

GIS Tools for Remediation of Groundwater

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Abstract

The Arkansas Department of Environmental Quality/The Regulated Storage Tank Division of ADEQ received a grant from EPA Region VI to GIS map all the active LUST sites (n=127) in Arkansas. A new Trimble XT GPS unit with TerraSync(tm) software was purchased to collect GPS data by case managers necessary to fully map the physical features of these sites. ArcView 8.3 and the 3D Analyst and Spatial Analyst extensions were purchased to complete this project. Almost immediately, we learned that not only could this information be used to make geo-referenced maps, but visual planning aids for remediation could be created to predict contaminant plume migration, potential impact to buildings and residential structures, groundwater and public water well contamination, etc. The impact of petroleum contamination on a public water system in Dardanelle, AR, will be discussed from models generated by utilizing GIS software.

The General Jack's Car Wash site is located at the intersection of Second and Union Streets in Dardanelle, Arkansas. Figure 1 presents a site location map for the facility. The property is situated in the NE ¼ of the NE ¼ of Section 31, Township 7N, Range 20W. The facility was formerly operated as a gasoline station/convenience store and car wash until 1997. In December of 1997, the facility discontinued retail sales of gasoline. The property is an approximately 15,984 square foot lot consisting of a 1,149 square foot single story commercial structure and a four (4) bay car wash. The property is approximately 333 feet above mean sea level.

The property is situated in a well-developed commercial/residential zoned area of central Dardanelle, Arkansas. To the north, northwest and northeast, the site is bordered by residential developments. The property is bound to the east by Second Street. Further east across Second Street is the Yell County Courthouse and City Library. The property is bound to the south by Union Street. Union Street (State Highway 7) is a main traffic thoroughfare through Dardanelle and is zoned for commercial establishments. Residential developments are located further north

and south of Union Street. Further south, across Union Street, is the Exxon convenience store/gasoline station and the Church of Christ. A Fina convenience store/gasoline station is located at the southeast intersection of Second and Union Streets. Residential developments are situated south of Union Street. To the west and adjacent to the site is the Weatherly residence. Further west of the Weatherly residence is a Sonic Drive-In restaurant.

Five (5) underground fuel storage tanks and two pump islands were previously located at the site. The USTs were installed in 1964 and have been out of service since 1997. They were permanently removed on January 9, 2001, and elevated levels of petroleum constituents were detected in a single soil sample taken under one of the tanks during the permanent removal of the (5) USTs. The owner reported that an incident occurred in 1988 when Sprint Communications' horizontal boring equipment punctured the upper wall of the 4,000 gallon gasoline UST during installation of a fiber optic cable trench along the north side of Union Street. The hole was reported to be approximately four (4) inches in diameter and located approximately six (6) to eight (8) inches below the top of the tank. (Figure 2). Upon discovering the damaged UST, the contents were pumped out of the tank on the same day and it reportedly remained out of service until its removal in January of 2001. The owner believes that the residual contamination from the punctured UST was likely responsible for the elevated levels of contamination documented from the January 2001 closure samples.

Potential receptors surrounding the site include the Arkansas River, located approximately 1,500 feet east/northeast of the property. Other potential receptors include two (2) water wells located approximately 350 feet north and east of the site. One (1) of these wells (the "State Street" well)

is located approximately one (1) block north at the north at the northwest intersection of State and Second Streets. The second well (the “courthouse well”) is located east/northeast of the site just north of the Yell County Courthouse. Dardanelle draws untreated groundwater from a total of nine (9) water wells located within the city limits. Six (6) of these wells are located approximately 3,000 to 4,500 feet south of the General Jack’s property. One well is located approximately 2,100 feet southwest of the property near the intersection of Market and Six Streets. The “courthouse” well was completed in 1971 and is 66 feet deep with 53 feet of casing and 10 feet of 12-inch screen. When operating, the “courthouse” well yields approximately 270 gallons of water per minute. The “State Street” well, was completed in 1983 and is approximately 70 feet deep with 60 feet of casing and 10 feet of screen. The “State Street” well currently yields approximately 260 gallon of water per minute.

According to the Arkansas Geologic Commission, several springs are located within Yell County. The majority of the springs are located approximately five (5) miles west of the site. No springs were reported to be located within a 1,000 foot radius of the site.

