Ground-Water and Surface-Water Hydrology of Camp Maxey, Lamar County, Texas

Final Report

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EXECUTIVE SUMMARY

Ground-water and surface-water investigations of Camp Maxey, Lamar County, Texas, were conducted to provide the Texas Army National Guard information needed to preserve environmental quality and resources while planning and conducting training and preparedness activities. Spatial information such as surface geology, watersheds, elevation data, floodplains, well locations, and water levels were converted to digital files and submitted to the Texas Army National Guard Geographic Information System office at Camp Mabry, Austin, Texas, for future use in managing the training facility. Similar investigations were conducted at Camps Barkeley, Bowie, Mabry, and Swift, and at Fort Wolters. Results of those studies are presented separately.

Previously published reports and public data files were examined to obtain background information on the camp and surrounding area. These data were used to guide more focused studies on the training facility. Ground-water studies included locating existing wells in and near the camp, installing new wells as needed, testing and sampling selected wells, determining ground-water levels, chemical compositions, and aquifer hydraulic properties, and developing a conceptual model of ground-water flow. Surface-water studies focused on delineating watersheds and mapping floodplains.

The Blossom Sand and the Woodbine and Paluxy Formations comprise the principal aquifers in Lamar County. Approximately 60 percent of all wells in Lamar County listed with the Texas Water Development Board (TWDB) are completed in the Blossom Sand, and 14 percent are completed in the Woodbine Formation. Although the Paluxy Formation is a significant water producer west of Camp Maxey, only about 4 percent of the wells listed by the TWDB are completed in this unit in Lamar County. The Eagle Ford and Bonham Formations, which immediately underlie Camp Maxey, have very limited use as aquifers.

Our well survey found six wells on the camp grounds and 92 wells around Camp Maxey, including 10 ground-water monitoring wells at a landfill just south of the camp. Long-term hydrographs for wells in the Woodbine, Paluxy, and Eagle Ford Formations show dissimilar changes in water levels that are attributed to differences in proximity of the wells to outcrop and to sites of heavy pumping. Ground-water quality in the strata beneath Camp Maxey is generally fresh and either is a sodium bicarbonate type or has no dominant cations or anions.

Watersheds at Camp Maxey are generally small and drain to Pat Mayse Lake and then to the Red River to the north. Floodplains that would result from a 100-yr storm are also small and generally do not extend far from the stream beds.

INTRODUCTION

This report summarizes ground-water and surface-water studies at Camp Maxey, Lamar County, Texas, conducted by The University of Texas Bureau of Economic Geology (BEG) for the Texas Army National Guard. This work was part of a larger study of Texas Army National Guard training facilities that included Camp Barkeley (Taylor County), Camp Bowie (Bastrop County), Camp Mabry (Travis County), Camp Swift (Bastrop County), and Fort Wolters (Parker County). These investigations, in conjunction with aquatic and biological surveys conducted by the Texas Parks and Wildlife Department, provide information needed by the Texas Army National Guard to plan and conduct training and preparedness activities in a way that will protect and enhance environmental resources without compromising training needs and national security readiness. Reports of similar investigations on the other training facilities are presented separately.

This report contains results of hydrogeologic and hydrologic analyses and describes how data files were prepared to provide digital Geographic Information System (GIS) coverages of the camp and surrounding area. The hydrogeologic analyses contain information regarding hydrostratigraphy, camp and perimeter well surveys, monitor well drilling, ground-water levels, well testing, aquifer properties, ground-water chemistry, and a conceptual ground-water flow model. The hydrologic analyses contain information regarding streams and drainage basins in and near the camp, watershed delineations, stream-flow duration, flood frequency, and floodplain analysis. The GIS data preparation section contains descriptions of the original data sets, how they were obtained, and how they were processed to obtain GIS coverages for the camp.

Regional Setting

Camp Maxey is located about 7 miles north of Paris, Texas, on Highway 271 in Lamar County (fig. 1). The Red River, which is also the state boundary to Oklahoma, is about 5 miles north of the camp. Pat Mayse State Park borders the camp on the north, and part of Pat Mayse Lake headwaters originates at the camp. Pat Mayse State Wildlife Management area lies west of the camp. The camp area is part of an upland area draining into the Red River.

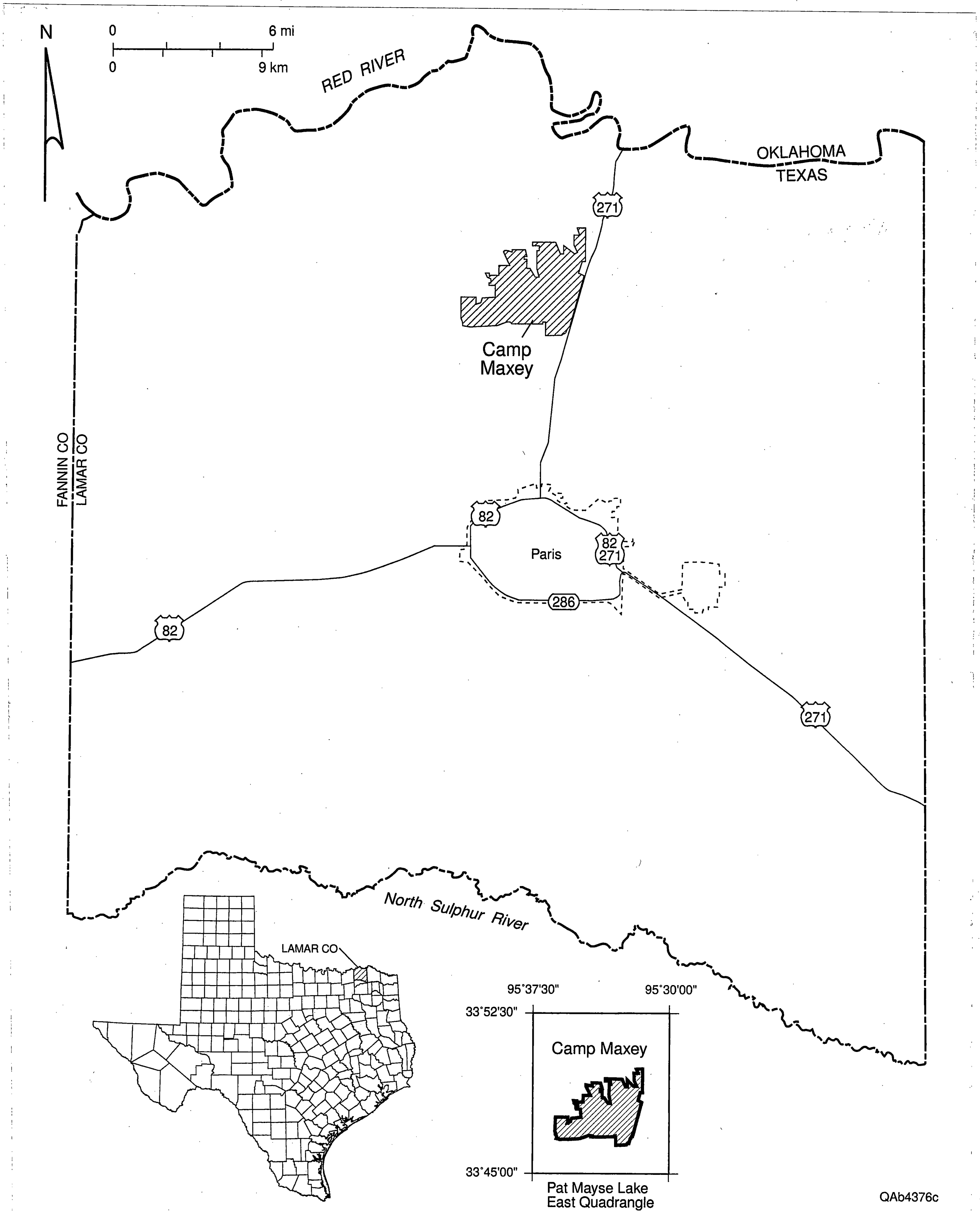


Figure 1. Index map showing location of Camp Maxey and major highways and towns.

The geomorphology of Camp Maxey is dominated by ridges and valleys draining into Pat Mayse Lake, a man-made lake covering the floodplain of Sanders Creek in the northern part of the camp. The topographic relief here ranges from 470 to 550 ft and is greatest alongside valley slopes. The southern part of the reservation has a low relief, its elevations ranging between 500 and 550 ft. There are several man-made lakes in the camp, the result of damming several small, intermittent streams. In the southern part of the camp, valleys are not as steep as in the north, and low-relief areas represent topographic highs.

Local soils are in the Annona-Freestone-Woodtell and the Whakana-Porum associations (Ressel, 1979). The Annona-Freestone-Woodtell association lies primarily on nearly level to gently sloping terrain, whereas the Whakana-Porum association rests on gently sloping to moderately steep slopes. Both of these map units have forested soils, marked by a loamy surface layer and a clayey subsoil in the Annona-Freestone-Woodtell association and by a loamy and clayey subsoil in the Whakana-Porum association. This association consists of soils that are well drained and have moderate to low permeability. In the Annona-Freestone-Woodtell association the Annona soils are poorly drained and have very low permeabilities, whereas the Freestone and Woodtell are moderately well drained but also have low to very low permeabilities.

Lamar County lies within the transitional zone of two vegetation regions. The Blackland Prairie extends from the southwest into Lamar County and is surrounded by Oak Hickory forest vegetation stretching along the northern, eastern, and southern edges of Lamar County (Kier and others, 1977).

Lamar County is in the humid subtropical climatic zone, having warm summers and mild winters (Larkin and Bomar, 1983). Wind directions generally are from the south, ranging from 9 to 13 mph in the Dallas–Fort Worth area, which is the nearest weather station (Bomar, 1983). Highest wind speeds, however, are from the north, accompanying cold fronts during the winter months.

Bomar (1993) summarized precipitation and temperature data for the Camp Maxey area. The average annual low temperature is 52.2°F, the highest average monthly lows occurring in July and the lowest monthly average lows occurring during January. The annual average high temperature is 74.1°F, the highest average monthly highs occurring in July and the lowest average monthly highs occurring in January. Precipitation is highest during April, May, and September, monthly averages ranging between 4 and 5 inches. Lowest monthly precipitation occurs in January, February, and July, when monthly averages are between 2 and 3 inches. Total annual average precipitation is 45 inches.

