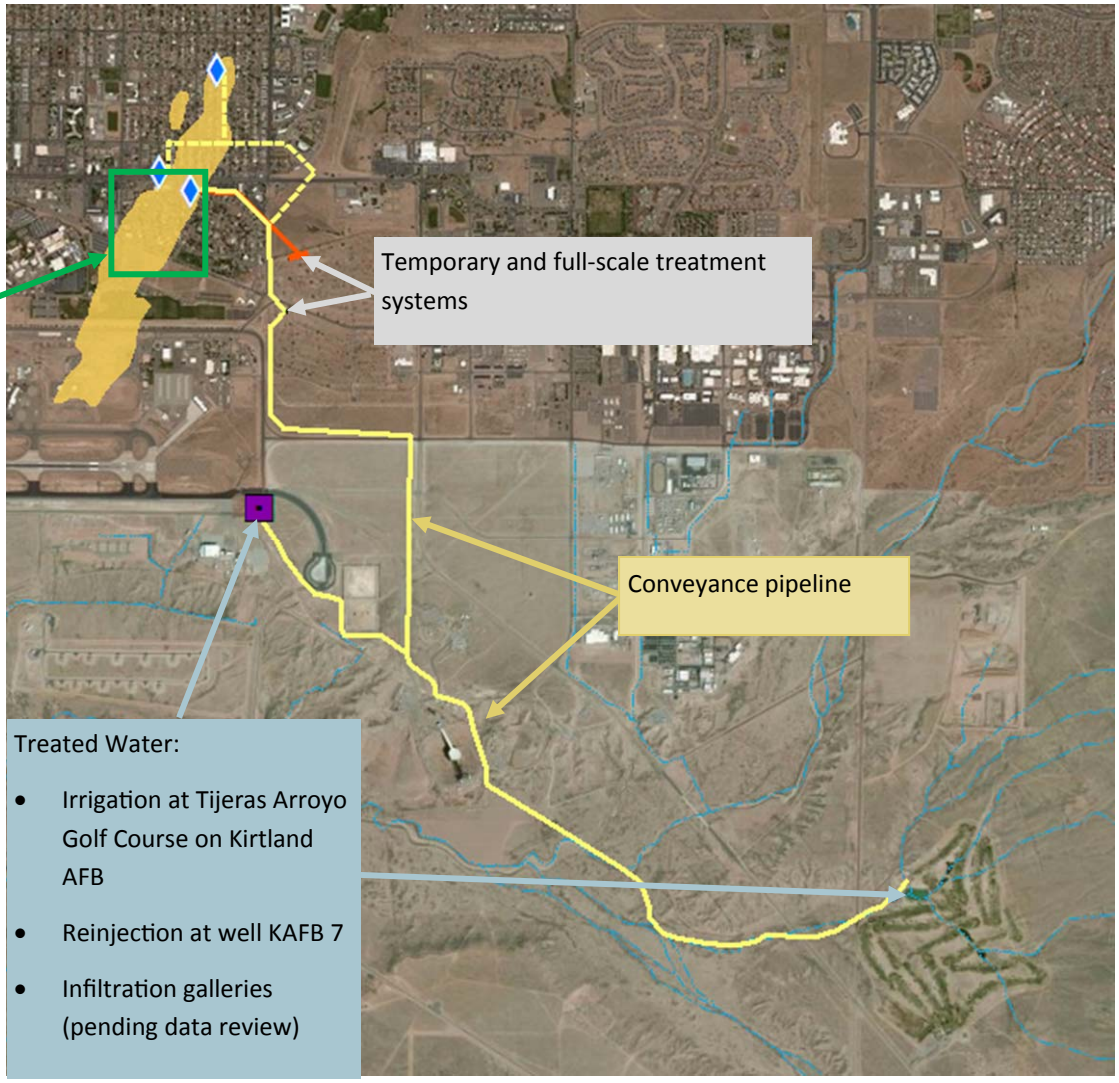
⇒ Stop migration of EDB towards drinking water wells;
⇒ Extract and treat EDB contaminated groundwater; and
⇒ Collapse the EDB plume back towards the Kirtland AFB boundary.

