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Induction Conductivity and Natural Gamma Logs Collected in 15 Wells at Camp Stanley Storage Activity, Bexar County, Texas

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Datums

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27) and North American Datum of 1983 (NAD 83).

Induction Conductivity and Natural Gamma Logs Collected in 15 Wells at Camp Stanley Storage Activity, Bexar County, Texas

By Gregory P. Stanton

Abstract

The U.S. Geological Survey, in cooperation with the Camp Stanley Storage Activity conducted electromagnetic induction conductivity and natural gamma logging of 15 selected wells on the Camp Stanley Storage Activity, located in northern Bexar County, Texas, during March 28–30, 2005. In late 2004, a helicopter electromagnetic survey was flown of the Camp Stanley Storage Activity as part of a U.S. Geological Survey project to better define subsurface geologic units, the structure, and the catchment area of the Trinity aquifer. The electromagnetic induction conductivity and natural gamma log data in this report were collected to constrain the calculation of resistivity depth sections and to provide subsurface controls for interpretation of the helicopter electromagnetic data collected for the Camp Stanley Storage Activity.

Logs were recorded digitally while moving the probe in an upward direction to maintain proper depth control. Logging speed was no greater than 30 feet per minute. During logging, a repeat section of at least 100 feet was recorded to check repeatability of log responses.

Several of the wells logged were completed with polyvinyl chloride casing that can be penetrated by electromagnetic induction fields and allows conductivity measurement. However, some wells were constructed with steel centralizers and stainless steel screen that caused spikes on both conductivity and resulting resistivity log curves. These responses are easily recognizable and appear at regular intervals on several logs.

Introduction

The Camp Stanley Storage Activity (CSSA), located northwest of San Antonio, Texas (fig. 1), a separate activity of Red River Army Depot (near Texarkana, Texas), serves as a weapons and munitions supply, maintenance, test, and storage facility. The CSSA encompasses about 4,000 acres with 630,000 square feet of storage space. The facility supports locations throughout the contiguous United States and selected overseas areas.

The U.S. Geological Survey (USGS), in cooperation with the U.S. Army, CSSA, collected induction conductivity and natural gamma logs of 15 selected wells on the facility. The logs were collected to constrain the computation of resistivity depth sections and to provide subsurface controls for interpretation of a helicopter electromagnetic (HEM) survey flown of the CSSA in late 2004 (Smith and others, 2005). The objective of the USGS studies is to improve understanding of aquifer catchment area hydrogeology particularly in regard to environmental issues (Vanderglas and Murphy, 2004).

Purpose and Scope

The purpose of this report is to document electromagnetic (EM) induction conductivity and natural gamma log data collected in wells (table 1) during March 28–30, 2005, at various depths below land surface to calibrate the recently surveyed HEM data. CSSA identified 15 wells for EM induction-gamma logging that range from 84 to 465 feet total depth. The geophysical logging focused on the 15 wells listed in table 1. Logging parameters were limited to EM induction conductivity and natural gamma.

Description of Study Area

The CSSA is located in northern Bexar County, northwest of San Antonio (fig. 1) and overlies the Trinity aquifer. The Glen Rose Limestone, which comprises the upper zone and upper part of the middle zone of the Trinity aquifer, crops out at the CSSA (Clark, 2004). Clark (2004) describes the detailed geologic framework and hydrogeologic characteristics of the CSSA. Camp Bullis Training Site, a U.S. Army field training site, is on the northeastern, eastern, and southern boundaries of CSSA.