The average annual gross lake surface evaporation rates of Lamar County are between 55 and 57 inches annually, and the highest rates occur in July. Lowest monthly rainfall occurs during January, which has an average of about 2 inches (Larkin and Bomar, 1983).

Geology and Hydrostratigraphy

The Cretaceous Eagle Ford and Bonham Formations crop out in Camp Maxey (fig. 2). The Eagle Ford Formation covers most of the camp, and the Bonham Formation crops out in the southeastern corner around Lamar Lake. The Eagle Ford Formation consists of shale with calcareous concretions and a few thin beds of sandstone and sandy limestone that are most abundant near the middle of the formation (Barnes, 1966). The Eagle Ford Formation grades into mostly quartz sand near the Lamar–Red River county line. The Bonham Formation, a greenish-gray marl and clay, becomes more sandy eastward and weathers to a yellowish gray (Barnes, 1966).

The principal aquifers in Lamar County are the Blossom Sand and the Woodbine and Paluxy Formations. About 60 percent of the wells listed with the Texas Water Development Board (TWDB) are completed in the Blossom Sand, which begins to crop out near Paris, Texas. About 14 percent of the wells listed with the TWDB are completed in the Woodbine Formation, a quartz sand with some thin beds of lignite, volcanic sand, and tuff. The outcrop of the Woodbine Formation straddles the Red River and dips south into the East Texas Basin beneath Camp Maxey. The Woodbine Formation immediately underlies the Eagle Ford Formation and lies 200 to 350 ft below the camp. Only about 4 percent of the wells listed with the TWDB are completed in the Paluxy Formation, although this formation is considered a major aquifer farther to the west. The Paluxy is composed of fine sand, sandy shale, and shale and lies between 1,200 and 1,350 ft below the camp. The Eagle Ford and Bonham Formations yield small quantities of water to shallow wells and are very limited as aquifers (Nordstrom, 1982).

METHODS

Ground-Water Analysis

Well Inventory

We visited Camp Maxey to locate wells in or near the camp and made detailed measurements and descriptions, including well location, type, depth, water level, diameter, and

(a)

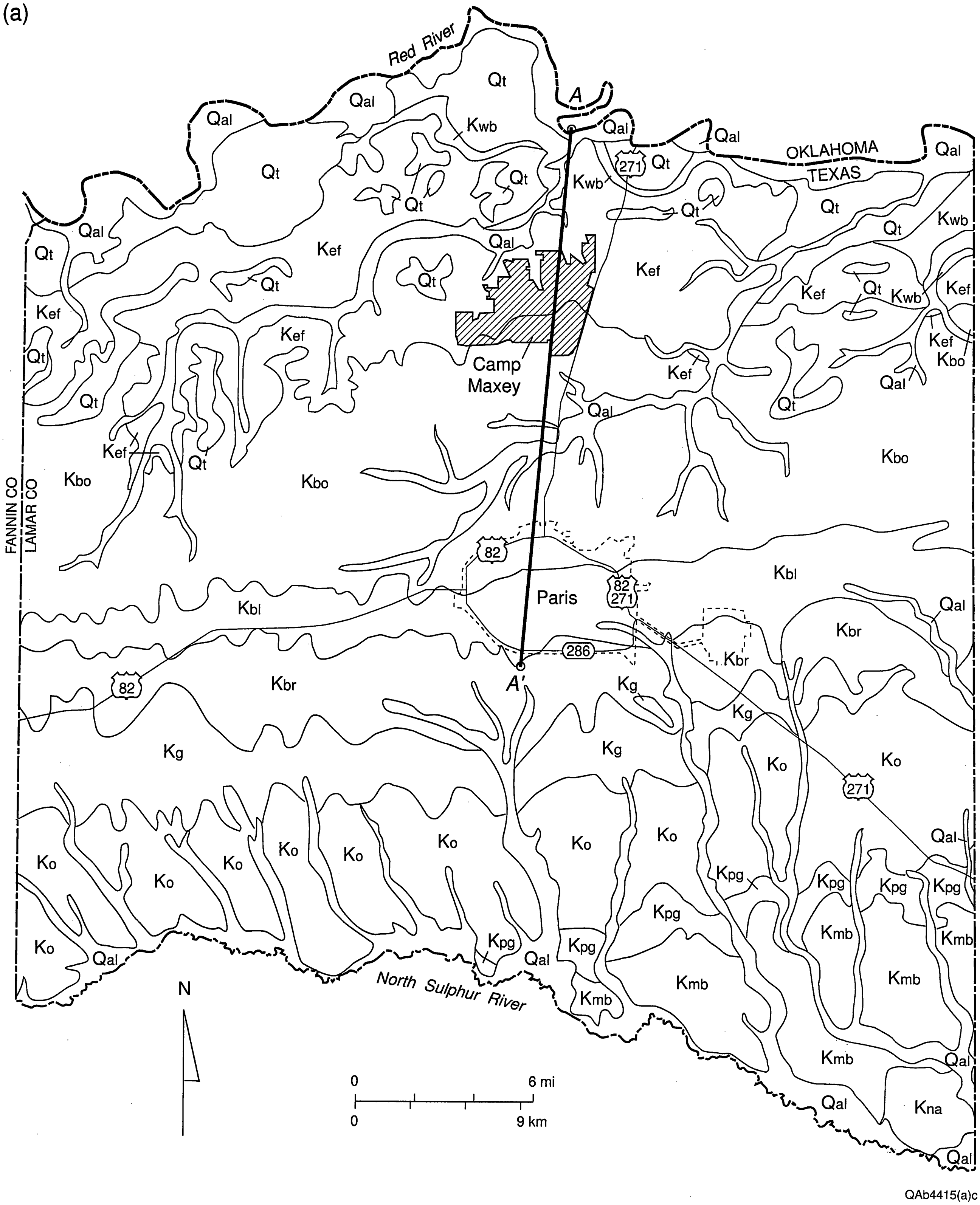
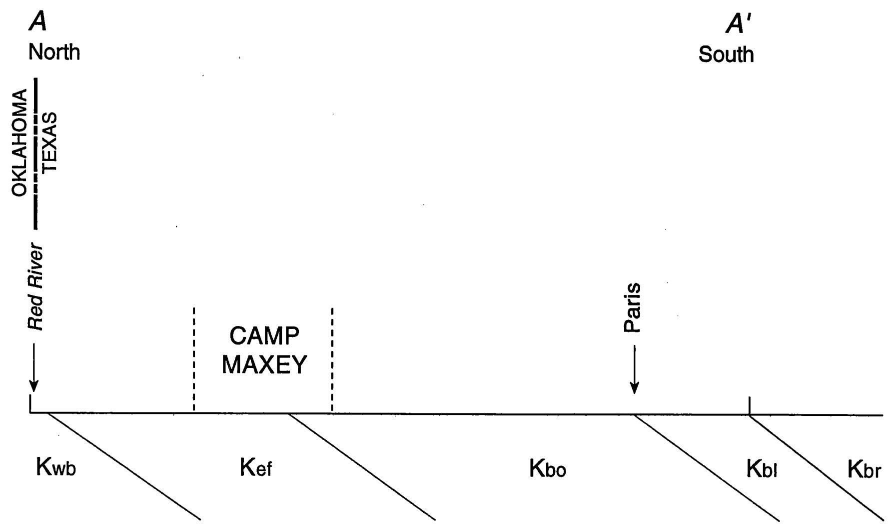


Figure 2. (a) Generalized geologic map (after Barnes, 1996), (b) schematic cross section, and (c) stratigraphic column (after Nordstrom, 1982), Lamar County.

(b)



(c)

QUATERNARY	RECENT	Qal	Alluvium	
	PLEISTO-CENE	Qt	Terrace deposits	
CRETACEOUS	GULF	Kna	Navarro Group (undivided)	
		Kmb	Marlbrook marl	Taylor Group
		Kpg	Pecan Gap chalk	
		Ko	Wolf City-Ozan Formations	
		Kg	Gober chalk	Austin Group
		Kbr	Brownstone marl	
		Kbl	Blossom sand	
		Kbo	Bonham Formation	
		Kef	Eagle Ford Group	
		Kwb	Woodbine Group (undivided)	

QAb4415(b)c

Figure 2 (cont.)

casing construction. Camp personnel were interviewed concerning known or potential well locations. We drove on all roads in the camp to investigate adjacent land for evidence of wells. We also inventoried wells near the camp and made measurements of water level and well depth where possible.

Monitor Well Installation

The installation of monitor wells at Camp Maxey included (1) selecting and staking appropriate hydrogeologic sites for well locations, (2) arranging access to the well sites and a source of water, (3) drilling the well, (4) developing the well, (5) installing casing, and (6) developing the cased well. Drilling sites were chosen to best investigate the hydrogeology of the sites and still be accessible to a drill rig. Before staking the well sites, we contacted camp commanders to ensure that the locations would not interfere with camp activities and were not located near any known buried utilities. We also coordinated our drilling with the camps to ensure that our activities would not interfere with training schedules.

We drilled the monitor wells with a Central Mine Equipment 75 drilling rig. Depending on the geology, we used hollow-stem augering, solid-stem boring, rotary/wet coring, or a combination thereof to install the wells. Most wells were installed using hollow-stem augering. A few wells required solid-stem boring or rotary/wet coring because of the presence of hard rock. The drilling mud we used for solid-stem boring and rotary/wet coring was biodegradable Super Mud. Where possible, we collected core and cuttings for inspection at our facilities.

After a well was drilled, we augered or flushed the cuttings from the hole and purged the well with a bailer, usually removing 1 to 2 wellbore volumes of water. Well completion consisted of installing 2-inch well screen and pipe, placing a sandpack around the screen, placing a bentonite seal above the sandpack, grouting to a few feet below land surface, installing a well guard, and cementing the guard in place with a well pad. We installed either 10- or 20-ft-long 0.010-inch slotted screen in the wells. The sandpack consisted of 20/40 sand and straddled the screen. We installed locking above-ground well guards on each of the wells. Once the well was completed and the cement had dried, we developed the well again with a bailer or an electrical submersible pump.