NMED will oversee the following actions to be performed by the Air Force and their contractors:

- Use hydrogeological data and numerical modeling simulations, as appropriate, to locate and design up to 4 additional extraction wells located throughout the dissolved-phase EDB plume.
- Drill and install up to 4 additional groundwater extraction wells.
- Construct a pipeline to convey water from the new groundwater extraction wells to the full-scale treatment system.
- Upgrade the current granular activated carbon filtration system to treat up to 800 gallons per minute of extracted water to at least the EPA drinking water MCL of 0.05 µg/L. System will be designed to handle the capacity from the maximum number of extraction wells to be installed.
- Evaluate performance data from the pilot test conducted at well KAFB 7 for the injection of treated groundwater, permitted by the NMED Ground Water Quality Bureau.
- Evaluate percolation test data to determine the viability of infiltration galleries for the discharge of treated groundwater. If applicable, submit work plans and construct an infiltration gallery, permitted by the NMED Ground Water Quality Bureau, to disperse the treated water into the subsurface and allow it to recharge groundwater.
- Explore other options for the beneficial use of treated water such as landscape irrigation and dust control.

Conceptual Diagram of Pump and Treat Remediation





Use hydrological data and numerical modeling simulations to locate and design up to 4 additional groundwater extraction wells for EDB plume collapse.

Temporary and full-scale treatment systems

Conveyance pipeline

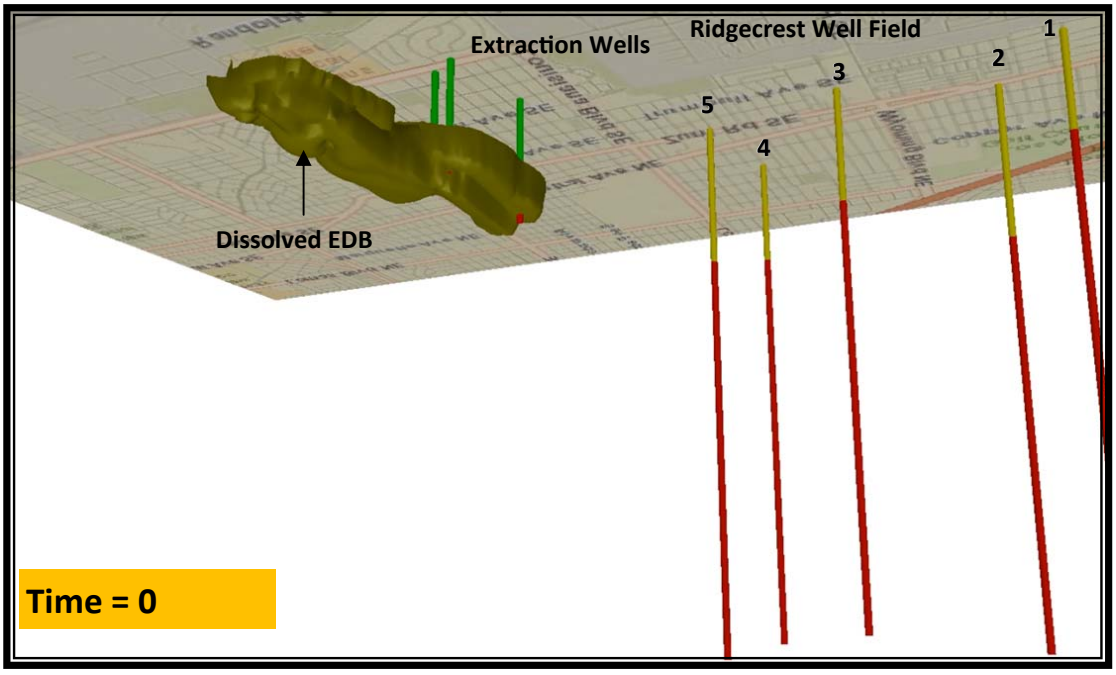
Treated Water:

