DEPARTMENT OF THE AIR FORCE
377th Civil Engineer Division (AFMC)

8 November 2007

MEMORANDUM FOR MS. DIANE SNYDER
7006 ELNA COURT, NE
ALBUQUERQUE, NEW MEXICO 87110

FROM: 377 MSG/CEVR
2050 Wyoming Blvd. SE, Suite 118
Kirtland AFB, NM 87117-5270

SUBJECT: CLIENT LETTER – KIRTLAND AFB BULK FUELS FACILITY REMEDIATION

Dear Ms. Snyder:

I am writing this letter to describe the design, construction, and operation services that CH2M HILL has provided to Kirtland AFB in regard to our ongoing challenges at the base's Bulk Fuels Facility. In 1999 the U.S. Air Force discovered that jet fuel had been leaking from the infrastructure at the Bulk Fuels Facility for an undetermined period of time, resulting in the discharge of a large volume of jet fuel to the subsurface. After preliminary investigation it became apparent that the amount of soil impacted was quite large and extended over 300 feet below ground surface. The need to rapidly and effectively address this environmental release quickly escalated to a high priority for Kirtland AFB because of the potential threat to two of the base's drinking water supply wells. Kirtland AFB engaged CH2M HILL to assist the U.S. Air Force in identifying and implementing a remedial action for the site. Working in unison with not only my staff within the base's Environmental Restoration group but also partnering with other stakeholders such as the base Utilities group and the New Mexico Environment Department, CH2M HILL identified a unique approach for the remediation system at the Bulk Fuels Facility.

The soil vapor extraction system utilizing internal combustion engines that CH2M HILL designed, installed, and continues to operate and maintain has been very successful. The integrated nature of the design, using internal combustion engines to provide both the subsurface vacuum and the onsite destruction of the recovered contaminants in a self-sustaining manner is unique and excellently suited for the site. The mass removal rates achieved by the system have substantially surpassed the expectations the U.S. Air Force had for a more typical remediation system for the site. Furthermore, the modest total project cost for construction and ongoing costs for operation and maintenance relative to the high mass removal rates may be unmatched at other remediation sites across the U.S. Air Force. The Bulk Fuels Facility Remediation project is routinely a stop on tours given to officials and groups visiting the base, including elected officials, and technology conference attendees.

CH2M HILL has been the primary force in the investigation, design, construction, and startup of the Bulk Fuels Facility Remediation system and continues to operate, maintain, and optimize the system on behalf of the U.S. Air Force. Throughout design, installation, and operation this project has met all internal Air Force metrics and regulatory requirements and has been delivered on time and on budget. The success of the project has been and continues to be a credit to Kirtland AFB's Environmental Restoration program and CH2M HILL. Kirtland AFB is extremely pleased with the work CH2M HILL has conducted on this project and we look forward to continuing to have CH2M HILL involved in this project.

If you require any additional information please feel free to contact me at (505) 853-6534.

CARL J. LANZ, P.G., YF-02
Chief, Restoration Section

cc:
377 MSG/CE, Mr. Wilson
377 ABW/PA. Ms Speake
377 MSG/CEV, Mr. Pike
USEPA-Region 6 (6PD-N), Ms. King
HQ AFMC/A7CVQ, Mr. Fort
AFCEE, Mr. Urrutia
CH2M HILL, Mr. Minchak
Admin. Record, Central New Mexico Community College, Montoya Campus
AR/IR
File

EXECUTIVE SUMMARY

THE PROBLEM

A leaking underground fuel transfer pipe was discovered at the Kirtland AFB Bulk Fuels Storage Facility in 1999. It was unknown how long the piping had been leaking. Investigation revealed extremely high concentrations of fuel in the unsaturated site soils in an over 2 acre area and to depths of over 300 feet below ground surface. The extent and magnitude of the jet fuel release threatened two Kirtland AFB water production wells located within a half mile of the site and the drinking water aquifer in the Albuquerque basin as a whole. A remediation system design was needed that could achieve aggressive mass removal rates and operate reliably and continuously in order to protect human health and the environment.