Well Testing

We conducted a bail test in a monitor well drilled in the camp. The bail test involved removing water quickly from the well and monitoring water-level recovery with an electronic water-level meter. Recovery data were input into a spreadsheet and interpreted for transmissivity using the Hvorslev (1951) time-lag method and Cooper and others (1967) curve-matching method. The other monitor well was not tested because seasonal fluctuations caused the water level to fall to near the bottom of the well.

Ground-Water Sampling

Ground-water samples were collected from one of two monitoring wells drilled during this project. The other monitoring well did not contain sufficient water for sampling. The well was sampled using a bailer to collect water. We first removed and discarded one bailer volume (approximately 500 mL) to rinse the bailer before sampling. A second bailer volume was then collected and the water used to measure pH and temperature at the well site. Water from the next bailer run was used to rinse field filtration equipment. Ground water produced by subsequent bailer runs was passed through a 0.45-micron filter and collected in sample bottles that had first been rinsed three times with filtered sample water. Aliquots intended for cation and trace metal analyses were preserved by adding 6N nitric acid to lower the pH to a value less than 2. Aliquots for all other analyses were filtered but otherwise untreated.

Surface-Water Analysis

Watershed Delineation

Watersheds were delineated for Camp Maxey by tracing surface-water catchments on USGS 7.5-minute topographic maps. The method involved carefully tracing surface-water divides and backtracking flow lines from subwatershed collection points. Tracing was done on Mylar overlays, which were subsequently digitized into a GIS. Watersheds were delineated by hand rather than digitally, as had been done at the other camps, because good-quality digital elevation maps were not available for the area.

Floodplain Analysis

Floodplain analysis involves determining the area adjacent to a river or stream that will flood for a specified return period (for example, a 100-yr flood). The standard procedure is to determine the 100-yr flood at key points on the stream and use backwater computation to determine stages upstream (Linsley and others, 1982, p. 452). If available, the 100-yr flood is usually determined from stream-gauge records. However, these data are usually sparse, and therefore regional frequency methods or loss rate and unit hydrograph applied to the 100-yr rainfall can be used (Linsley and others, 1982, p. 452). Because most of the camps lack stream-gauge records, we used the loss rate and unit hydrograph method to estimate the 100-yr floodplain.

Our floodplain analysis consisted of (1) designing 100-yr 24-hr synthetic storms, (2) determining the 100-yr flood hydrographs at strategic points in the watersheds, (3) assessing 100-yr flooding surfaces, and (4) mapping the 100-yr floodplains on 1:2,400 USGS topographic maps.

To design the 100-yr 24-hr synthetic storms, we first used maps published by the U.S. Weather Bureau (Herschfield, 1961, as shown in Chow, 1964, p. 9–56) to determine the 100-yr 24-hr rainfall for each camp and fort. We then used these rainfall rates with the SCS Type II distribution (Bedient and Huber, 1988) to generate the storms.

To determine the 100-yr flood hydrographs, we used HEC-1 (Hydrologic Engineering Center, 1981) with SCS unit hydrographs (Soil Conservation Service, 1957) and Muskingum routing (McCarthy, 1938). Input to HEC-1 included subbasin drainage area, runoff curve numbers, basin lag, routing storage coefficient, and routing weight factor. Runoff curve numbers are used to define the unit hydrographs and are a function of soil type, vegetation, land use, antecedent moisture, and the hydrologic properties of the catchment surface. Basin lag, also called catchment lag, is the elapsed time, or response time, between rainfall and runoff occurrence and is partly a function of hydraulic length, catchment gradient, drainage density, and drainage patterns. The routing storage coefficient, or time constant, is a function of the channel reach length and the speed of the flood wave. The routing weight factor is a function of the flow and channel characteristics that affect the dispersion of the flood wave downstream.

We delineated detailed subwatersheds and determined subwatershed drainage area with ArcInfo (ESRI, 1993; Maidment, 1995). We calculated weighted curve numbers in ArcInfo for each subwatershed using STATSGO (Soil Conservation Service, 1991) digital hydrologic soil data and land-use data assuming moderate antecedent moisture conditions (I_a = 0.25 inch). Because most of the watersheds were ungauged, we estimated the basin lag, t_p, using the following equation (Linsley and others, 1982, p. 224):

$$t_p = C_t\left(\frac{LL_c}{\sqrt{s}}\right)^n \tag{1}$$

where C_t is a constant that varies between 1.8 and 2.2 for units of miles (Snyder, 1938), L is the distance from discharge point to watershed divide, L_C is the stream length, n is 0.35 for valley drainage areas (Linsley and others, 1982, p. 225), and s is the channel gradient. For this study, we chose a mean C_t value of 2.0. We assigned the routing storage coefficient as 0.20, a typical value for most natural streams (Linsley and others, 1982, p. 219). We measured L, L_C, and s from USGS 1:24,000 topographic sheets. We estimated the routing traveltime constant, K, using the following equation (Linsley and others, 1982, p. 465–541):

$$K = \frac{bL\sqrt{A}}{\sqrt{s}} \tag{2}$$

where A is the drainage area and b is a constant between 0.04 and 0.08 for L in miles and A in square miles. For this study, we chose a mean b value of 0.06. With the above data input into HEC-1, we modeled 100-yr flood hydrographs for subwatersheds on or just outside the camps and fort. We recorded peak flows for these 100-yr flood hydrographs for assessing flooding depths.

We used HEC-RAS (Hydrologic Engineering Center, 1995) to estimate 100-yr flooding surfaces at the locations where we determined the flood hydrographs. Input to HEC-RAS included topographic cross sections at hydrograph locations, stream lengths between cross sections, Manning's n values, discharge rates, and stream-flow boundary conditions. We measured topographic cross sections from USGS 1:24,000 topographic sheets perpendicular to the stream path. Using a map roll gauge, we measured stream lengths between cross sections from the topographic sheets. We assumed Manning's n values to be 0.06 on the banks (Hydrologic Engineering Center, 1995) and 0.05 in and near the stream channel. HEC-1 supplied the peak 100-yr discharge rates for each hydrograph location. We assigned the stream-flow boundary condition at the output end of the model as a critical depth boundary. In all simulations, we assumed subcritical flow. After inputting the above information, HEC-RAS determined the flood surface at each of the chosen locations.

We mapped the 100-yr floodplains by transcribing the 100-yr flood surfaces estimated by HEC-RAS onto USGS 1:24,000 topographic sheets and interpolating between and extrapolating from hydrograph locations. Once mapped, the floodplains were digitized in ArcInfo GIS and printed.

GIS Data Preparation

An effort was made to move spatial hydrologic and hydrogeologic information into a geographic information system (GIS). Where possible, databases having spatial coordinates were uploaded into the GIS and interpreted data such as contour maps were digitized and attributed. The information was placed into ArcInfo GIS so data coverages could be overlaid and compared. Care was taken to ensure that proper projections were used when transferring information from digital files downloaded from State computers or when digitizing from USGS topographic sheets. Well postings and hydrologic and hydrogeologic analysis were done on virgin USGS topographic sheets to facilitate data automation and to ensure the best possible data transfer.

A data dictionary was prepared for the coverages for Camp Maxey to ensure that subsequent users will be informed about the method of data automation and the accuracy of the information. All GIS data files were delivered to the Adjutant General's Office of the Texas Army National Guard at Camp Mabry, Texas, for inclusion in its GIS program.

GROUND-WATER HYDROLOGY

Well Inventory

TWDB records, TNRCC records, Lt. Col. Dan Wisely, and a field survey of camp grounds provided information for locating wells at Camp Maxey. We found six wells or well sites at Camp Maxey (fig. 3) during this study.

- CMX-B001 is hand dug to a depth of 15.3 ft and has water 11 ft below land surface. The casing is made of native stone and extends 0.25 ft above grade. The diameter of the well is 2.5 ft and flares out below surface, suggesting that perhaps it used to be a cistern. Water in the well appears murky.

- CMX-B002 is an old well site where the hand-dug well has been filled. There are remnants of brickwork at the filled well.

- CMX-B003 is a possible well site that has a thick cement pad that possibly covers an old well.

- CMX-B004 is an old hand-dug well or cistern filled to about 3 ft from surface. Hole diameter is about 2.5 ft, and there is no casing or crown.