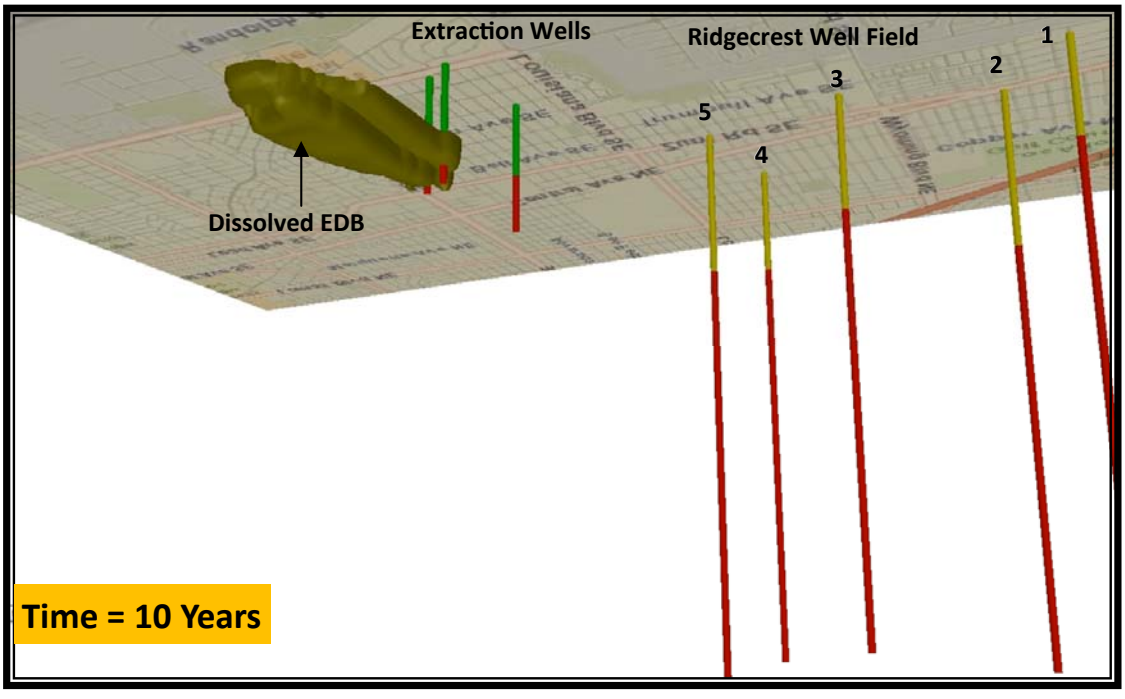
- Irrigation at Tijeras Arroyo Golf Course on Kirtland AFB
- Reinjection at well KAFB 7
- Infiltration galleries (pending data review)

"Collapsing the plume" refers to the collective actions of an extraction well system that will locally reverse ground water flow gradients, pulling the EDB contamination south and away from Water Utility Authority drinking water wells. The system will contain, capture, and extract the EDB plume, reducing its area and eliminating its potential for threatening clean drinking water wells. Contaminated water extracted from the EDB plume is treated to drinking water standards.

An animated model produced by scientists at EPA can be found on the NMED website:
http://www.nmenv.state.nm.us/NMED/Issues/KirtlandFuelPlume/KAFBProjectDocs.html

Below are two still images from the animated model.





Final Corrective Measure Evaluation, Selection, and Implementation

- In accordance with the requirements of RCRA, interim measure performance data (e.g. pump and treat capture zones) and other information will be evaluated to select and implement final corrective measure(s) for groundwater remediation. This may include a combination of different treatments.
- Implement long-term operation, maintenance, and optimization of pump and treat system to collapse the EDB plume and pull it back towards the boundary of Kirtland AFB.

Performance Measures and Timeline

The success of Strategy 3 will be measured by:

- Installation of up to 4 additional groundwater extraction wells by Fall 2016;
- Activation of the full-scale treatment system with the increased capacity of 800 gpm of extracted groundwater by December 2016;
- Installation and sampling of additional data gap groundwater monitoring wells by December 2016; and
- Continued monitoring of influent and treated discharge water for the EDB plume collapse treatment system.

STRATEGY 4

Meet or exceed all requirements for providing public information and involvement.

2016 Strategy

Our continued goal is to communicate accurate, comprehensive information to the public. We hold poster sessions to make our experts directly available to the public, offer field trips to educate the public on the geology and remediation activities of the area, host public meetings, and post information on our website. The public is invited to attend the public meetings and other numerous outreach opportunities that the NMED provides throughout each step along the path to final remedy.

