Case Study Abstract

Kelly Air Force Base
San Antonio, Texas

Site Name and Location: Kelly Air Force Base San Antonio, Texas 78241-5842	**Geophysical Technologies:** Vertical seismic profile	**CERCLIS #** Not Applicable
Period of Site Operation: From the 1940s-1980s, Site MP housed metal plating and degreasing operations for aircraft **Operable Unit:** Zone 3 Groundwater Operable Unit SS037		**Current Site Activities:** Soil organic vapor survey complete, second phase began in April 1998 which consisted of (1) a seismic reflection survey of 318 points, (2) soil samples from 83 geoprobe locations and nine soil borings, (3) installation of one recovery and three monitoring wells, and (4) the extraction of approximately 1,000 gallons of dense nonaqueous phase liquid (DNAPL)
Point of Contact: Rhonda Hampton Zone 3 Groundwater Project Manager 307 Tinker Drive Kelly Air Force Base, Texas 78241 (210) 925-3100 Extension 226	**Geological Setting:** Quaternary alluvium overlying several hundred feet of Cretaceous limestones, shales, and clays	**Technology Demonstrator:** SeisPulse Development Corporation 93 Northridge Terrace #27 Medford, Oregon 97501 541-535-4641

Purpose of Investigation:
To map the bedrock surface and determine the locations of structural highs and lows where DNAPL could collect

Number of Images/Profiles Generated During Investigation: 317 shotpoints along 16 seismic reflection lines

Results: The surface of the Navarro Formation was mapped utilizing data acquired from SeisPulse Development Corporation “Vertical Reflection profile” (VRP) method of seismic survey and the SeisPulse seismic source. Depressions on the Navarro Formation were found to contain pooled DNAPL.

EXECUTIVE SUMMARY

Kelly Air Force Base is situated in metropolitan San Antonio within the encircling route 410 freeway. The site is located in the eastern portion of Kelly AFB, north of the Tinker Drive and Berman Road intersection. Surrounded by offices, industrial buildings, and an adjacent Union Pacific Rail yard, the site is approximately 90,000 square feet and consists of two former buildings (258 and 259) and an adjacent container storage area. Surface topography can be described as flat with maximum changes in elevation of 4.17 feet northward across the site.

From the 1940s to the 1980s, Building 258 and 259 housed metal plating and mechanical degreasing operations. Both buildings were leveled in 1981 and only their foundations remain. Solvents leaked from the degreasers, especially in the propeller line, which ran the width of Building 258. In December 1997, during an initial phase of well monitoring, a dense nonaqueous phase liquid (DNAPL) was discovered beneath former Building 258. Based on this discovery, a second phase of field activity began in April 1998, which included a seismic reflection survey, soil sampling, installation of a recovery well and monitoring wells, and the removal of approximately 1,000 gallons of DNAPL.

The Kelly AFB study area is underlain by a thin layer of fill material averaging several feet in thickness. Fill material may be absent in some surface locations, exposing the lower strata. Beneath the fill material are Quaternary alluvial deposits ranging in thickness from 30 to 45 feet, and consist of clay, gravel, and sand.

A seismic reflection survey was conducted in 1998 as part of a larger site investigation. The information presented in this report was derived from the interpretive report of the geophysical investigation. The Vertical Reflection Profile (VRP) (seismic) method was used to determine the structural highs and lows of the confining layer of the shallow aquifer that could provide migration pathways for dense non-aqueous phase liquids (DNAPLs). The seismic survey included the acquisition of 16 seismic reflection lines which radiated in a general northwest to northeast pattern across the site. An estimation of each seismic reflection peak associated with the top of the bedrock was made and the bedrock surface was identified and mapped. Multiple depressions were identified in cross sections produced with the seismic reflection data. The DNAPL was located in one of the depressions.

The “near offset” method of acquisition results in a series of discrete vertical reflection data points. However, obstacles such as buried building foundations act as reflective surfaces and can hinder reflection interpretation associated with the bedrock. Strong acoustical vibrations, such as rail yard activity, act as an additional seismic source and can also interfere with reflections. The bedrock surface was mapped and larger depressions were identified. However, the survey was unable to find small or narrow channels that could also facilitate DNAPL transport. Seismic surveying should be utilized in conjunction with other geophysical methods in understanding the subsurface and possibly contributing to the discovery of DNAPLs.