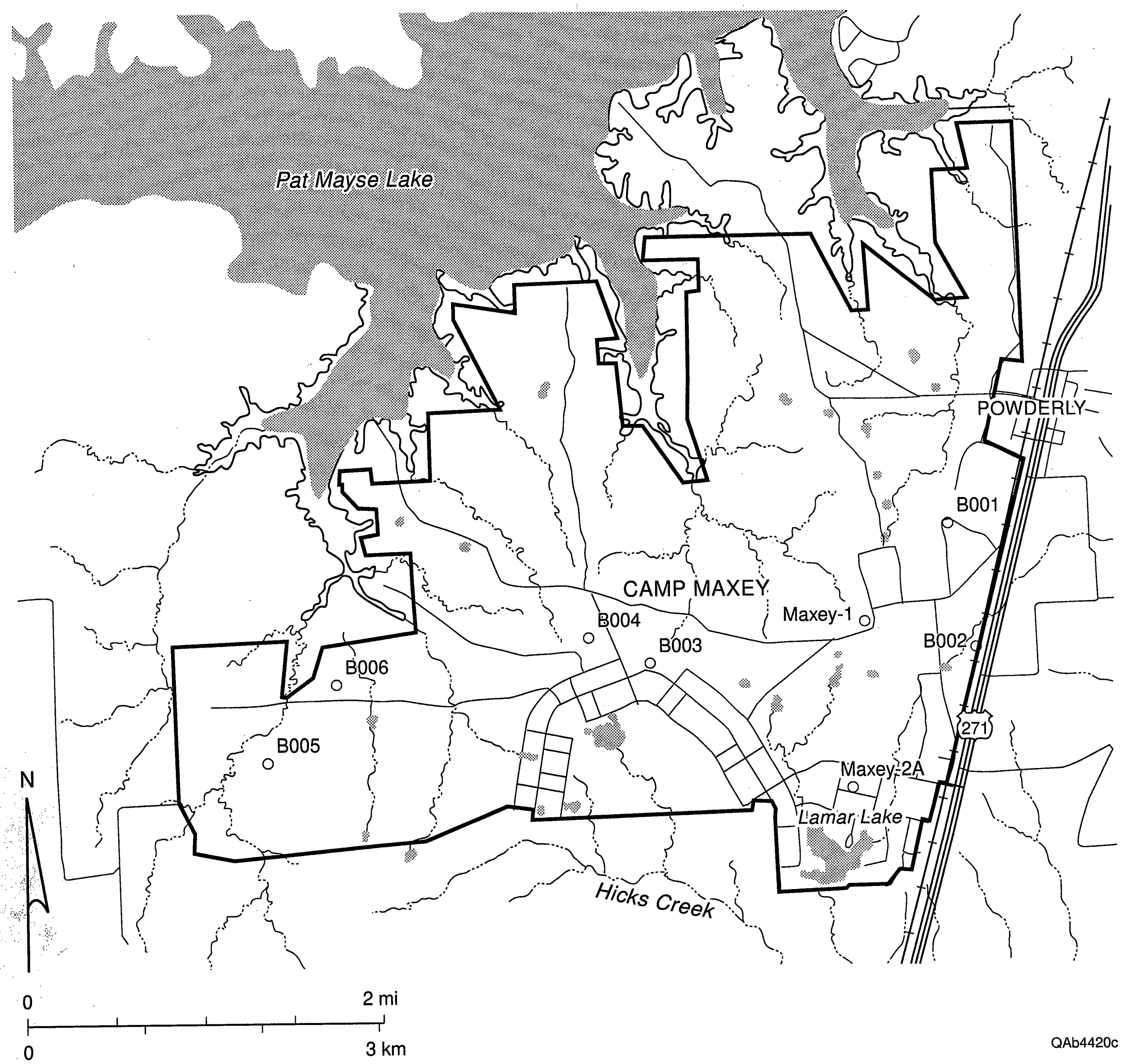


Figure 3. Well locations at Camp Maxey, including monitor wells drilled during this study.

- CMX-B005 is an old hand-dug well or cistern that has caved in to 12 ft below land surface. The diameter of the well is 2.5 ft, and the stone casing is at grade.

- CMX-B006 is an old hand-dug well or cistern that is 15 ft deep and has water 8 ft below land surface. The diameter of the well is 2.5 ft, and the casing is made of native stone that rises 1.2 ft above grade. Water in the well appears murky.

A total of 92 wells were mapped during the well survey (fig. 4, app. 1). Lamar County has an extensive water supply system, and many wells appear to have been abandoned. Well depths were measured or provided by owners for eight wells and were estimated by the residents for another eight. Three wells were 25 ft or less, four were between 26 and 60 ft, three were 100 to 130 ft, and the rest were more than 200 ft deep, to a maximum depth of about 275 ft. Water-level measurements were made on five wells, one of which may have been a cistern, and were estimated by the owner on three more. Depths to water ranged from 7.4 ft to an estimated 90 ft below ground surface. One 57-ft-deep well was dry. Four water levels were less than 17.5 ft. One well was measured at 35.4 ft, but the well was in use at the time of measurement. The other two wells were estimated to be in the range of 85 to 95 ft below ground surface.

The six wells deeper than 200 ft are all west or southwest of the camp. Two of the wells that are more than 100 ft deep are north of Pat Mayse Lake, and the third in that depth range, southeast of the camp, produced poor-quality water and was backfilled. In general, wells east and south of the camp are shallow, whereas those to the north, west, and southwest are deeper. According to a local driller, the shallowest ground water to the west is at about 40 ft but is of poor quality. The next water-bearing unit, at about 210 ft, has good-quality water. One resident reported that wells east of the camp were all shallow and that deeper wells had been tried, although none were completed.

Camp Maxey is bordered on the south by an extensive landfill operated by B&B Equipment (TNRCC Permit #1454) (fig. 5). This landfill has 10 ground-water monitoring wells around its perimeter, some of which border Camp Maxey.

Monitoring Well Construction

We drilled and completed two wells at Camp Maxey along a transect that incorporates a preexisting hand-dug well in the camp (fig. 3). One well (MAXEY-1) is drilled 53 ft into the Bonham Formation and the other (MAXEY-2A) is drilled 61.2 ft into the Eagle Ford Formation. We initially tried rotary/wet coring to install MAXEY-2 but had difficulty with the sides of the hole washing out

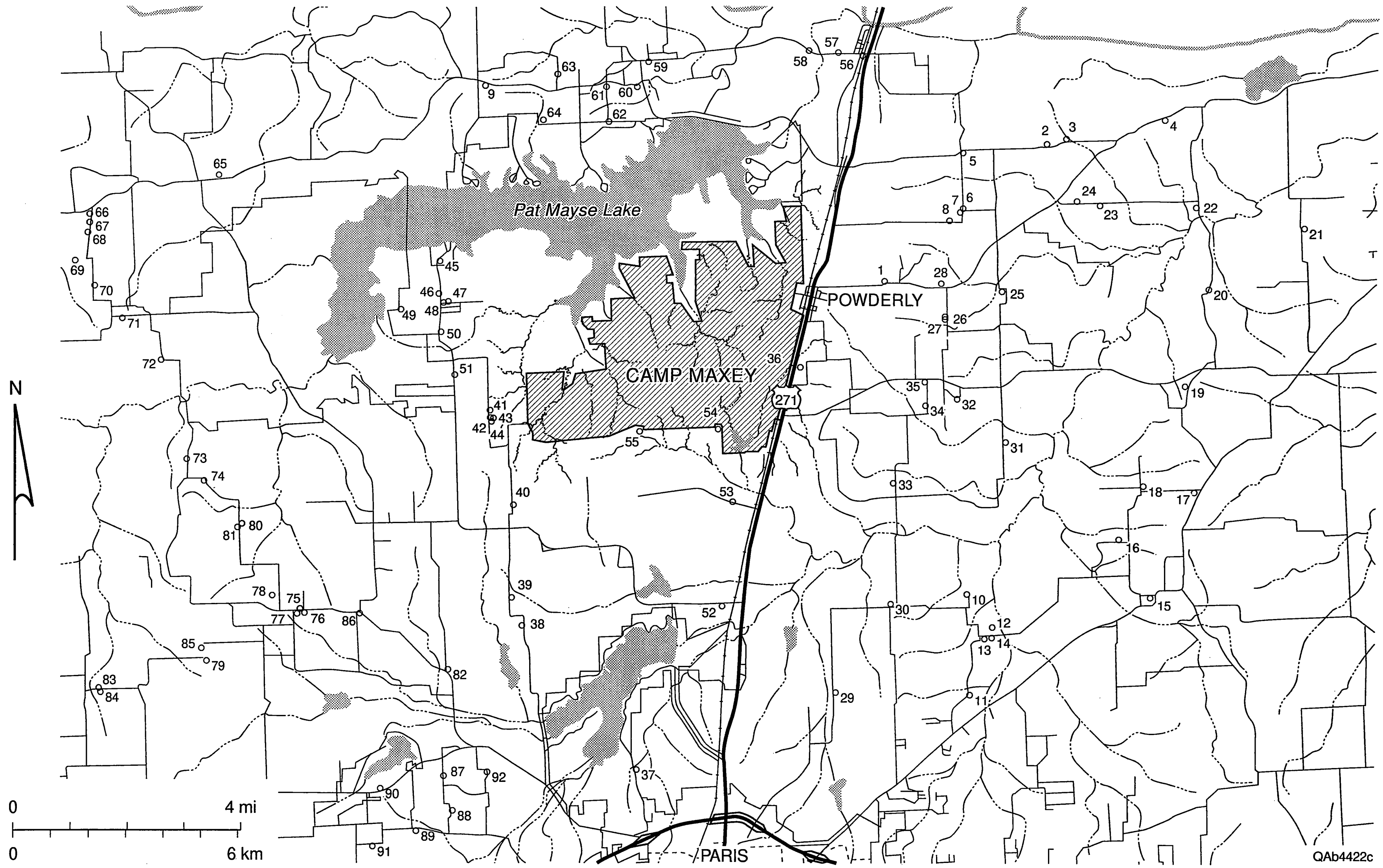


Figure 4. Private wells located near Camp Maxey.

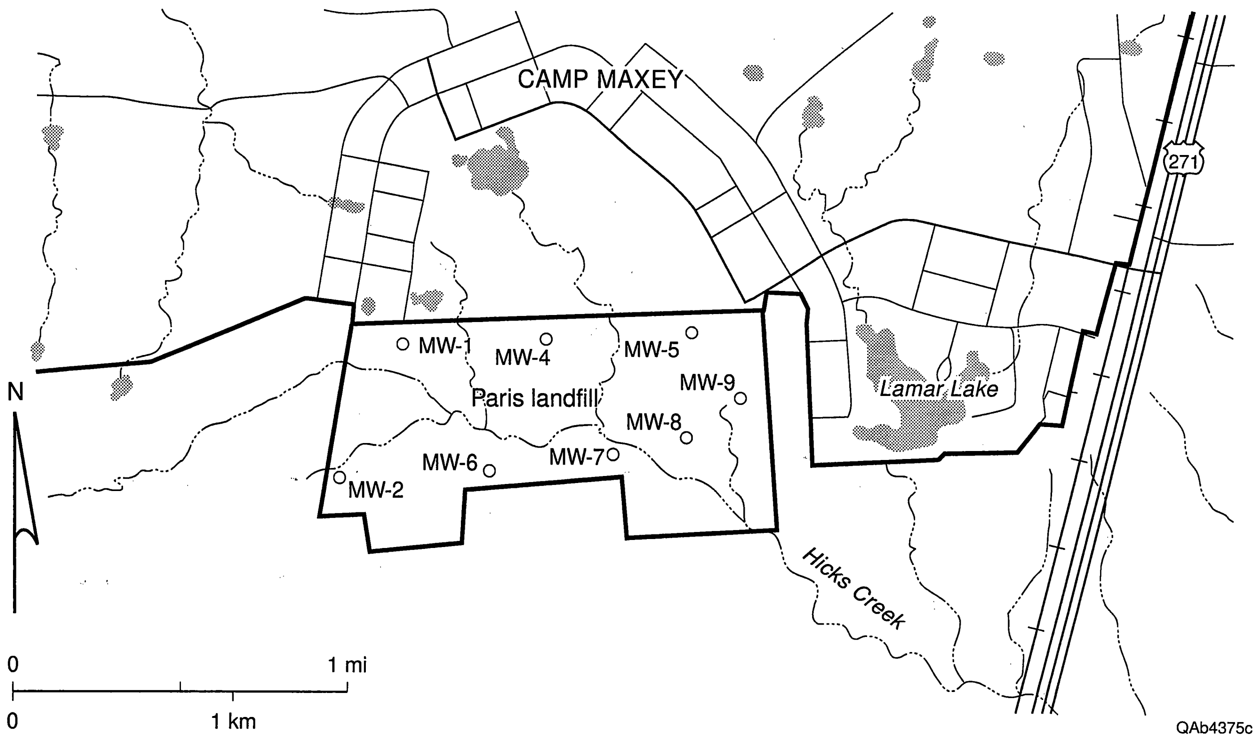


Figure 5. Monitor wells at the Paris landfill south of Camp Maxey.

and collapsing. We filled and sealed this uncompleted well and used hollow-stem augering to install another well, MAXEY-2A, nearby. We used solid-stem boring to install MAXEY-1. Detailed well schematics and drilling reports are included in appendix 2.