The shallow subsurface soils at this site are generally characterized by alternating sequences of alluvial sediments deposited by the Arkansas River including sands and clays of varying silt content. The upper soil column is composed of fine grained silty sand to a depth of approximately 12 feet below ground surface (bgs). At 12 feet bgs, clay content increased in the sand matrix to a depth of 14 feet bgs. Below the sequence of lean clay, a moist fine grained sand layer extended from 14 feet bgs to a depth ranging between 17 to 20 feet bgs. A second clay sequence was encountered from an estimated depth of 17.5 bgs to approximately 20 feet bgs. A

wet sandy clay was typically observed from 20 to 22 feet bgs followed by another thin sequence of wet sandy loamy clay from 23 to 24 feet bgs. A second layer of firm plastic silty clay was encountered from 24 to 25 feet bgs.

The deeper strata indicated a recurrence of silty to clayey fine grained sand to 41 feet bgs. Fine grain sand was encountered from 41 feet bgs to the lower extent of the boring at 55 feet bgs.

Groundwater saturation was encountered at 498 feet bgs. Shale bedrock was encountered at 57 feet bgs.

A total of 32 soil samples were collected for laboratory analysis during the investigation. The soil samples were selected for chemical analysis based on the results of the head space analysis, visual and olfactory inspection. Each sample was analyzed for Benzene, Toluene, Ethyl benzene and Xylene (“BTEX”), Methyl Tertiary Butyl Ether (“MTBE”) and Naphthalene in accordance with Environmental Protection Agency (“EPA”) SW-846 Method 8021B/5030A. Chemical analysis data for soil indicated the presence of detectable levels of petroleum constituents present in the majority of the soil samples. The highest contaminate levels were present at the ten (10) to 14 foot depth interval. Total BTEX soil concentrations in the soil ranged from non-detect to 3,925 parts per million (“ppm”). The highest level of Total BTEX was in Boring B-3 at ten (10) feet bgs (3,925 ppm), with the second highest Total BTEX concentrations found at the 12 foot depth interval in Boring B-2 (3,067 ppm). Relatively low concentrations of MTBE were detected in Boring B-1 at 20 feet bgs (0.564 ppm) and Boring B-2 at the 10 and 22 foot depth intervals (1.99 and 17.3 ppm, respectively). MTBE was also detected in Boring B-3 at the ten

(10) foot interval (54 ppm). The distribution and relative concentration of naphthalene was similar to the pattern of distribution observed with the BTEX.

The Arkansas Health Department has analyzed water samples for all the public water wells and found traces of MTBE in all nine (9) of the wells. MTBE levels were under EPA advisory levels. This has the Health Department concerned may threaten to shut down the current water system. If that were to occur, the city of Dardanelle would have to purchase water from a nearby municipality. A Global Positioning System (GPS) data collection survey was conducted in Dardanelle, AR of all public water wells, retail gasoline facilities and the General Jack's Car Wash site on October 28, 2003. (Figure 3). GPS data collection would provide better understanding of the area and contamination plume with geo-referenced maps of the area.

A Trimble GeoExplorer XT CE series GPS unit loaded with TerraSync Pro 2.40 software was utilized to collect the GPS positions. The unit was setup in accordance with the "Standards for Collection Mapping Grade Global Positioning System Positions" required as official state rule dictated by the Arkansas State Land Information Board. Data points, lines and polygons were transferred to Path Finder Office 3.00 and differentially corrected and exported as ESRI shape files.

ESRI ArcView 8.3 was used to create layers to analysis the data at the Dardanelle site. Digital Orthographic Quarter Quadrangle (DOQQ) of the city of Dardanelle was imported into ArcMap as the base layer. Shape files of the GPS data was projected on the DOQQ as public water wells, center of tank pits at the retail gasoline facilities, monitoring wells and buildings. (Figure 4).

Soil boring data was entered into an Excel spreadsheet along with corresponding GPS data and imported into ArcMap. (Figure 4). Monitoring well plume delineation for both shallow (approximately 24 feet) and deep wells (approximately 55 feet) was projected on the DOQQ using the Inverse Distance Weighted Interpolation feature in the ESRI Spatial Analyst extension. These maps provided excellent maps that visually projected the plume delineation of benzene. (Figures 5 & 6). MTBE plume delineation is shown in Figure 7. The data was used in ESRI 3D Analyst to compile the layers as one view. Videos of the 3D layers were created to emphasize the dramatic effect for presentations. (Figure 8).

The contamination has remained basically on site due to the second clay layer that was encountered from a depth of 17.5 bgs to 20 feet bgs. However, on-site groundwater data from the alluvial aquifer suggest that contaminant migration to the City water supply has occurred across a leaky perching mechanism of the second clay layer. This low-level benzene impact has been detected in samples from city wells in close proximity to the General Jack's site. Impact by gasoline on site in vadose zone soils is present at concentrations that suggest the presence of free-phase petroleum bound by the soil matrix.