SITE INFORMATION

Identifying Information

Kelly Air Force Base (AFB), Site MP
San Antonio, Texas 78241-5842
Building 258 SWMU
CERCLIS #: Not applicable
Investigation Date: 16 April to 19 April, 1998

Background [1, 2]

Physical Description: Kelly Air Force Base (AFB) is located in central Bexar County, Texas (Figure 1). The base is situated in metropolitan San Antonio within the encircling Route 410 freeway. The site is located in the eastern portion of Kelly AFB, north of the Tinker Drive and Berman Road intersection, shown in Figure 2. The site is surrounded by offices, industrial buildings, and an adjacent Union Pacific Rail yard, to the southeast. The site is approximately 90,000 square feet of the approximately 371 acres of Zone 3 and consists of two former buildings (258 and 259) and an adjacent container storage area. Surface topography can be described as flat with maximum changes in elevation of 4.17 feet northward across the site.

Site Use: Aircraft operations and maintenance were performed at Kelly AFB from the 1940s to the 1980s. During this period, Building 258 and 259 housed metal plating and mechanical degreasing operations. Both buildings were leveled in 1981 and only their foundations remain. The entire area was then converted to an asphalt parking lot. Currently Kelly AFB is host to several tenant organizations representing Air Force, Army, and other government organizations. Kelly AFB is in transition from an Air Force Base to an industrial park. Transfer of ownership to the city is scheduled for completion July 13, 2001.

Release/Investigation History: Former Buildings 258 and 259 were used for aircraft maintenance and metal plating. Solvents leaked from the degreasers, especially in the propeller line, which ran the width of Building 258. In December 1997, during an initial phase of well monitoring, a dense nonaqueous phase liquid (DNAPL) was discovered beneath former Building 258. Based on this discovery, a second phase of field activity began in April 1998, which included a seismic reflection survey, soil sampling, installation of a recovery well and monitoring wells, and the removal of approximately 1,000 gallons of DNAPL. The asphalt parking surface was removed from the foundations of former buildings 258 and 259 for inspection, sampling, and, cleaning. At the conclusion of the investigation, the area was paved again.

Figure 1: Site Location

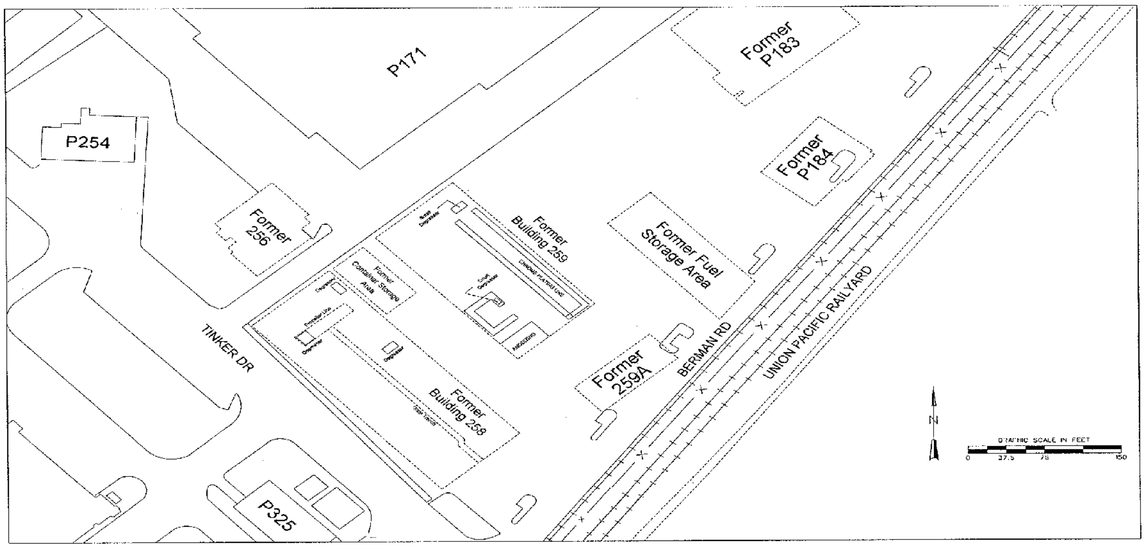

Figure 2: Site Map [1]

Regulatory Context: RCRA and Texas National Resource Conservation (TNRCC) regulations.