Hydraulic Properties

There are no pumping tests reported in the Paluxy, Woodbine, Eagle Ford, and Bonham Formations in Lamar County. However, there are reported values from other areas and limited well yield tests. Mace and others (1994) reported that transmissivity in the Paluxy Formation just west of Lamar County ranges from 170 to 1,900 ft^2/day and has a geometric mean of 600 ft^2/day and that storativity ranges from 4.0×10^{-5} (confined) to 0.02 (confined/unconfined transition). Nordstrom (1982) reported that hydraulic conductivity of the Woodbine Formation ranges between 0.8 and 20 ft/day and has a mean of 7 ft/day. Mace and others (1994) reported that transmissivity in the Woodbine Formation just west of Lamar County ranges from 45 to 3,500 ft^2/day and has a geometric mean of 400 ft^2/day and that confined storativity ranges from 2.0×10^{-5} to 7.1×10^{-4}. Nordstrom (1982) reported that hydraulic conductivity of the Woodbine Formation ranges between 11 and 22 ft/day and has a mean of 6 ft/day. Reported yields from the Woodbine Formation in Lamar County range from 10 to 100 gallons per minute (gpm).

Although no aquifer tests in the Eagle Ford Formation in Lamar County have been reported, studies have been located elsewhere in the formation. Bradley (1993) found the hydraulic conductivity of the weathered and unweathered Eagle Ford in the Waco, Texas, area to be 0.5 and 3.7×10^{-5} ft/day, respectively. This large difference in hydraulic conductivity is caused by near-surface fracturing resulting from unloading and weathering. However, the Eagle Ford in the Waco area does not include the many sand stringers in the Eagle Ford found at Camp Maxey. Dutton and others (1994) reported hydraulic conductivities of 1.7×10^{-3} ft/day in the unweathered Eagle Ford Formation near Waxahachie, Texas. Again, the Eagle Ford Formation in this area is not sandy as it is in the camp, and therefore permeability may be locally much higher. The only aquifer test data reported for the Bonham Formation are three well yields (6, 6, 10 gpm) for the undifferentiated Austin Group.

We conducted site-specific aquifer tests in a monitor well we drilled in the Eagle Ford Shale/Bonham Formation at Camp Maxey. The formation near monitor well MAXEY-2A has a transmissivity of about 4.5 to 6 ft^2/day, based on the interpretation of a bail test (fig. 6). Aquifer storativity based on curve fitting with the Cooper and others (1967) method was 10^{-5}.

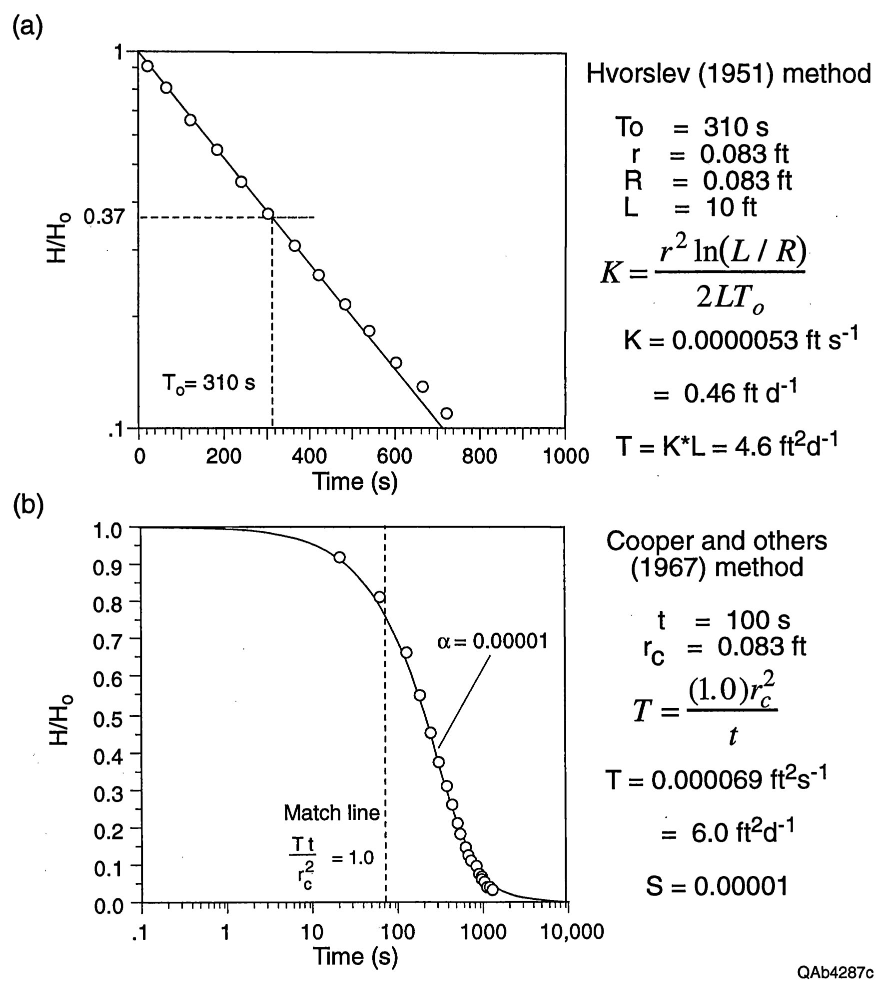


Figure 6. Interpretation of bail test results at MAXEY-2A in Camp Maxey using the (a) Hvorlslev (1951) method and (b) Cooper and others (1967) method.

Ground-Water Chemistry

TWDB files have limited water-quality data for each of the formations of interest (table 1). Total dissolved solids (TDS) for the Paluxy Formation have a wide range of values, from a value at 391 mg/L to three values between 1,044 and 1,241 mg/L. This range probably reflects the change in water facies from fresh water in the north to slightly saline water in the south. This transition occurs 15 miles south of Paris, Texas (Nordstrom, 1982). The Paluxy Formation beneath Camp Maxey probably holds the fresher water. TDS for the Woodbine Formation ranged from three values between 219 and 463 mg/L to a value of 1,010 mg/L. Ground water is fresh in the northwestern part of the county and has slightly saline values in the south and southeast across a transition that cuts through Paris (Nordstrom, 1982). Solitary values of TDS exist for the Eagle Ford Formation and the Austin Group: 242 and 602 mg/L, respectively. These values come from relatively shallow wells completed in the formations.

Waters from the Paluxy Formation have a sodium bicarbonate composition (fig. 7a). Waters from the Woodbine Formation are chloride waters having no dominant cation type except for one sample that has a sodium bicarbonate composition similar to waters from the Paluxy Formation (fig. 7b). On the basis of a single sample, waters from the Eagle Ford Formation have a sodium bicarbonate composition (fig. 7c). Waters from the Austin Group have a calcium sulfate composition, based on a single sample (fig. 7d).

Several wells at the Paris landfill were sampled in 1992 and 1994 for basic anions and cations and for a suite of metals (table 2). A wide range of chemical composition in the waters was found. It is not clear from the reports how the landfill may have affected water quality, although it is possible that this has happened. For example, well MW-01 has a pH of 3.54, which might suggest ground-water contamination caused by landfill operations. None of the wells sampled showed high concentrations of heavy metals. Results from the chemical analyses on ground water collected from the Camp Maxey monitor well is shown in table 3.

Water Levels

TWDB files had sufficient water-level data to construct long-term hydrographs for the Woodbine Formation (fig. 8a, b), the Paluxy Formation (fig. 8c), and the Eagle Ford Formation (fig. 8d). These hydrographs show dissimilar patterns of water-level fluctuations that are probably caused by proximity of the well to the outcrop and to pumping centers. Two wells in the Woodbine Formation show very different patterns of water-level fluctuation (fig. 8a, b). Well 17-27-201, located in Brookston 6 miles west of Paris, had a decline in water level of nearly 60 ft between

Table 1. Chemical analyses of selected ground waters from the Paluxy Formation, Woodbine Formation, Eagle Ford Formation, and the Austin Group (contains the Bonham Formation) in Lamar County.