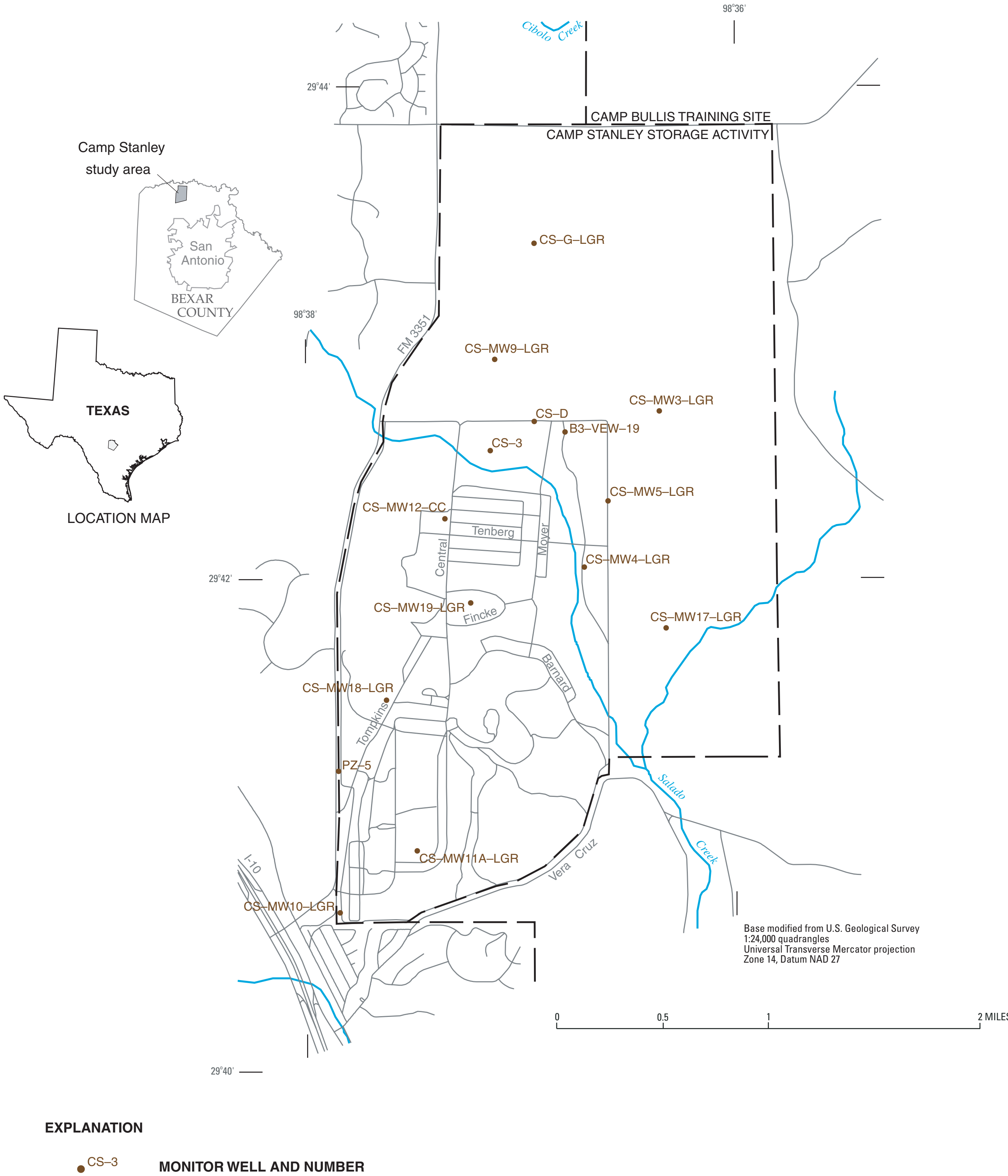

Figure 1. Map showing location of Camp Stanley Storage Activity and immediately adjacent area, Bexar County, Texas, with locations of wells logged.

Acknowledgments

The author thanks Chris Beal and Samantha Elliot, CSSA Environmental Office contractors, for providing technical information on the wells and removing pumps prior to logging. The author also thanks Michael Nyman, USGS, for his assistance in the field during logging.

Methodology

Fifteen wells selected by the CSSA Environmental Office were logged using geophysical methods of EM induction and natural gamma (fig. 1, table 1). Pertinent information for wells such as well identifier, location, altitude, total depth, and casing/well construction record was provided by CSSA Environmental Office (table 1). The CSSA Environmental Office removed all downhole equipment such as pumps and cleared all obstructions from the borehole or casing prior to logging.

EM induction probes, which measure conductivity in air-filled or water-filled holes, perform well in open holes or polyvinyl chloride (PVC) cased holes. Conductivity measurement commonly is used to provide logs with both resistivity and conductivity curves (Keys, 1997) as shown by the logs in this report. The conductivity can be affected by the salinity of borehole and formation fluids and by the type of lithology encountered. Generally, pure carbonates, sands, and gravels have a lower conductivity (thus a higher resistivity) than clays or shales. All of the previous electrical logging of CSSA wells was done by resistivity logging methods (Keys, 1997), which is the most commonly used electrical logging method for Edwards-Trinity aquifer studies at the CSSA (Chris Beal, Camp Stanley Storage Activity, oral commun., 2004). Resistivity logging requires an uncased and water-filled drill hole (Keys, 1997). Consequently there is little information from the shallow part of the hydrogeologic section above the water table, which is critical in interpretation of the HEM method that has a penetration depth on the order of about 15 to 30 feet in this geoelectrical setting (Smith and others, 2005).

A Geonics EM39 induction conductivity probe was used on all wells and interfaced to surface instrumentation in the logging truck through a 0.25-inch-diameter, four-conductor wireline and a Mount Sopris MGXII log acquisition system. The EM39 was calibrated twice daily using manufacturer's recommended procedures (Geonics Limited, 1992) at temperatures within the range expected in the boreholes. To attain a stable temperature, the probe was hung in a well for 20 to 30 minutes prior to calibration. During a two-point calibration process, the probe was calibrated to a (1) zero conductivity environment, and (2) calibration coil of known conductivity with the bottom of the probe at least 9 feet above the ground. The calibration also was checked periodically between calibrations (appendix 1).