Site Logistics/Contacts

Federal Lead Agency: U.S. Air Force

Federal Oversight Agency: EPA

Remedial Project Manager:
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MEDIA AND CONTAMINANTS

Matrix Identification

Type of Geology Investigated: Bedrock surface

Site Geology/Stratigraphy [1]

The Kelly AFB study area is underlain by a thin layer of fill material averaging several feet in thickness. Fill material may be absent in some surface locations, exposing the lower strata. Beneath the fill material are Quaternary alluvial deposits ranging in thickness from 30 to 45 feet, consisting of clay, gravel, and sand (see Figures 3 and 4). The upper sequence of the alluvial deposits are composed of a black to brown clay ranging in thickness from 15 feet to 28 feet. The lower sequence of the alluvial deposits are composed of a permeable clayey gravel unit ranging in thickness from eight to 25 feet. Interbedded within the clayey gravel unit are sand and silt layers of various thicknesses which tend to laterally grade into gravelly clay and gravel with little clay.

A shallow groundwater aquifer lies within this permeable zone of clayey gravel at approximately 20 to 25 feet below ground surface (bgs). Groundwater generally flows eastward, off base, at 0.07 to 3.2 feet/day with a hydraulic gradient of approximately 0.001. Flow is influenced by compositional variation within the alluvium and channel-like features of interbedded gravel and clayey gravel formed on the bedrock surface. Beneath the alluvium lies several hundred feet of Cretaceous limestones, shales, and clays that compose the Navarro Formation, which acts as a bedrock aquitard. The bedrock separates the near-surface soil from the Edwards Aquifer, which is San Antonio’s sole drinking water source.

Contaminant Characterization [1]

Primary Contaminant Groups: The primary groundwater contaminants at the site are halogenated aliphatics. Groundwater maximum contaminant levels (MCL) were exceeded for chlorinated solvent concentrations including tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE), and vinyl chloride (VC). Inorganic contaminants, including chromium, nickel, manganese, and arsenic were detected below their MCLs.

Matrix Characteristics Affecting Characterization Cost or Performance [1]

The seismic survey was affected by rail yard seismic noise originating northeast of the site. The passing trains of the active rail yard caused earth-penetrating acoustical vibrations that acted as reflective sources, obscuring the actual bedrock reflections. Seismic energy reflects from any change in density, which can be the bedrock surface or a buried foundation. In addition to the rail yard seismic noise, buried structures affected the seismic survey by acting as another reflective boundary. The shallow depth of bedrock did not hinder the survey. The overall homogeneity of the alluvium and lack of topographical relief facilitated the seismic survey.

GEOPHYSICAL INVESTIGATION PROCESS

Investigation Goals [4]

The goal of the geophysical investigation was to map the bedrock surface and determine the locations of structural highs and lows that could provide migration pathways for DNAPL.

Geophysical Methods [2]

The SeisPulse Development Corporation patented the SeisPulse Seismic Source, which acquires seismic reflection data utilizing the Vertical Reflection Profile (VRP) method. The VRP method utilizes near-vertical ray reflection paths to acquire data. Since the 1920s, types of seismic sources have included vibrating masses, combustible gas mixtures, weight drops, dynamite, shotguns, and modified rifles. All of these sources produce destructive ground roll and airwave interference. The SeisPulse seismic source inhibits the destructive interference by producing an elastic (deformable) wave.

The SeisPulse system is a propane-combustion lightweight portable seismic source. A high-velocity pressure ridge resulting from the propane-air combustion is directed down an attached funnel-shaped wave guide. This source wave impacts the earth's surface, resulting in a strong seismic wave. Energy travels along the surface and into the earth, where it reflects from subsurface horizons such as lithological boundaries or erosional surfaces. The differences between interval velocities indicate changes in soil or rock properties.