State well number	YR	Temp (C°)	Si (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Sr (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	F (mg/L)	NO_3 (mg/L)	pH	TDS (mg/L)	Total alk (mg/L)	Total hardness (mg/L)	Spec. cond. (mΩ)
Paluxy Formation:																		
1721709	1984	-	-	20	1	136	-	-	275.8	61	36	1.5	0.35	8.3	391	226	54	720
1727301	1974	-	16	5	5	407	-	-	781	149	72	3.8	3.1	8.3	1044	640	33	1890
1729103	1976	36	18	5	0.12	422	-	-	793.2	150	80	3.4	0.4	8.3	1068	650	12	1890
1729601	1983	43	20	5.2	1.7	473	-	-	706.6	189	195	3.8	0	8.4	1241	589	19	2256
Woodbine Formation:																		
1712101	1971	-	39	33.8	8.63	24	-	-	101.3	6	58	0.1	0.4	6.6	219	83	120	375
1712102	1993	18	31	64	20	88	2.2	0.4	168.4	5	167	0.09	2.74	6.6	463	138	242	719
1713402	1993	18	20	78	19	59	1.9	0.52	196.5	8	158	0.18	1.86	6.4	443	161	273	755
1726202	1993	24	15	1.4	0.3	390	2.4	0.13	566.2	157	151	1.82	0.04	8.5	1010	486	4	1605
Eagle Ford Formation:																		
1710801	1983	-	12	6.2	0.85	90	-	-	233.1	4	14	0.5	0.49	8.3	242	191	18	408
Austin Group:																		
1719401	1971	-	16	103	10	78	-	-	195.3	281	12	0.6	5.5	7.2	602	160	298	1032

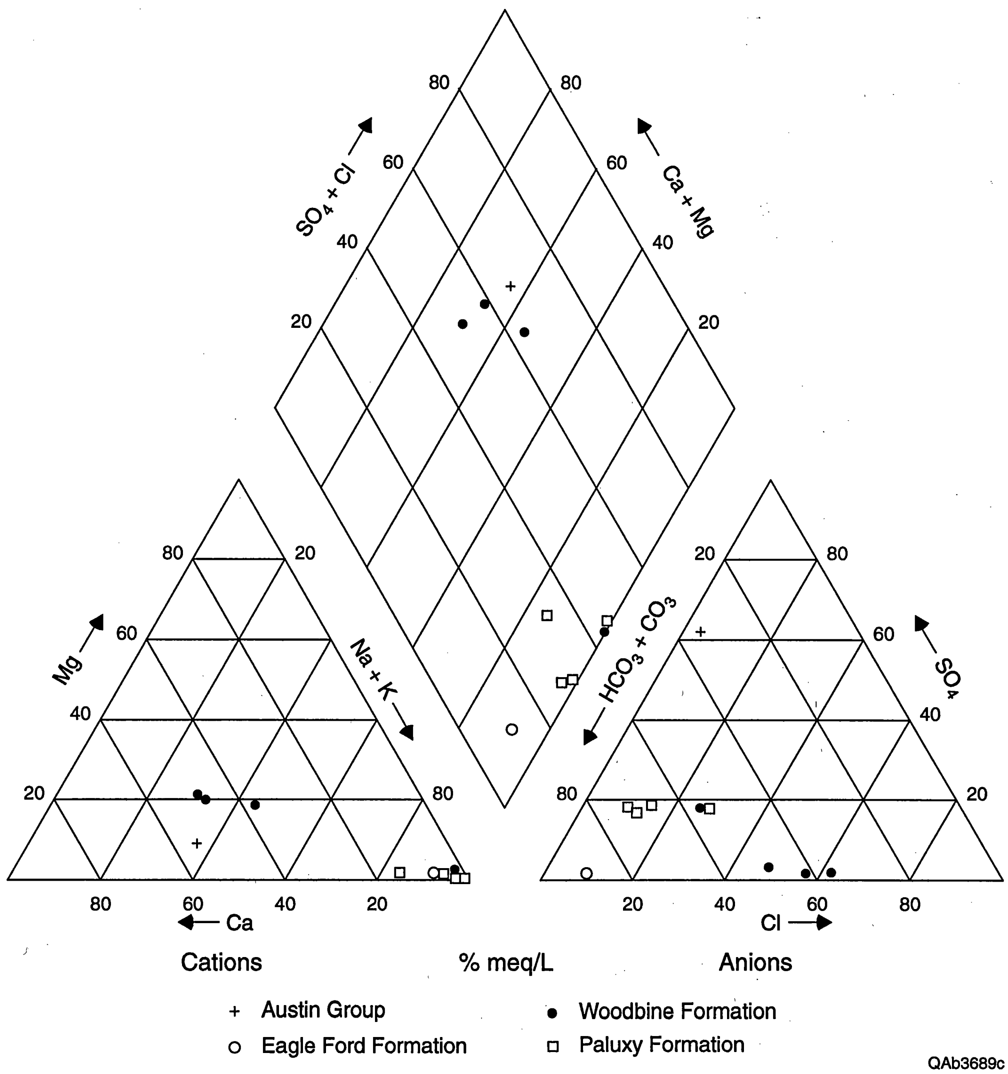


Figure 7. Trilinear diagram showing chemical composition of ground-water samples from the Paluxy Formation, the Woodbine Formation, the Eagle Ford Formation, and the Austin Group in Lamar County.

Table 2. Chemical analyses of ground waters from the Bonham Formation collected from monitoring wells at the Paris landfill along the southern border of Camp Maxey.

Well	Month	Day	Year	Cl (mg/L)	pH	Fe (mg/L)	Mn (mg/L)	Spec. Cond. (umhos/cm)	TDS (mg/L)
MW-01	9	14	1994	1700	3.54	0.438	1.94	7130	6300
MW-02	9	14	1994	1800	6.80	0.128	0.184	5190	3740
MW-04	10	7	1992	927	5.49	<0.1	0.78	4950	3910
	9	14	1994	1000	5.36	0.105	0.48	4930	4490
MW-04A	10	7	1992	56.7	6.15	<0.1	0.42	571	478
	9	14	1994	56	6.16	0.482	0.683	550	414
MW-05	10	7	1992	797	4.00	0.25	3.85	5040	5140
	9	14	1994	820	3.92	0.385	3.47	4820	4810
MW-06	10	7	1992	418	6.60	0.14	<0.02	2570	1930
	9	14	1994	410	6.88	0.049	<0.005	2160	1620
MW-07	10	7	1992	233	5.40	<0.1	12.9	1500	1320
	9	14	1994	140	6.35	0.337	6.71	1130	888
MW-08	10	7	1992	827	6.20	<0.1	4.02	3950	3540
	9	14	1994	880	6.32	0.233	2.34	3980	3300
MW-08A	10	7	1992	85.3	6.72	<0.1	0.44	891	670
	9	14	1994	110	6.79	0.134	0.463	933	655
MW-09	10	7	1992	282	6.75	<0.1	0.01	2570	2130
	9	14	1994	270	6.76	0.164	0.021	2460	2020

Well	Month	Day	Year	As (mg/L)	Ba (mg/L)	Cd (mg/L)	Cr (mg/L)	Cu (mg/L)	Pb (mg/L)	Hg (mg/L)	Se (mg/L)	Ag (mg/L)
MW-04	10	7	1992	<0.001	<1	<0.003	<0.03	<0.02	<0.005	<0.001	<0.001	<0.01
MW-04A	10	7	1992	<0.001	<1	<0.003	<0.03	<0.02	<0.005	<0.001	<0.001	<0.01
MW-05	10	7	1992	<0.001	<1	<0.003	<0.03	<0.02	<0.005	<0.001	<0.001	<0.01
MW-06	10	7	1992	<0.001	<1	<0.003	<0.03	<0.02	<0.005	<0.001	<0.001	<0.01
MW-07	10	7	1992	<0.001	<1	<0.003	<0.03	<0.02	<0.005	<0.001	<0.001	<0.01
MW-08	10	7	1992	<0.001	<1	<0.003	<0.03	<0.02	<0.005	<0.001	<0.001	<0.01
MW-08A	10	7	1992	<0.001	<1	<0.003	<0.03	<0.02	<0.005	<0.001	<0.001	<0.01
MW-09	10	7	1992	<0.001	<1	<0.003	<0.03	<0.02	<0.005	<0.001	<0.001	<0.01

Table 2 (cont.)

Well	Month	Day	Year	Zn (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	CO3 (mg/L)	HCO3 (mg/L)	SO4 (mg/L)	F (mg/L)	N (mg/L)	Alkalinity (mg/L)	Hardness (mg/L)
MW-04	10	7	1992	<0.04	777	19.7	435	8.2	0	28	1720	0.33	0.9	28	2020
MW-04A	10	7	1992	<0.04	48.6	12.2	57.2	7.9	0	56	137	0.25	0.8	56	172
MW-05	10	7	1992	0.39	7487	260	308	29.4	0	<0.1	2250	5.03	1.1	<0.1	2941
MW-06	10	7	1992	<0.04	252	48.3	279	46.1	0	200	632	0.25	<0.1	200	829
MW-07	10	7	1992	0.06	177	37.3	103	4.8	0	10	433	0.21	<0.1	10	597
MW-08	10	7	1992	<0.04	512	102	421	27	0	182	1037	0.23	0.2	182	1700
MW-08A	10	7	1992	<0.04	46.1	11.4	155	12.9	0	196	158	0.35	1.1	196	162
MW-09	10	7	1992	<0.04	308	48.5	284	1.7	0	428	690	0.23	<0.1	428	970

Table 3. Chemical analysis of water from monitoring well MAXEY-2 (mg/L).

pH	6.7
T (^{o}C)	19.6
Na	226.7
K	3.7
Mg	115.0
CA	298.6
F	4.4
Cl	272.9
Br	1.2
NO_3	0.1
SO_4	802.0
HCO_3	502
TDS	2294