- Continue to maintain the NMED and Kirtland AFB fuel leak cleanup websites (links in Appendix A) to make correspondence and technical information readily available to the public. Documents to be posted include, but will not necessarily be limited to, proposed and final work plans, quarterly reports, technical working group meeting minutes, RFI reports, and NMED approval letters.
- Continue to maintain a NMED Listserv to send out periodic messages informing the public of important news and opportunities for involvement.
- Co-host at least 3-4 public update meetings to include informative poster sessions, presentations and an open question / answer session.
- Make presentations, as requested, to neighborhood associations, city and county governmental agencies, legislative committees, and to other organizations interested in the KAFB fuel cleanup.
- Host field trips, in coordination with other stakeholders, to inform the public about site geology, hydrology, geochemistry, and cleanup actions.
- Explore potential for facilitated public working groups to address various components of site investigation and cleanup. Host working group sessions, in coordination with other stakeholders, if public interest exists.
- Conduct periodic surveys and interviews with area residents to determine specific areas of concern and additional outreach needs.
- Continually identify additional opportunities for constructive public outreach and communication.
- Update this Strategic Plan on an annual basis.

Performance Measures and Timeline

The success of Strategy 4 will be measured by:

- Participation and public satisfaction in three public meetings, spring, summer and fall/winter, 2016;
- Participation and public satisfaction in 1 to 2 field trips;
- Participation and public satisfaction in other organized public participation events; and
- Issuance of a draft 2017 Strategic Plan in December 2016.

Acronyms

AFB	Air Force Base
AFCEC	Air Force Civil Engineer Center
CME	Corrective Measures Evaluation
CSI	Complex Site Initiative
EDB	Ethylene dibromide
EPA	U.S. Environmental Protection Agency
LNAPL	Light non-aqueous phase liquid
MCL	Maximum Contaminant Level
NMED	New Mexico Environment Department
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SDWA	Safe Drinking Water Act
SVE	Soil vapor extraction
WQCC	Water Quality Control Commission

Glossary of Terms

A

Adsorption

A technical term referring to the bonding of a substance to soil or another medium.

Aerobic Biodegradation

The breaking down of organic contaminants by microorganisms when oxygen is present. In aerobic biodegradation, organisms convert oxygen to water in the process of transforming other components to simpler products.

Alluvial Fan

A triangle-shaped deposit of gravel, sand, and fine-grained sediment (clay or silt). This sediment referred to as alluvium.

Alluvium

Material such as clay, silt, sand, and/or gravel deposited by rivers and streams.

Anaerobic Biodegradation

The degradation of compounds by microorganisms in the absence of oxygen. Common substitutes for oxygen include nitrate, sulfate, and iron.

Aquifer

A zone of soil or rock below the surface of the earth capable of producing water.

B

Bio-augmentation

The addition of bacteria, nutrients, and other growth factors to enhance the efficacy of biodegradation of contamination in soil and/or groundwater.

Biodegradation

The breaking down of organic substances by microorganisms through the breaking of intramolecular bonds.

Bioremediation

The use of living organisms to cleanup contaminants from soil, water, or wastewater.

Bioventing

Bioventing is the process of stimulating the natural in situ biodegradation of contaminants in soil by providing air or oxygen to existing soil microorganisms. This technology uses low air flow to provide just enough oxygen to sustain microbial activity within the vadose zone.

C

Calibration

A process to ensure accuracy of measurement by a particular analytical method or instrument.

Cleanup

The removal of a chemical substance or hazardous material from the environment to prevent, minimize, or mitigate damage to human health, or the environment, that may result from the presence of the chemical substance or hazardous material. The cleanup is carried out a specific cleanup criteria.

Compound(s)

A thing that is composed of two or more separate elements.

Concentration

The amount of a chemical or substance in a given environmental medium.

Conceptual Site Model (CSM)

A conceptual site model is a way to organize and communicate technical information about a site. The CSM reflects the best interpretation of available information on how and where contaminants are expected to move and what impacts such movement may have.

Confined Aquifer

An aquifer bounded above and below by confining beds and completely filled with water under pressure.