Vertical resultant reflections at the site were received by a Mark Products (Mark 40A) geophone placed at a one-foot distance from the base of the seismic source. Shot point spacing of 10 feet between each station was used with the exception of two stations where seismic data was acquired at five-foot intervals, for a total of 1,606 shot points. The seismic reflection profile was not affected by the shot point station spacing. Reflection data was recorded on a 12-channel Geometric S-12 seismograph. Vertical reflection data from the initial source firing is recorded on channel one, and the next shot is recorded on channel 2 and summed together with the first shot on channel 12. This process is repeated until data acquisition for that specific station is complete. The station data is saved to an individual data file, and the source and geophone are moved to the next station. The data was recorded at a 1/4 millisecond sample interval and a record length of 512 millisecond.

The seismic source and geophone were operated by one technician while another technician acquired the data. At each shot point the records where collected, edited, and summed together to increase the signal to noise ratio. This additive process assumes that all coherent reflective energy arrives at the same time while noise is random and will not arrive at the same time.

Minimal separation of the source and geophone allows the ground roll and air wave to pass over the receiving geophone before the arrival of target data. The "near offset" method of placing the geophone within one foot of the source eliminates the need for large field crews and long cable layouts, which allows interpretation of survey material within 24 hours.

GEOPHYSICAL INVESTIGATION PROCESS

Technology Justification

The choice of seismic reflection for investigating the bedrock topography at the Kelly AFB was based on the need for a cost-effective method for mapping depressions in the bedrock which may represent migration pathways for contaminants. The depth to bedrock was well within the effective range for seismic reflection, yet not so shallow that the return wave would conflict with the ground roll wave.

GEOPHYSICAL FINDINGS

Technology Calibration [2]

A “walk-away” noise test was conducted to assure that data acquired is a reflection and not another source of wave energy such as source signatures or ground roll. The test involves placing a single geophone (receiver), at a one-foot distance from the source, igniting the source, and recording one trace. The geophone is moved in one-foot increments away from the stationary source and the test is repeated. After a typical distance of nine to 11 feet, the returning signals are studied to determine the reflector from the noise background. Ground roll energy will move at a constant velocity whereas reflector energy does not; this velocity difference is used to identify the reflector data from background noise. The ground roll or direct surface wave was identified from the reflector reflection data. The time necessary to complete a walk-away noise test using the SeisPulse system is approximately 30 minutes. Two walk-away tests were conducted at the site.

A geologic description from fifteen borings provided the depth to bedrock data, allowing proper identification and timing of reflection events. Two of the borings were used to complete down-hole velocity check shot surveys. The velocity surveys were initiated by suspending a two-inch diameter down hole geophone tool by means of a cable to the deepest accessible depth. A hammer and plate source were used near the boring and the time required for energy to travel to the geophone was recorded. The geophone was raised three feet and the procedure was repeated. The result was a set of one-way travel times, from the surface to various depth, which were used to determine the interval and average velocity of the overlying alluvium to make a general time-depth calculation required for the upcoming seismic survey.

The ability to visually connect or “time tie” line intersections with an identifiable reflector such as the bedrock surface throughout the survey can be an indicator of the seismic survey accuracy within localized areas. Reflection energy is received by the geophone and recorded as a trace. Each trace represents a station and each subsurface reflector or event should be visually identifiable on the trace, and connected to other traces within the survey. Since the bedrock is a continuous surface, each trace should have a event that marks its boundary and that event can be time tied to the next trace reflection event. This connection of events makes up the seismic profile. The bedrock surface reflectors were “time tied” at all line intersections.

GEOPHYSICAL FINDINGS

Investigation Results [1]

The purpose of this investigation was to map the bedrock surface and determine the locations of structural highs and lows in which DNAPLs could collect. The seismic survey included the acquisition of 16 seismic reflection lines which radiated in a general northwest to northeast pattern across the site. An estimation of each seismic reflection peak associated with the top of the bedrock was made and the bedrock surface was identified and mapped.