THE SOLUTION

The challenges at the Kirtland AFB Bulk Fuels Facility were met with an atypical application of a common technology. The remediation system design uses soil vapor extraction to draw volatile contaminants out of the subsurface for treatment. To address the very high fuel concentrations at the site, and to provide high mass removal rates, a unique treatment system was selected for the site that uses internal combustion engines (ICEs). The engine manifold vacuum of the modified ICEs is applied to the subsurface to extract the contaminant vapors which are then drawn through the engines themselves where they are burned as fuel to operate the system in a sustainable fashion. Since system operation began the equivalent of over **120,000 gallons of jet fuel** have been recovered. The design has met the complex technical demands of the project while achieving very high mass recovery rates at a project cost at least an order of magnitude less than most other remediation approaches. The project was delivered on time and on budget meeting all U.S. Air Force metrics and regulatory requirements.

CH2MHILL

A. ROLE OF CH2M HILL IN THE PROJECT

CH2M HILL provided the design, project management, and construction management for the Kirtland Air Force Base (AFB) Bulk Fuels Facility Soil Vapor Extraction (SVE) Remediation Project. The project included design of the SVE system, oversight and direction of three primary subconsultants during system construction, and coordination with the U.S. Air Force as the project owner. After construction CH2M HILL conducted initial system startup and evaluation, developed the operations and maintenance manual for the system, and continues to operate the system on behalf of the U.S. Air Force.

B. ROLE OF OTHER CONSULTANT'S PARTICIPATING IN PROJECT

CH2M HILL was the prime contractor for design, construction, and startup for the Kirtland AFB Bulk Fuels Facility Soil Vapor Extraction Remediation project. Key subconsultant partners included Remediation Services International (RSI) which provided the unique remediation system components and Laguna Construction and WDC Exploration and Wells that provided site construction services.

C. BRIEF DESCRIPTION OF CH2M HILL'S CONTRIBUTION TO THE PROJECT

1. Original or Innovative Application of New or Existing Techniques

The Kirtland AFB Bulk Fuels Storage Facility provides bulk fuel storage for use at the base. The current annual throughput of jet fuel at the facility is roughly 20 to 25 million gallons. The site had a large fuel offloading rack where fuel was delivered and then pumped through two 14-inch-diameter below-ground transfer pipelines to two above-ground storage tanks that are 2.1 and 4.2 million gallons in size. A leak in the transfer piping was identified in November 1999. It was unknown how long the piping had been leaking or how much fuel had been released at the site. Investigation revealed extremely high concentrations of fuel in the unsaturated site soils over a horizontal and vertical footprint that made physical removal of the contaminated soil infeasible; an in-situ remedial technology was needed. ***Following consideration of various remediation options an atypical application of a common technology was identified for the site.***

Soil vapor extraction has been utilized in the environmental engineering industry for decades. Vacuum is applied to the subsurface and contaminants that have been discharged into the soil are removed in the form of volatile vapors. The challenge of soil vapor extraction comes in pairing an appropriate mechanism for applying vacuum to the subsurface with a viable technology for treating the extracted vapor stream in order to maximize contaminant mass removal. A highly successful project is a design that achieves a high mass removal rate to project cost ratio.

The high contaminant concentrations identified in the extracted soil vapors at the Kirtland AFB Bulk Fuels Facility made use of more typical offgas treatment technologies such as granular activated carbon vessels or catalytic oxidizer units infeasible. While capable of treating the offgas vapors, the volume of carbon required and the frequency with which the carbon would need to be replaced would inhibit effective, sustainable operation of a remediation system. The size of the catalytic oxidizer required to treat the high concentrations would also have been more expensive to operate and a much larger system than the selected treatment alternative.