It is planned later this year to begin removal of the contaminated soil by implementing a technique not used in Arkansas before. The normal procedure of "dig and haul" to remove the contamination is not possible at this site due to the location of the site within a downtown location and small lot size. A four (4) foot auger will be used to remove one core soil down to 20 feet at a time. The contaminated soil will be trucked off to a local landfill and placed in a

treatment cell. The single hole will be filled with fresh clean soil before moving over to bore the next hole. This process will continue until site is clear of all contaminated soil. It is estimated 15,000 cubic yards of soil will be removed from the site.

This was the first site that the new GPS equipment was used to see what types of GIS maps could be utilized to determine effects of contamination of leaking underground tanks. GIS can make quick assessments of monitoring well data, but it has been found that the initial use of GIS is very beneficial at new sites to make determinations for a plan of action prior to conducting any remediation work. Work plans can be devised by having geo-referenced maps of the work site and surrounding area that are detailed in features to make professional decisions on remediation actions and alleviate unnecessary work that will ultimately save money for the taxpayers.

References:

Site Assessment Report for Former General Jack's Carwash. The Southern Company of North Little Rock, Inc. prepared for the Arkansas Department of Environmental Quality. September 27, 2002.

Limited Site Assessment Report for General Jack's Car Wash. Pollution Management, Inc. prepared for Burris Oil Company and Arkansas Department of Environmental Quality. September 21, 2001.

Figures

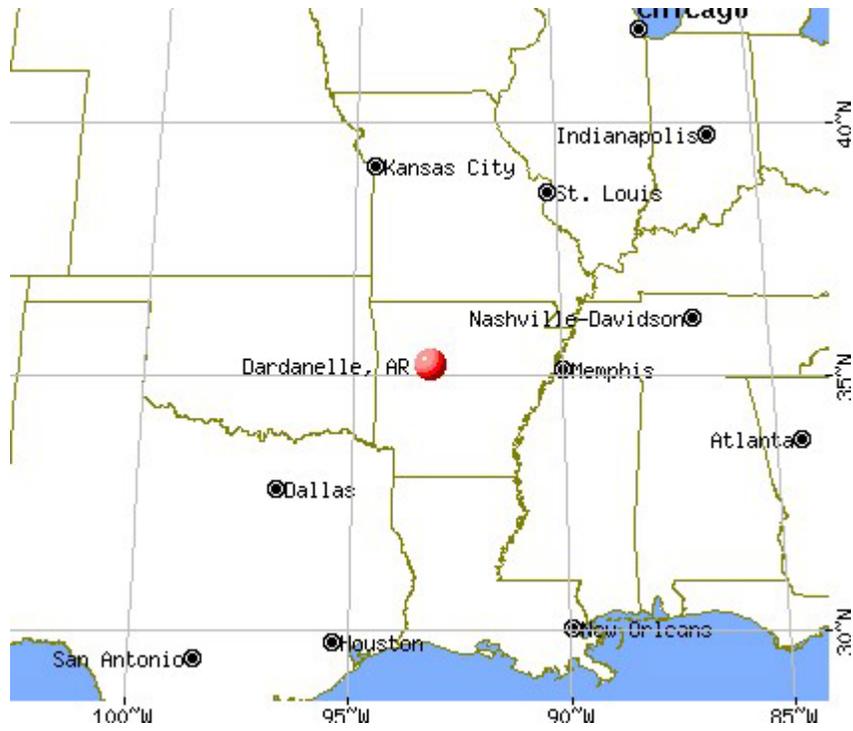


Figure 1

City of Dardanelle, Arkansas



EPA LUST GRANT for Mapping Active Leaking Sites (n=134)