Contaminant

Any physical, chemical, biological, or radiological substance in air or soil or water that has an adverse effect. Any substance whose concentration exceeds background concentrations or which is not naturally occurring in the environment.

Contamination

Introduction into air, water, and soil of chemicals, toxic substances, wastes, or wastewater in a concentration that makes the impacted medium unfit for its next intended use.

Corrective Action

The term corrective action typically refers to the cleanup process or program under RCRA and all activities related to investigation, characterization, and cleanup of a release of hazardous wastes or hazardous waste constituents. The term may also refer to a specific action taken to remediate contamination at a given facility.

Corrective Measures Evaluation (or Study)

Before choosing a cleanup approach or set of final remedies, a range of measures will be analyzed and evaluated for their advantages and disadvantages relative to the site-specific conditions. Significant public participation is encouraged during this portion of the corrective action proces

D

Data Quality Objectives

Qualitative and quantitative statements of the overall level of uncertainty that a decision-maker will accept in results or decisions based on environmental data.

Dissolved Phase

The part of hydrocarbon contamination which has partitioned into a body of water.

E

Effluent

Treated (or un-treated) wastewater that flows out a treatment plant.

Ethylene Dibromide (EDB)

A colorless, heavy, synthetic liquid that was primarily used in anti-knock gasoline mixtures, particularly aviation fuel. The maximum contaminant level for EDB in groundwater is 0.05 micrograms per liter (or 0.05 parts per billion), as defined by the NMED and EPA.

Extraction Well

A well specifically designed for the removal of groundwater or air.

F

Fate and Transport

A term used to discuss the movement of chemical contaminants through water or air, the synergistic effects of the contaminants in that environment, and the eventual disposition of that contaminant.

G

Granulated Activated Carbon

A porous adsorbent material created through the heating of organic material such as coal, wood, or coconut shell, which is then crushed into granules. The granular activated carbon is positively charged and therefore able to remove dissolved organic solutes by adsorption onto the activated carbon.

Groundwater

Water under the subsurface of the earth that fills pores in soil or opening in rock. When groundwater accumulates in sufficient quantities and quality, it may be used as a source of drinking water.

H

Hydrocarbons

Chemical compounds that consist primarily of carbon and hydrogen, such as petroleum.

I

Influent

Untreated wastewater flowing into a treatment plant.

In situ

Where contaminated material(s) are treated, in place, without prior excavation or extraction from the ground.

Interim Measure

Early action(s) taken to eliminate, reduce, or control the hazards posed by a site or to expedite the completion of site cleanup. An interim measure is a step preceding the final corrective measures and often occurring while site characterization is underway.

L

Lithology

A term used to describe the physical and mineralogical characteristics of rock. Common names may denote a specific type of rock (e.g., sandstone, granite, etc.) or may denote the general mode of rock formation (e.g., sedimentary).

M

Maximum Contaminant Level

The maximum permissible level of a contaminant; an enforceable standard.

Media

The fundamental components of the environment including water, sediment, soil, and biota.

Microorganism

A microscopic organism, especially a bacterium, virus, or fungus.

Migration

The movement of chemicals, bacteria, and gases in flowing water or vapor in the subsurface.

Model

A conceptual, mathematical, or physical system intended to represent a real system. The model is used to understand processes in the physical system that are analogous.

Monitoring

The continuous or periodic measurements at a site to determine the ongoing nature and performance of remediation. Monitoring also includes measurements taken for compliance purposes.

Monitoring Well(s)

A well that provides access to groundwater or soil vapor for field measurements and the collection of samples for laboratory analysis.

N

Non-Aqueous Phase Liquid (NAPL)

Contaminants that remain undiluted as the original bulk liquid in the subsurface (e.g., free product).

P

Paleochannel

A remnant of an ancient river or stream channel either filled in or buried by younger sediment. Paleochannels can often act as conduits for groundwater contamination.

Pathway

The means by which a hazardous substance, or agent, comes into contact with a receptor.

Plume

A visible or measurable discharge of a contaminant from a given point of origin.

R

RCRA (or ACT)

Resource Conservation and Recovery Act (RCRA), enacted in 1976, is the principle federal law in the United States governing the disposal of solid waste and hazardous waste.