The soil vapor extraction and treatment remedial alternative that was identified for the Kirtland AFB Bulk Fuels Facility was the use of *internal combustion engines* (ICEs). The final remediation system design included two 460 cubic inch Ford V-8 engines that were modified to RSI's specifications.

The engine manifold vacuum is applied to the subsurface to provide the active soil vapor extraction. The volatile jet fuel hydrocarbon vapors are drawn from the extraction wells, through manifold piping, and then into the system's ICEs where they are burned. Computer-controlled carburetors optimize the mixture of the extracted soil vapors with ambient dilution air to maintain an ideal combustion ratio in the engines. Exhaust gases are polished through onboard catalytic converters, destroying over 99% of the hydrocarbon vapors. A minimal amount of supplemental propane is used for system startup and to balance variable soil vapor concentrations.

Once the unique ICE technology was selected for the Kirtland AFB Bulk Fuels Facility project an effective design that integrated the treatment technology with the site specific conditions and addressed the regulatory requirements was needed.

The final system design provides flexibility to 1) protect human health and the environment, 2) maximize mass removal, and 3) limit future re-engineering of the system to address changing conditions as remediation progresses.

In addition to the ICE treatment units, the SVE system design included installing a series of nested soil vapor extraction wells that allow specific soil zones of interest to be targeted for remediation. The individual SVE wells are manifolded together with high density polyethylene piping specified for its resistance to degradation in the presence of high concentration petroleum hydrocarbon vapors. Each extraction well is equipped with individual well flow-control valves that can be adjusted to maximize flow of subsurface vapors. Other adjacent monitoring points are used as venting wells to allow oxygen-rich atmospheric air to be drawn into the subsurface, allowing more of the needed fuel-oxygen combustion mixture to be provided by the subsurface vapors. This increases extraction rates and reduces the need to add ambient dilution air for combustion. The increased subsurface oxygen also stimulates in-situ bioremediation that further enhances and complements the ongoing SVE remediation. The overall SVE treatment design has been highly successful. Since system operation began the equivalent of over **120,000 gallons of jet fuel** have been removed from the subsurface.

2. Future Value to the Engineering Profession

The successful application of this large scale SVE system utilizing ICE units is a model for other environmental cleanups of large petroleum hydrocarbon discharges. Numerous tours have been conducted at the site to showcase the application of the technology and design. Visitors have ranged from governmental officials to tour groups from technical conferences to college classes. The very high mass recovery rates and success of the current system have resulted in the U.S. Air Force moving forward with installation of another ICE SVE system at Kirtland AFB to address fuel product impacts to groundwater. This application of the technology to recover fuel from the groundwater table at depths of nearly 500 feet below ground surface will be a similarly unique application of this technology. However, based on the success of the current system, the same technology will be applied to this new application with a high degree of confidence.

3. Social, Economic, and Sustainable Design Considerations

a. Social Considerations

The extent and magnitude of the jet fuel release at the Kirtland AFB Bulk Fuels Facility presents a serious and real threat to the drinking water aquifer in the Albuquerque basin. The sustainable and reliable SVE approach utilizing ICEs provides aggressive mass removal rates at the site; more quickly moving the site towards cleanup. The technology further provides continuous, onsite destruction of the removed contaminants with minimal emissions to the environment.

b. Economic Considerations

The mass removal to cost ratio for annual operation of the remediation system is roughly $2 per pound of contaminant removed and destroyed. Other technologies typically have costs of $100's or $1000's of dollars per pound. This relatively low cost is achieved because no offsite waste disposal is required and system operations and maintenance activities are analogous to basic car engine maintenance. Materials and parts are readily available, reducing the need for expensive and difficult to obtain replacement components. The unique ICE SVE remediation system at the Kirtland AFB Bulk Fuels Facility is estimated to have saved the U.S. Air Force upwards of $1 million dollars relative to other technologies that could be utilized.

c. Sustainable Design Considerations

The integrated nature of the extracted vapors providing fuel for the ICEs which in turn provide the vacuum that extracts more contaminant mass from the subsurface epitomizes sustainability. The standard maintenance activities such as changing the engine oil, spark plugs, filters, and coolant produce waste streams that are well characterized and readily accepted for recycling. The engine components themselves, when they reach the end of their effective lives, are recyclable as scrap metal. Although not currently integrated into the operating system at the Kirtland AFB Bulk Fuels Facility the ICE units can be fitted with a generating set module that will produce electricity from the engines which can provide onsite power or potentially be connected to a receiving electrical utility grid.