Figure 3 shows a geologic cross-section of the typical stratigraphy from northwest to southeast. The bedrock surface is shown at approximately 35 feet bgs and relatively horizontal. In the northwest section, the depression which collected DNAPL was shown. The approximate dimension of the DNAPL pool is approximately 100 feet by 50 feet with a maximum thickness of seven feet.

Figure 4 shows a southwest to northeast cross-section of the bedrock surface approximately 40 to 45 feet bgs. The bedrock surface varies in nature and areas of highs and lows are evident. Two depressions are shown separated by a relatively high area. The southwest depression is approximately 20 feet long and five feet deep. The northeast depression is approximately 30 feet long and five feet deep. DNAPLs were not discovered in either of the low areas.

Results Validation [1]

On May 30, 1998, three hollow-stem auger soil borings were taken to verify the seismic survey data used to map the bedrock surface. Two borings reached the bedrock surface at depths which closely matched the seismic survey reported depths. The third boring encountered a DNAPL pool at approximately 37 feet bgs and was terminated for health and safety reasons. This boring verified the existence of depressions in the clay surface as indicated by the seismic survey.

Comparison of lithologic units encountered at 15 wells or soil borings depths to calculated seismic depths indicate the seismic findings are consistent with actual depths to bedrock. The seismic depth errors ranged between -2.5 to +2.4 feet, and resulted from the use of a constant wave velocity. Interval velocities may have varied from station to station due to near-surface differences within the alluvium. The wells and soil boring locations were chosen based on their close proximity to the seismic lines.

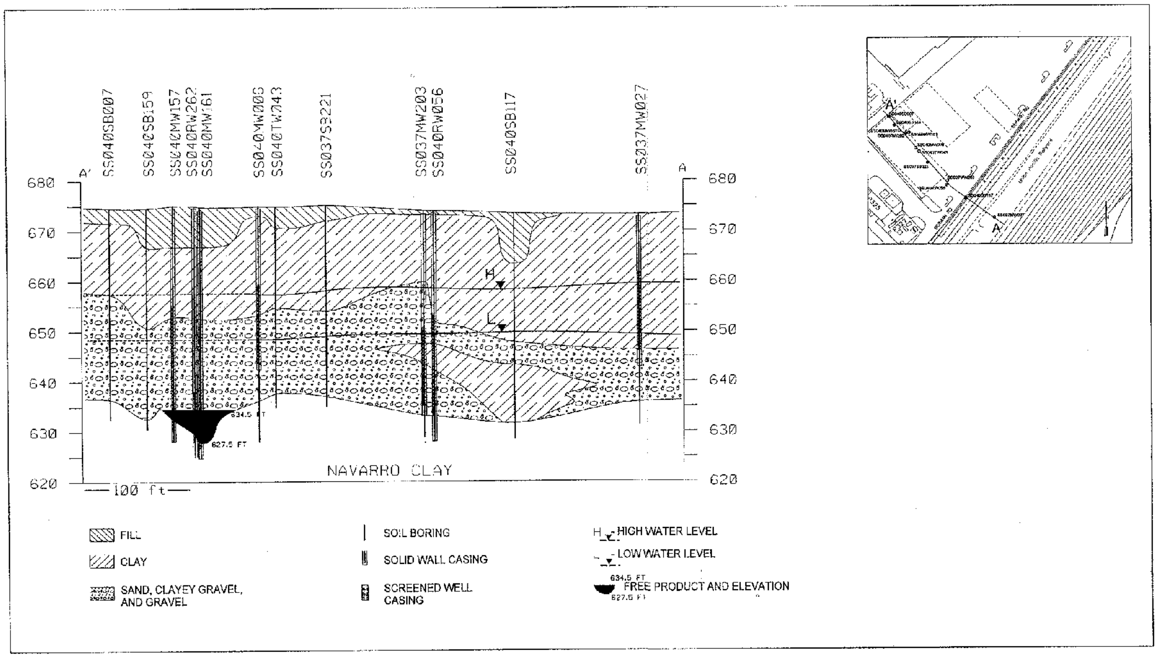

Figure 3: Northwest to Southeast Cross-Section, in Feet Above Mean Sea Level [1]