Natural gamma logs provide a record of gamma radiation detected at depth in a borehole. Fine-grained sediments that contain abundant clay tend to be more radioactive than quartz-grain sandstones or carbonates (Keys, 1997). The natural gamma probe was run in tandem above the EM induction probe and was recorded in natural gamma counts per second simultaneously as the induction log was recorded. A Mount Sopris 2PGA–1000 natural gamma probe with a sodium iodide detector was used. The natural gamma probe is calibrated at the factory and does not require calibration in the field. The natural gamma and induction logs (appendix 2) collectively can be very useful in determining lithologies and contact depths of the strata penetrated in the borehole.

The EM induction conductivity measurements (commonly sensitive to metallic conductive objects) were affected at depths corresponding with metal objects such as centralizers and stainless steel screens in several of the logged wells or in wells with steel casing from the surface to the open part of the borehole. Likewise, natural gamma count rates, which commonly increase in the proximity of clay and shale, could increase slightly adjacent to any bentonite seals in the wells. Some wells contained steel casing that extended from the surface to the open interval of the well. In this case, induction logs were only recorded in the open borehole section.

Logs were recorded digitally while moving the probe in an upward direction; this removed all slack from the wireline and aided in maintaining proper depth control. All log depths are referenced to land surface datum altitude (table 1). Logging speed was no greater than 30 feet per minute. During logging, a repeat section of at least 100 feet was recorded to check repeatability of log responses. Digital data are in appendix 3 on the enclosed compact disc and are available for download with this report.

Because all of these wells are used for ground-water-quality sampling and some contain contaminated ground water, the logging equipment that was lowered into the wells was decontaminated. This decontamination procedure occurred prior to equipment mobilization to CSSA and upon probe removal from wells that contained contamination.

Induction and Natural Gamma Logs

The 15 wells were logged during March 28–30, 2005, by USGS personnel with assistance from contractors of the CSSA Environmental Office. Well information listed in table 1 was provided by the CSSA Environmental Office for the 15 wells. The logs are included in Appendix 2 of this report.

Several of the logged wells were completed with PVC casing that can be penetrated by the EM induction fields and allows conductivity measurement of the formation and associated fluids. However some wells were constructed with steel centralizers in the annulus between the borehole wall and the PVC casing and with stainless steel screen sections at the bottom of the well. These metal objects perturb the electromagnetic fields and cause numerous spikes on both conductivity and resulting resistivity log curves. These responses are easily recognizable and appear at regular intervals on logs collected in the following wells: CS–MW3–LGR, CS–MW4–LGR, CS–MW5–LGR, CS–MW9–LGR, CS–MW10–LGR, CS–MW11A–LGR, CS–MW12–CC, CS–MW17–LGR, CS–MW18–LGR, CS–MW19–LGR, and PZ–5. All other log measurement data are considered to be of good quality. Other wells, such as CS–3, CS–D, and CS–G–LGR, have steel casing from surface to a certain depth; in this case, the resistivity and conductivity curves were not recorded in the steel-cased intervals. Because the wells were logged in an upward direction, the logging wireline was not pulled to full tension until the probe was lifted from the bottom; thus no probe movement occurred until full tension was regained. For this reason, when using the logs or generated computer files, it is generally advisable to not use the first 2 feet of the log curves or values in the computer files.

All logs collected were recorded digitally and archived in the Log ASCII Standard (LAS) version 2 format, which is the industry standard for borehole geophysical data storage. The digital data are in appendix 3 on the enclosed compact disc and available for download. The LAS file format has been developed and promoted by the Canadian Well Logging Society (2005). The LAS files contain several lines of header data followed by columns of borehole geophysical data with depth at an interval of 0.162 foot. Geophysical data values of -999.250 for any parameter in the LAS file represent null values for that parameter.

Summary

The U.S. Geological Survey (USGS), in cooperation with the U.S. Army, Camp Stanley Storage Activity (CSSA), conducted EM induction conductivity and natural gamma logging of 15 selected wells on the CSSA during March 28–30, 2005. The CSSA is located in northern Bexar County, Texas, northwest of San Antonio and overlies the Trinity aquifer. In late 2004, an HEM survey of the CSSA was flown as part of a USGS project to better define subsurface geologic units, structure, and catchment area of the Trinity aquifer. The EM induction and natural gamma log data were collected to refine the calibration and provide subsurface controls for interpretation of the HEM data.