4. Complexity

Investigation techniques are limited in their ability to assess the three-dimensional nature and extent of contaminants in the subsurface. Additionally, the goal of any remediation is to remove contaminant mass and ultimately achieve site cleanup. Therefore, as any successful remediation progresses the site conditions are constantly changing. These conditions inherently add a level of complexity to a remediation project because absolute site conditions and performance criteria can not always be established prior to the start of design. At the Kirtland AFB Bulk Fuels Facility the unknown total volume of jet fuel released and time over which the release occurred further complicated design of an appropriately aggressive yet flexible remediation system. Additional engineering concerns regarding safety (related to recovery of highly flammable fuel vapors), system durability (the system is located outside and components must withstand exposure to high concentration petroleum hydrocarbons vapors), and regulatory drivers (air emissions standards and protection of the regional groundwater aquifer) all added complexity to the design of the Kirtland AFB Bulk Fuels Facility remediation system.

5. Exceeding Client/Owner Needs

The project has exceeded the expectations of the different stakeholders involved including the U.S. Air Force and the New Mexico Environment Department. Continuous system operation is protective of the environment and achieves a mass recovery rate at least an order of magnitude higher than most other remedial technologies. The project design and construction was delivered at an actual cost that met the budgeted cost of roughly $750,000, with no overruns or required change orders. Following construction the initial startup and testing activities were conducted to establish standard operation and maintenance parameters. Full-scale system operation began in 2005 and the final Construction Summary Report was submitted to the owner and the regulatory agency in January 2006. CH2M HILL continues to operate and maintain the remediation system on behalf of the U.S. Air Force. All U.S. Air Force metrics and regulatory timelines were met.

6. Project Uniqueness

The Kirtland AFB SVE Remediation System design harnesses the onsite destruction of the very contaminants being remediated to actually power the system. This integrated, self sustaining design alone distinguishes the project, however, when coupled with high mass removal rates and relatively low operational costs it makes the project truly unique.

ADDITIONAL KEY PARTICIPANTS

Remediation Service, International
4835 Colt St, Unit D
Ventura, California 93003
(805) 644 8382

WDC Exploration and Wells
3621 Highway 47
Peralta, New Mexico 87042
(505) 865-5222

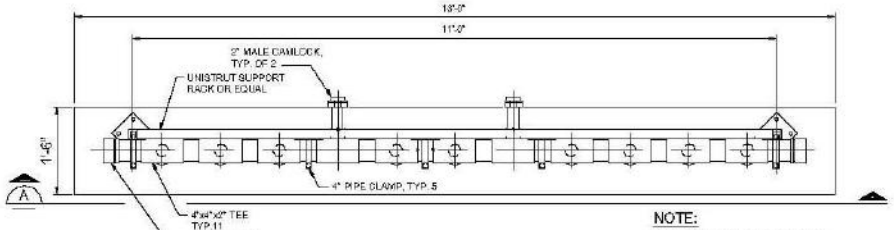
Laguna Construction Company, Inc.
5201 Venice NE, Suite A
Albuquerque, New Mexico 87113
(505) 890-5441