Receptor

A person, organism, habitat, or controlled water that is being, or could be, harmed by a potential contaminant.

Remediation

An action taken to improve a contaminated site in order to prevent, minimize, or mitigate damage to human health, or the environment. Remediation includes the development and application of a planned approach that removes, destroys, contains or otherwise reduces the availability of contaminants to receptors of concern.

Remediation Criteria

Numerical limits or narrative statements specific to individual variables or substances in water, sediment, or soil which are recommended to protect and maintain the specific use of a contaminated site (e.g., residential use, etc.). When measurements of a particular variable indicate that the remediation criteria are being exceeded, the need for remediation is indicated.

Respiration

A process in living organisms involving the production of energy, typically with the intake of oxygen and the release of carbon dioxide, from the oxidation of complex organic substances.

Risk Assessment

The scientific examination of the nature and magnitude of risk to define the effects of contaminant(s) on humans and other receptors.

S

Saturated Zone

The zone where voids of the soil or rock are filled with water. In an unconfined aquifer, the water table forms the upper boundary of the saturated zone.

Soil Vapor (Soil Gas)

The vapor or gas phase of a substance that is found in the unsaturated zone.

Soil Vapor Extraction (SVE)

A physical treatment process for remediation of volatile contaminants in a vadose zone.

Surfactant

A chemical substance that lowers the surface tension of a liquid in which it is dissolved.

U

Unconfined Aquifer

An aquifer where the water level (water table) is free to rise and fall. The pressure is atmospheric at the water table.

V

Vadose Zone

The zone between the earth surface and the water table within which the moisture content is less than saturation. The soil pore space typically contains air or soil vapor. This zone is also referred to as the Unsaturated Zone.

Vapor Intrusion

Vapor intrusion is a process by which chemicals in soil or groundwater migrate to indoor air above a contaminated site.

Volatile Organic Compounds (VOCs)

Human-made hydrocarbon compounds that have low boiling points and therefore evaporate readily. Propane, benzene, and other components of gasoline are all volatile organic compounds.

W

Water Level

The upper limit of the saturated zone. It is measured by installing wells that extend a few feet into the saturated zone and then recording the water level in those wells.

Water Table

The level of groundwater.

New Mexico Environment Department:

⇒ KAFB Jet Fuel Plume Remediation web section: www.nmenv.state.nm.us/NMED/Issues/KirtlandFuelPlume

- **Project Documents Page: Groundwater Extraction Pilot and Additional Characterization**
  - KAFB workplan, August 1, 2014 Link to PDF on NMED website
  - NMED approval letter, August 20, 2014 Link to PDF on NMED website

- **Public Outreach Archive Page: Public Meeting Presentations and Field Trip Handouts**

- **Site also includes:** additional documents, modeling videos, biographies of technical working group members

- **Historical Reports and Correspondence** (dating back to 1999)
  - NMED Hazardous Waste Bureau Webpage link http://www.nmenv.state.nm.us/HWB/kafbperm.htm

Kirtland Air Force Base:

⇒ Project website: http://www.kirtlandjetfuelremediation.com

- **Project Documents Page: Quarterly Monitoring and Site Investigation Reports** (full text, figures and tables)

- **Site also includes:** past meeting materials, maps & photos, frequently asked questions, contacts

U.S. Environmental Protection Agency :

- **EPA's RCRA Orientation Manual** http://www.epa.gov/osw/inforesources/pubs/orientat/

Multidisciplinary working groups have been established to provide detailed review and analysis of highly technical issues pertaining to the investigation and cleanup of the Kirtland Air Force Base fuel leak. The groups consist of staff scientists and engineers from the NMED, Air Force, ABCWUA, City of Albuquerque, EPA, and contractors. Each working group shall prepare minutes documenting the attendance, discussion, and homework assignments from each meeting, and the minutes shall be posted on the NMED web site.

Hydrogeology Working Group

The hydrogeology working group will review published maps and reports, lithologic logs, well records, core samples, drill cuttings, airborne, surface and borehole geophysical data, water level data and other information. The hydrogeology group will use this information to define stratigraphy, structural features, and aquifer hydraulics in the vicinity of the fuel contamination. The hydrogeology group also will define background aquifer geochemistry, but will not address geochemical alterations caused by fuel contamination as that subject will be addressed by the biogeochemistry/LNAPL working group.