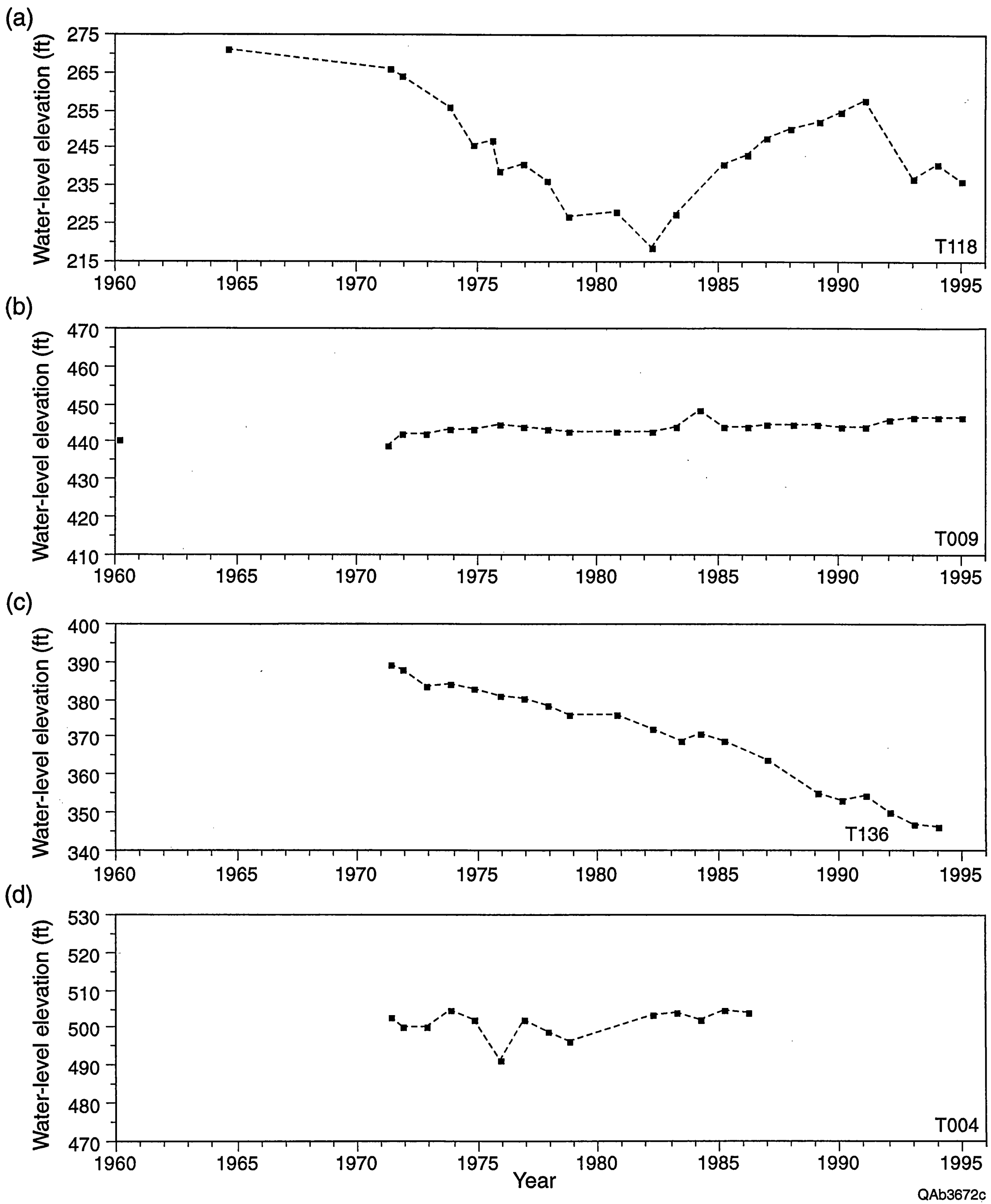


Figure 8. Water levels measured in the Woodbine Formation in (a) well 17-27-201 and (b) well 17-12-101 and in the Paluxy Formation in (c) well 17-29-601 and in the Eagle Ford Formation in (d) well 17-10-801 in Lamar County.

1965 and 1982 and then recovered almost 50 ft from 1982 to 1991 before water levels dropped again (fig. 8a). Because this well is so far from the outcrop of the Woodbine Formation (18 miles), we believe these fluctuations are due to changes in water production from the well or from other wells in the area. It is also possible that there is regional influence from large withdrawals from the Woodbine Formation further east of the county, where water levels have dropped as much as 400 ft since the turn of the century (Mace and others, 1994). The other well completed in the Woodbine Formation, 17-12-101, is located on the north side of Pat Mayse Lake and is only a few miles from the Woodbine outcrop. Water level in this well has been relatively stable since 1960 (fig. 8b), probably owing to the confined nature of the aquifer and the lack of substantial pumping from the Woodbine Formation in this area. The water-level elevation of the Woodbine Formation beneath Camp Maxey is about 400 ft.

A well drilled into the Paluxy Formation, 17-29-601, near Pattonville and 8 miles southeast of Paris, shows a steady decline in water level since measurements began in 1971 (fig. 8c). This steady decline in water level is due to the production of ground water from the aquifer locally and perhaps regionally, where declines as large as 450 ft have been recorded (Mace and others, 1994). There is no information on the elevation of the water level of the Paluxy Formation beneath Camp Maxey.

Water levels appear somewhat stable in an Eagle Ford Formation well, 17-10-801, located in the northwest part of the county 12 miles west of the camp, which has fluctuations of less than 10 ft (fig. 8d). This household well is 104 ft deep and most likely taps into a sand stringer that behaves as a confined aquifer. Two shallow (~16 ft deep) hand-dug wells in the Eagle Ford Formation on Camp Maxey have depths to water of 8 to 11 ft.

Water levels in wells at the camp did not show much variation during the course of the project (table 4). However, there were declines in water level in well MAXEY-1 from January 1996 to April 1996 and in well CMX-B001 from September 1995 to January 1996 that are perhaps due to seasonal variation (there was very little rainfall during this time). Well MAXEY-2A showed a slight rise in water levels.

Water levels in the shallow Eagle Ford and Bonham are strongly influenced by topography, water flowing generally down topographic gradient. Figure 9 shows our interpretation of water levels in the Camp Maxey area. Water levels are presumed to be deeper beneath hilltops and shallower toward creeks and drainages.

Table 4. Water-level measurements in Camp Maxey wells.

Date	Time	Depth to water (ft)	Water-level elevation (ft)
MAXEY-1			
1/5/96	1000	51.85	503.15
4/2/96	1700	53.75	501.25
MAXEY-2A			
1/5/96	0907	26.56	493.44
4/2/96	1642	26.26	493.74
CMX-B001			
9/27/95	1630	11.29	513.71
1/5/96	1040	14.40	510.6
CMX-B006			
1/5/96	1125	10.60	499.40

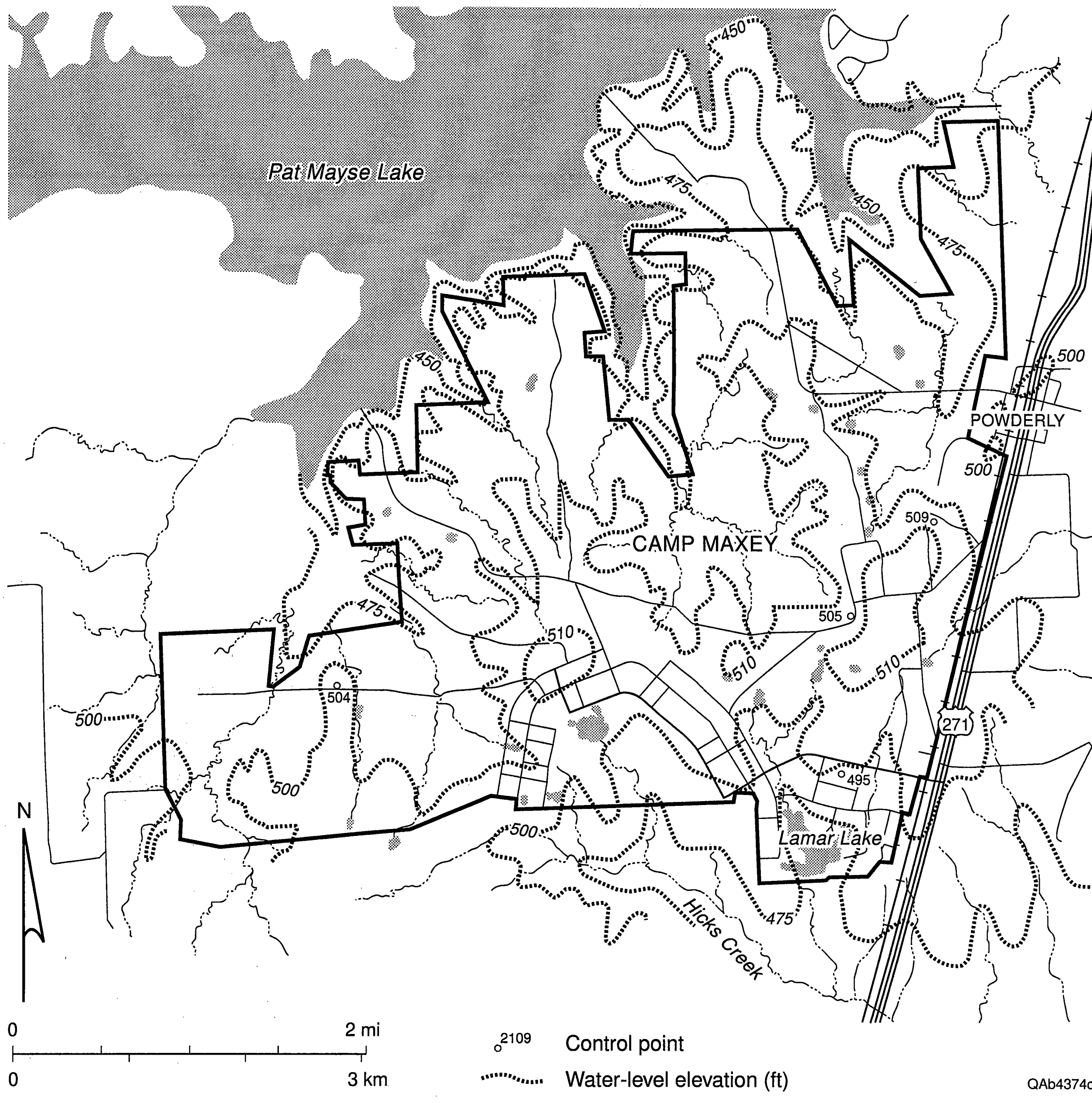


Figure 9. Water-level map of the shallow Eagle Ford and Bonham Formations in the Camp Maxey area.

Conceptual Flow Model

Our conceptual model of ground-water flow at Camp Maxey is based on the data we compiled and collected and our understanding of ground-water flow at the camp. Rain falls onto the Eagle Ford and Bonham outcrops, and a small percentage percolates into the ground to recharge shallow, unconfined water-bearing units. Recharge to the aquifer is greater in higher elevations and in sandier patches of the outcrop. This water moves from topographic highs toward topographic lows, where it discharges into local creeks and streams. Some of the flow follows longer flow paths and discharges into locally major topographic lows such as Pat Mayse Lake to the north and Hicks and Pine Creeks to the south. A small amount of flow may discharge from the Eagle Ford Formation into the underlying Woodbine Formation.

SURFACE-WATER HYDROLOGY

This section discusses the principal streams and drainage basins, watersheds, flow duration and flood frequency, and floodplain analysis, which includes 100-yr flood hydrographs near the camp boundary and a map of the 100-yr floodplain.