CH2MHILL


STOP
NO
PARKING

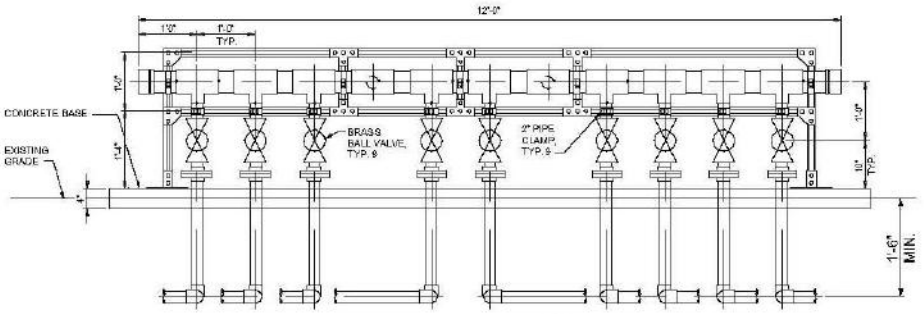
KIRTLAND AFB BULK FUELS FACILITY REMEDIATION
CATEGORY E – ENVIRONMENTAL

Photo 1. Drilling rig being used to install subsurface infrastructure. This rig advances temporary 10-inch diameter casing to depths of over 500 feet below ground surface. The PVC or stainless steel well is constructed inside the temporary casing and the casing is then removed from the borehole and decontaminated prior to drilling the next borehole. The technique has been used to install the soil vapor extraction, soil vapor monitoring, and groundwater monitoring wells at the site.

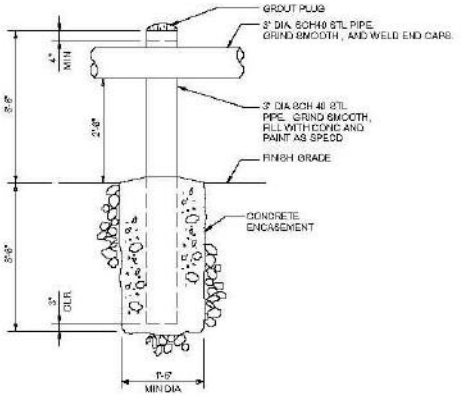


MANIFOLD PLAN VIEW 1
1/2"=1'-0" FIG. 2

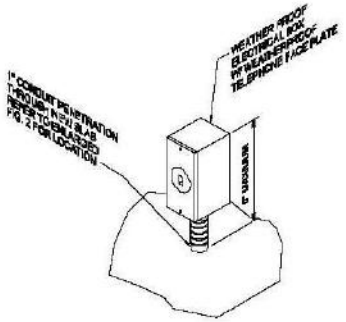
NOTE:
ALL FITTINGS TO BE HDPE, EXCEPT BRASS BALL VALVES.



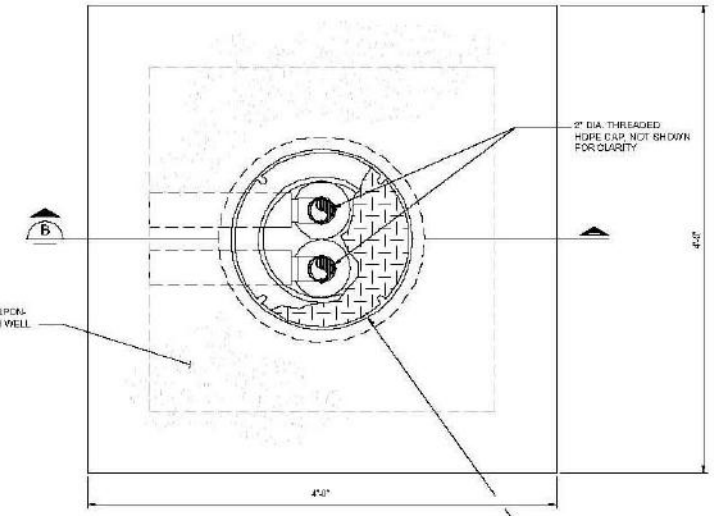
SECTION A
1/2"=1'-0"