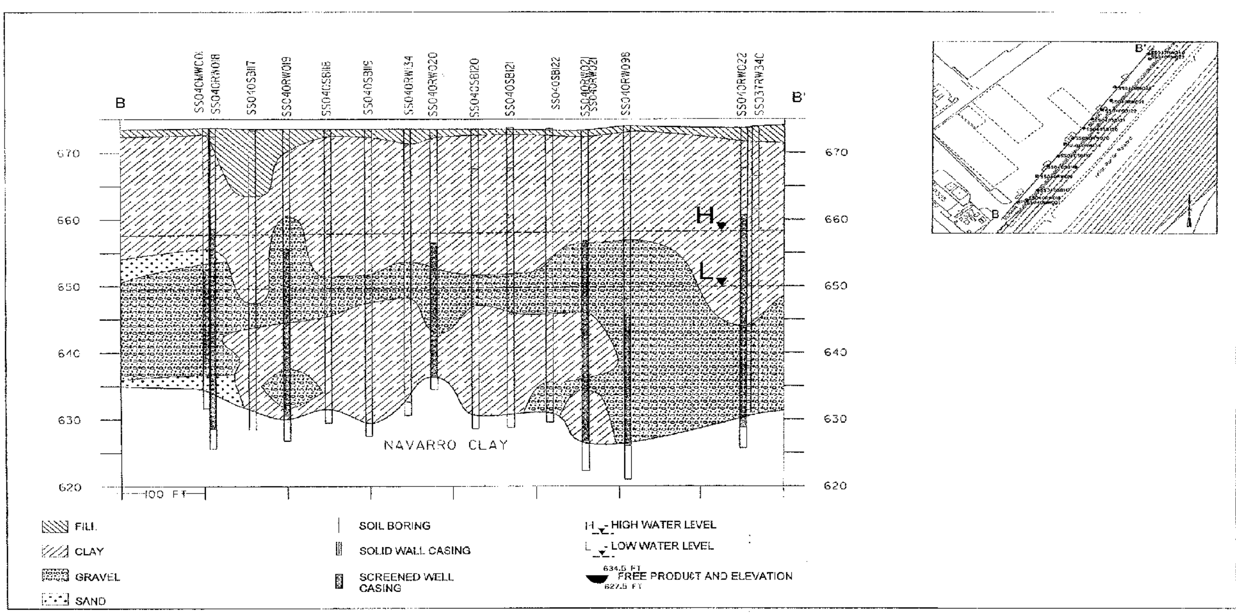

Figure 4: Southwest to Northeast Cross-Section, in Feet Above Mean Sea Level [1]

LESSONS LEARNED

Lessons learned at the Kelly AFB include the following:

- The “near offset” method of acquisition results in a series of discrete vertical reflection data points. However, obstacles such as buried building foundations act as reflective surfaces and can hinder reflection interpretation associated with the target bedrock. Strong acoustical vibrations such as rail yard activity act as an additional seismic source and can also interfere with bedrock reflections.

- The varying nature of DNAPLs suggest that they can follow cracks, offsets, and smaller scale features found on the boundary surface. At the site, the seismic reflection survey was implemented to define areas on the bedrock surface in which DNAPLs could collect and potentially migrate. The bedrock surface was mapped and larger depressions were identified. However, because of the error rates, the survey was unable to find small or narrow channels that would facilitate DNAPL transport. Seismic surveying should be utilized in conjunction with other geophysical methods in understanding the subsurface when investigating to find DNAPLs.

REFERENCES

- San Antonio Air Logistics Center, Environmental Management Restoration Operations. *Current Conditions Report for the Building 258 Solid Waste Management Unit*, Kelly AFB, Texas. Science Applications International Corporation. July 1998.

- Science Applications International Corporation. *Seismic Reflection Geophysical Survey Report*, Kelly AFB, Texas. SeisPulse Development Corporation. May, 1998.

- Personal communication with Mike King, President of SeisPulse Development Corporation, Vancouver, Washington. September 4, 1998.

- Personal communication with Rhonda Hampton. Zone 3 Groundwater Project Manager. Kelly AFB, Texas. September 17, 1998.

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