The hydrogeology group will have the following specific responsibilities:

1. Assembly or, if necessary, preparation of maps, cross sections, fence diagrams, graphs, Stiff diagrams, trilinear plots, time trends, interpretations and other material as appropriate to document site hydrogeologic conditions.
2. Provide detailed stratigraphic and other geotechnical information to the SVE, biogeochemistry/LNAPL and modeling work groups for their consideration and use in their areas of responsibility.
3. Field oversight of drilling operations, including review and approval of lithologic logs and proposed well completions.
4. Oversee borehole geophysical logging; analysis of logging data.
5. Oversee the design, implementation and interpretation of aquifer performance testing.
6. Develop a conceptual site model in coordination with other technical work groups.
7. Identify and resolve field and laboratory QA/QC issues.
8. Review water-level and water-quality monitoring data from the hydrodynamic dissolved-phase EDB extraction system.
9. Coordinate with ABCWUA, KAFB and NMVAHCS on protection of public drinking water wells.
10. Define background conditions for dissolved oxygen, nitrate, alkalinity, bromide and other parameters of concern.
11. Develop indicator parameter concentrations for sentinel wells that, if observed, would trigger additional review, increased monitoring, or intervention.
12. Plan and host occasional geological field trips for the general public, in coordination with other working groups.
13. Optimize the current groundwater monitoring program including the wells sampled and the laboratory analyses.

Biogeochemistry/LNAPL Working Group

The biogeochemistry/LNAPL working group will investigate and define the physical, microbial, geochemical, and hydrogeological processes that control the fate and transport of dissolved, non-aqueous liquid, gaseous and adsorbed phase contaminants, and evaluate potential remediation options. Dissolved phase contaminants of concern include: ethylene dibromide (EDB), benzene, toluene, ethylbenzene, and xylene isomers (BTEX), polynuclear aromatic and aliphatic hydrocarbons, and 1,2-dichloroethane. Parameters of interest regarding natural and engineered degradation processes include dissolved oxygen, oxidation reduction potential, nitrate, manganese, iron, sulfate, methane, carbon dioxide, alkalinity, bromide, chloride, and stable isotopes of various elements.

The biogeochemistry/LNAPL group will have the following specific responsibilities:

1. Characterize the physical and chemical properties of light non-aqueous phase liquids (LNAPLs) that are submerged within or floating atop groundwater.
2. Identify specific chemical and biological mechanisms that have transformed or degraded contaminants, along with reaction rates and byproducts.
3. Make recommendations for additional sampling and analysis as needed.
4. Use stoichiometric equations to calculate the amounts of contaminants that have been transformed or degraded in the vadose zone and in groundwater.
5. Maintain a running quantification of the amount of EDB that has been removed by the pump-and-treat system.
6. Evaluate potential remediation options for additional removal or destruction of fuel contaminants. Such options may include, but may not necessarily be limited to, pump and treat, air or steam sparging, soil vapor extraction, biostimuation, bioaugmentation, bioventing, surfactant flooding, and monitored natural attenuation.
7. Make recommendations for scaled up laboratory and field-scale pilot tests of potentially viable remediation technologies.

Vadose Zone Working Group

The vadose zone working group will review lithologic data, soil vapor concentrations, and performance data from historical and ongoing SVE operations to make recommendations on increasing the robustness of SVE activities.

The Vadose Zone group will have the following specific responsibilities:

1. Identify soil vapor hotspots needing additional treatment.
2. Recommend locations and completion specifications for additional extraction wells.
3. Identify areas where biodegradation is ongoing and would benefit from active bioventing.
4. In coordination with the biogeochemistry/LNAPL group, maintain a running quantification of the amounts of hydrocarbons that have been removed by SVE and by biodegradation in the vadose zone.

Modeling Working Group

The modeling working group will design, run and calibrate numerical simulations of contaminant transport and fate.

The modeling group will be responsible for the following types of simulations:

1. EDB transport times to drinking water wells in the area under various scenarios.
2. Hydrodynamic capture zones for various configurations of extraction wells with various pumping rates for pump-and-treat remediation.

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