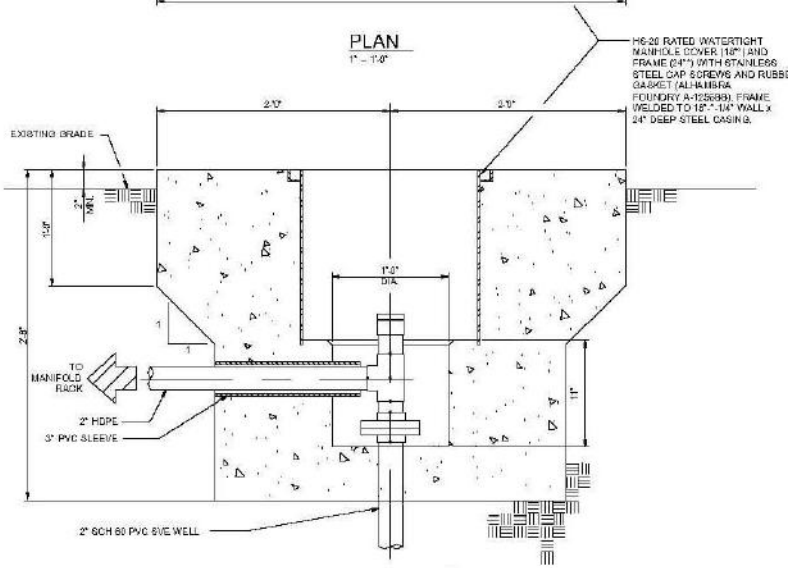
BOLLARD DETAIL - PROPANE TANK 2
N.T.S. FIG. 2



TELEPHONE JACK RISER DETAIL 3
N.T.S. FIG. 2



PLAN
1" = 1'-0"



SECTION B
1"=1'-0"

FIGURE 3. SVE SYSTEM CONSTRUCTION DETAILS

SVE WELL HEAD HANDHOLE 4
1"=1'-0" FIG. 1

CH2MHILL

P:\PORTLAND\198209.TO.1\8S-VE-SYSTEM DESIGN\DRAWINGS\198209-DETAILS.DWG

KIRTLAND AFB BULK FUELS FACILITY REMEDIATION
CATEGORY E – ENVIRONMENTAL

Photo 2. The manifold plan and section views in the upper left illustrate how the fuel vapors are delivered to the remediation system from the extraction wells. The well head detail in the lower right illustrates how individual vapor extraction wells are connected to the piping runs leading to the manifold.


249

KIRTLAND AFB BULK FUELS FACILITY REMEDIATION
CATEGORY E – ENVIRONMENTAL

Photo 3. Completed system showing the propane storage tank and protective barrier. This tank supplies a small amount of liquid propane which is slowly blended with the contaminated soil vapors to balance the fuel loading in the engines. The liquid propane is warmed and vaporized just before it enters the three-way computer controlled carburetor.


THIS MACHINE
STARTS AND STOPS
AUTOMATICALLY

KIRTLAND AFB BULK FUELS FACILITY REMEDIATION
CATEGORY E – ENVIRONMENTAL

Photo 4. Completely assembled soil vapor extraction system following construction. The system is located on the concrete pad with secondary containment to capture potential spills. The inlet to each of the engines is connected to the extraction well manifold.

KIRTLAND AFB BULK FUELS FACILITY REMEDIATION
CATEGORY E – ENVIRONMENTAL

Photo 5. Completed well control manifold. Flow from each depth interval can be controlled with manual valves. This allows remediation to be simultaneously focused at as many as nine locations at four depth intervals of 150, 250, 350, and 450 feet below ground surface.


REMEDIATION SERVICE, INT'L.
In Support Of The Environment

KIRTLAND AFB BULK FUELS FACILITY REMEDIATION
CATEGORY E – ENVIRONMENTAL

Photo 6. Internal combustion engine used for both extraction of the subsurface fuel vapors and destruction of the contaminants by burning in the engines. The system includes two engines that each burn the equivalent of 60 gallons of fuel per day. A total of roughly 120 gallons of spilled fuel is recovered from the ground each day and destroyed onsite.