Figure 2



Figure 3

Storage_C	Depth	V_Deep	Vol	Long	Lat	Type of RA Profile	Grouped Contaminant	TPH	PCB	Contaminant	TOH	DRO	AFRO	PP_data
10	00	1989	35.22343	332.76			285.74							30
20	00	1989	35.22395	332.68			274.35		1.24					80
30	00	1989	35.22395	332.7			273.65			23	174			300
40	00	1989	35.22396	332.67			273.37		95	0.264	23	1.807		300
50	00	157	35.22395	332.14			262.85							300
60	00	1671	35.22367	332.89			286.26							80
70	00	1573	35.22373	332.11			275.05							25
80	00	1571	35.22330	332.64			273.62							25
90	00	1987	35.22372	331.82			272.71			0.130				25
100	00	1984	35.22362	332.71			273.62			0.600				80
110	00	1982	35.22376	332.88			273.86							80
120	00	1989	35.22404	331.55			271.81		8.11					80
130	00	1986	35.22408	332.62			272.80							300
140	00	1576	35.22399	330.72			271.22							300
150	00	1573	35.22409	330.64			271.12							30
160	00	1987	35.22410	331.84			273.99							30
170	00	1988	35.22446	334.85			285.18							30
180	00	1978	35.22347	332.47			286.22							30
190	00	1989	35.22344	332.7			340.85			18.09	23	598		
200	00	1987	35.22361	332.7			340.05							
210	00	1989	35.22394	332.89			318.3			217.4				
220	00	1989	35.22395	332.58			300.95			0.148				
230	00			332.8			310							
240	00	140	35.22330	332.79										
250	00	1587	35.22373	331.82										
260	00			332.71			300.15							
270	110		35.22408	332.71			300.15							
280	120		35.22402	332.77										
290-300		00	1988	35.22389	332.7		332.7		95	136.2				
310-320		00	1989	35.22397	332.9		302.9		95	0.738	23	1.805		
330-340		00	1989	35.22347	332.2		332.2		95	16.37	23	18.673		
350-360		00	1989	35.22379	332.8		332.2		95	16.37	23	1.959		