EM induction conductivity and resistivity log responses can be affected by the salinity of borehole and formation fluids and by the type of lithology encountered. Generally, pure carbonates, sands, and gravels have a lower conductivity (thus a higher resistivity) than clays or shales. Similarly, natural gamma logs provide a record of gamma radiation detected at depth in a borehole. Fine-grained sediments that contain abundant clay tend to be more radioactive than quartz-grain sandstones or carbonates. These logs, when run in tandem, can be very useful in determining lithologies and contact depths of strata penetrated in the borehole.

Logs were recorded digitally while moving the probe in an upward direction to maintain proper depth control. Logging speed was no greater than 30 feet per minute. During logging, a repeat section of at least 100 feet was recorded to check repeatability of log responses.

Several of the wells logged were completed with PVC casing that can be penetrated by the EM induction fields and allows conductivity measurement; however, some wells were constructed with steel centralizers and stainless steel screen, which caused spikes on both conductivity and resulting resistivity log curves. These responses are easily recognizable and appear at regular intervals in several logs. Otherwise all log measurement data are considered to be of good quality.

References

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Table 1. Well completion information for wells logged during March 28–30, 2005 (Chris Beal, Camp Stanley Storage Activity, written commun., 2005).

[CSSA, Camp Stanley Storage Activity; USGS, U.S. Geological Survey; LSD, land surface datum; PVC, polyvinyl chloride; --, not applicable; SS, stainless steel; OH, open hole]

CSSA well ID	USGS site ID	Latitude NAD 1983 (degrees, minutes, seconds)	Longitude NAD 1983 (degrees, minutes, seconds)	Altitude of LSD (feet above NGVD 29)	Top of casing (feet above NGVD 29)	Cored depth (feet below LSD)	Final reamed/ drilled depth (feet below LSD)	Steel casing diameter (inches) and depth (feet below LSD)	PVC riser diameter (inches) and depth (feet below LSD)	Annular grout seal interval (feet below LSD)	Bentonite seal interval (feet below LSD)	Sand pack interval (feet below LSD)	Opening interval (feet below LSD) and type
CS–MW3–LGR	294241098362301	29 42 41.2	98 36 23.1	1,329.43	1,332.45	438.5	428	--	4.0 / 402	--	395–400 428–438.5	400–428	402–427 SS
CS–MW4– LGR	294203098364401	29 42 02.8	98 36 43.9	1,205.30	1,207.84	336.5	325	--	4.0 / 299	--	291.5–296.5 325–336.5	296.5–325	299–324 SS
CS–MW5–LGR	294220098363701	29 42 19.8	98 36 37.1	1,335.47	1,338.51	462	446	--	4.0 / 420	--	413–417 446–462	417–446	420–445 SS
CS–MW9–LGR	294254098371001	29 42 54.1	98 37 10.4	1,252.76	1,255.58	323	322	--	4.0 / 296	--	289–294 322–323	294–322	296–321 SS
CS–MW10–LGR	294042098375301	29 40 42.1	98 37 52.6	1,184.97	1,187.68	405	396	--	4.0 / 370	--	363–368 396–405	368–396	370–395 SS
CS–MW11A–LGR	294048098373101	29 40 48.0	98 37 30.7	1,201.24	1,204.03	494	445	--	4.0 / 420	0–413	413–418	418–445.5	420–445 SS
CS–MW12–CC	294214098372401	29 42 14.4	98 37 23.5	1,254.73	1,257.31	502	465	--	4.0 / 440	0–432.5	432.5–437.5 465.5–502	437.5–465.5	440–465 SS
CS–MW17–LGR	294150098361901	29 41 50.1	98 36 19.2	1,254.01	1,257.01	401	392	--	4.0 / 367	0–359	359–364 392–401	364–392.5	367–392 SS
CS–MW18–LGR	294130098373901	29 41 29.6	98 37 39.2	1,280.62	1,283.61	422	411	--	4.0 / 385	0–378	378–383	383–411	385–410 SS
CS–MW19–LGR	294154098371601	29 41 54.4	98 37 15.9	1,252.71	1,255.53	382	365	--	4.0 / 340	0–331	331–336 365–382	336–365	340–365 SS
CS–G–LGR	294322098365801	29 43 22.1	98 36 57.8	1,324.80	1,325.47	339.5	339	5.5 / 183	--	0–155	--	--	183–339 OH
CS–3	294231098371201	29 42 30.9	93 37 11.9	1,236.87	1,240.17	--	314	6.0 / 205	--	0–205	--	--	205–314 OH
CS–D	294240098365801	29 42 39.9	98 36 57.6	1,233.31	1,236.03	--	263		--	0–205	--	--	205– 263 OH
PZ–5	294055098375501	29 40 55.2	98 37 55.2	1,208.86	1,210.97	--	125	--	4.0 / 85	--	--	--	85–125 PVC
B3–VEW–19	294236098365001	29 42 35.7	98 36 49.5	1,242 (estimated)	1,242 (estimated)	284	84	--	2.0 / 34	--	--	--	34–84 PVC