Figure 4

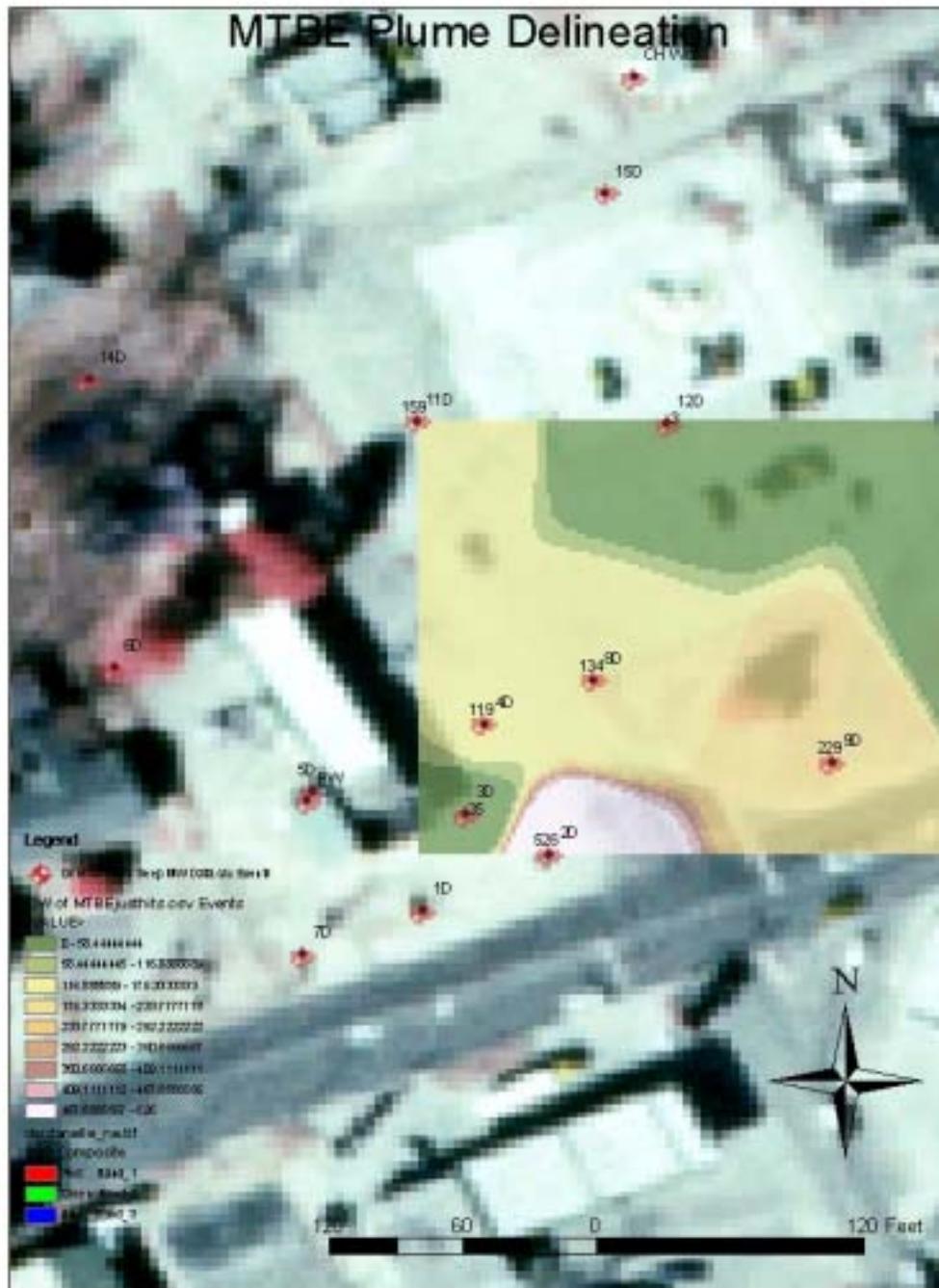


Figure 7

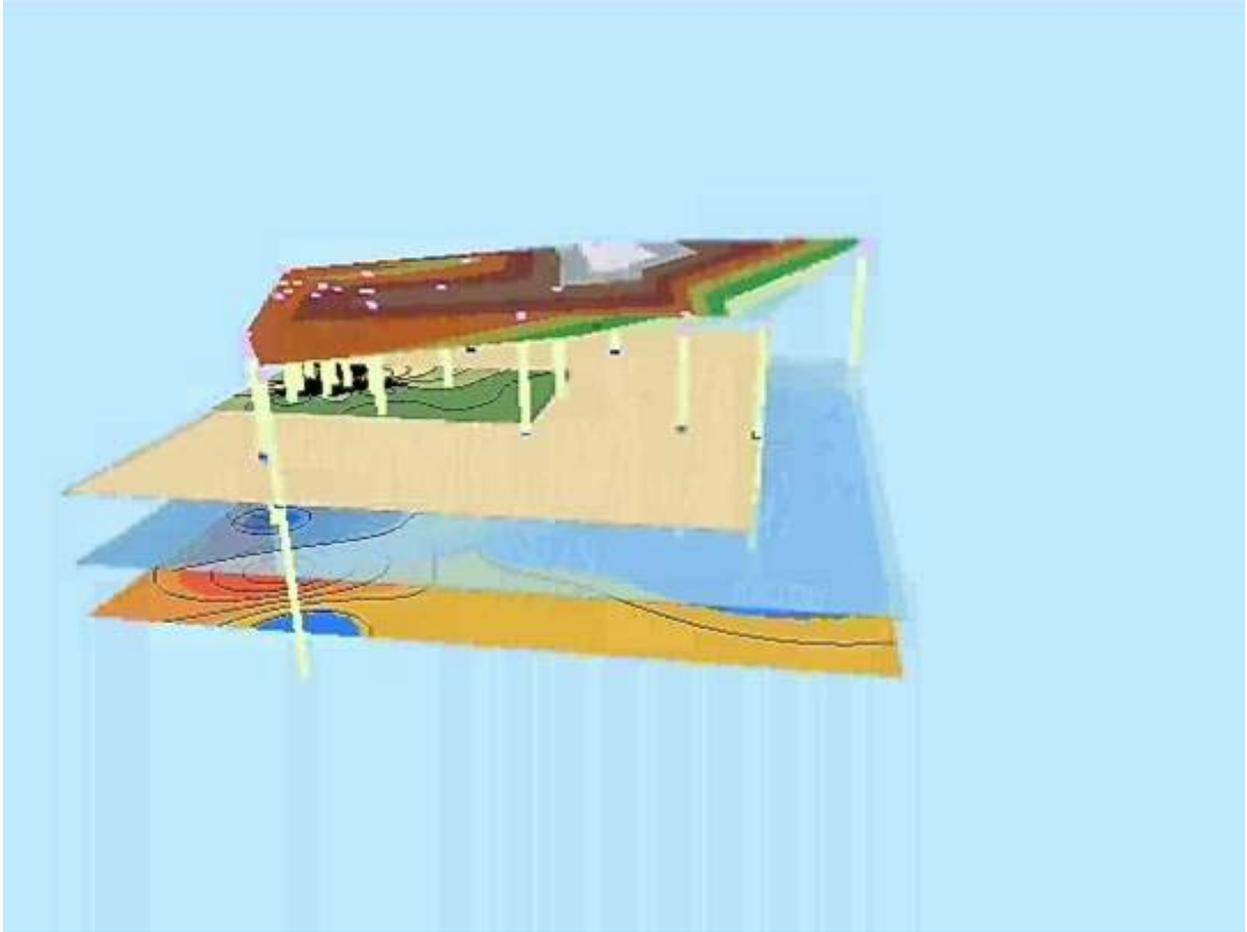


Figure 8

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