Drainage Basins and Floodplains

Camp Maxey drains into the Lower Red River Basin (TDWR, 1984), which is part of the Red River basin (zone 3) (TDWR, 1984). Surface water in the camp moves into first-order tributaries of Pine Creek and Sanders Creek (Pat Mayse Lake) drainage basins. Runoff in the north and southwest areas of the camp feeds into locally intermittent creeks that drain north into Pat Mayse Lake. The lake feeds Sanders Creek, which empties into the Red River to the north. Runoff on the southeast side of the camp feeds into locally intermittent creeks that connect into intermittent Hicks Creek. Hicks Creek then empties into Pine Creek, which in turn empties into the Red River near the very northeast corner of Lamar County. Watersheds tend to be small, and most of the drainage area feeds into Pat Mayse Lake to the north (fig. 10).

Floodplain Analysis

Camp Maxey has several streams that either drain north into Pat Mayse Lake or south into Hicks Creek. Floodplains for these streams are not large and exist as halos around the stream beds, generally becoming wider downstream, especially as they feed into Pat Mayse Lake (fig. 11). USGS topographic maps show a controlled flooding surface for Pat Mayse Lake. This

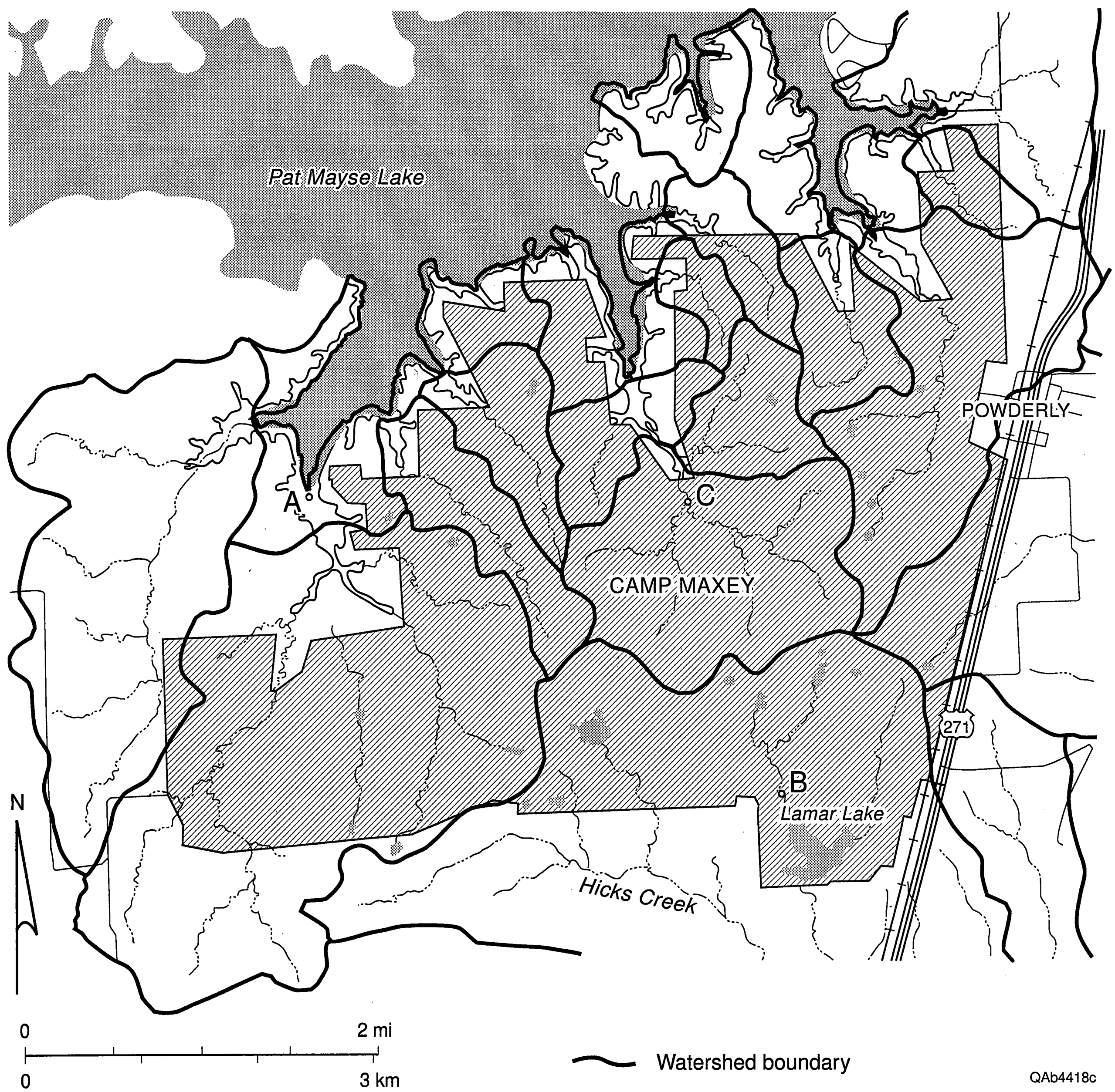


Figure 10. Watershed delineations of Camp Maxey. Points A, B, and C refer to flood hydrographs in figure 12.

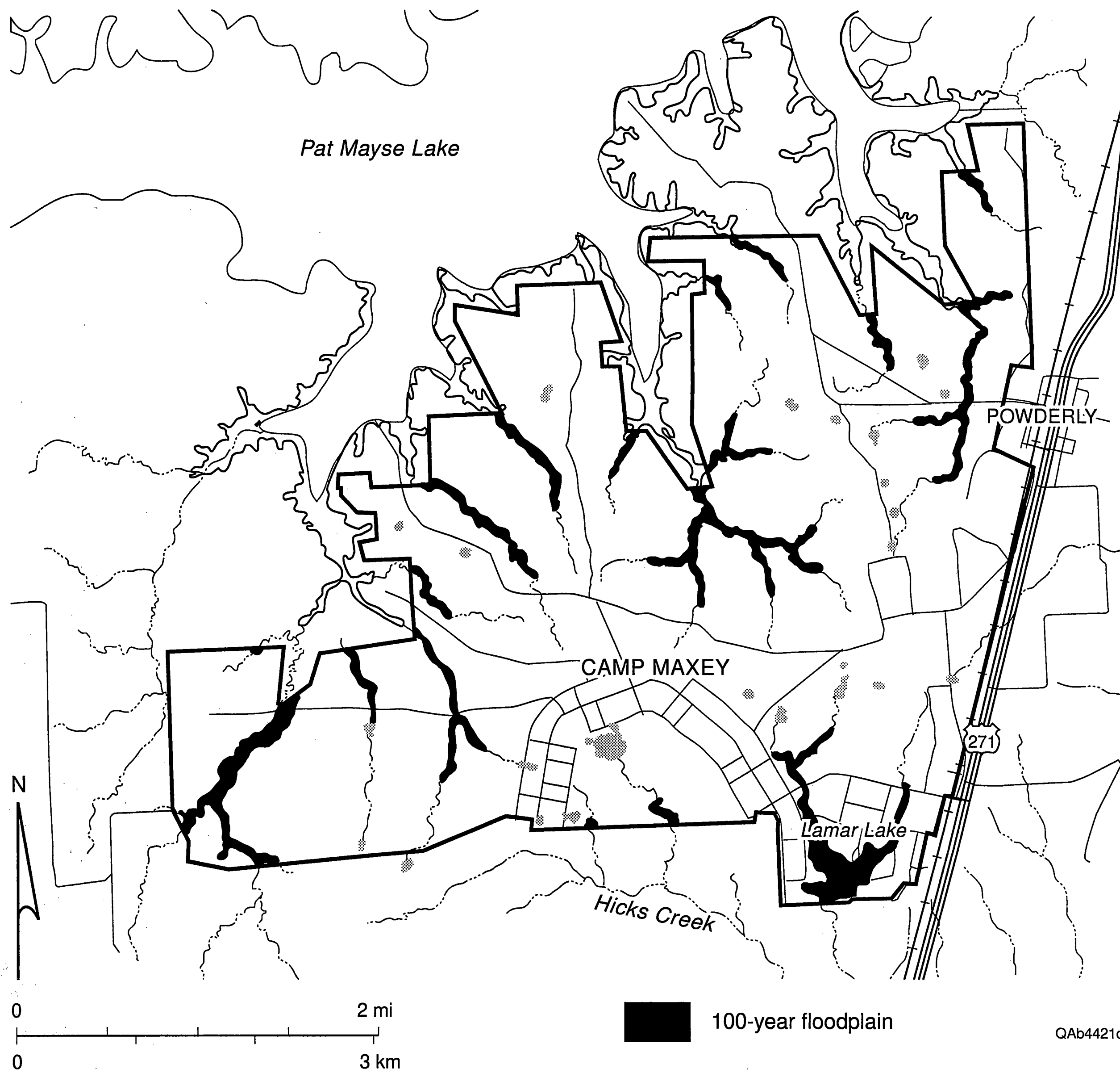


Figure 11. One-hundred-year floodplains of Camp Maxey.

surface extends minimally (<250 ft) into Camp Maxey. The 100-yr 24-hr rainfall is 9.75 inches, and there is a maximum SCS Type II distributed rainfall intensity of 4.14 inches/hr (fig. 12a). This 100-yr rainfall results in a maximum flow of 4,452 cfs in the eastern tributary to Pat Mayse Lake (fig. 12b for point A in fig. 11), 688 cfs for the creek that drains into Lamar Lake (fig. 12c for point B in fig. 11), and 1,236 cfs for the northern tributary to Pat Mayse Lake near the camp boundary (fig. 12d for point C in fig. 11).

GIS DATA PREPARATION

Several layers of data and information were automated for inclusion into a geographical information system (GIS). These layers include

- Roads
- Watersheds
- Digital elevation map (DEM)
- Floodplains
- Soil maps
- Location of off-camp wells
- Location of on-camp wells
- Water-level maps

The data dictionary for these coverages is included in appendix 3.

SUMMARY

Ground water is pumped from the Blossom Sand and the Woodbine and Paluxy Formations in and around Camp Maxey, and most wells are completed in the Blossom Sand. Ground-water quality is generally good, and fresh water is present in aquifers underlying the camp. Ground-water recharge at the camp occurs principally from rainfall onto higher elevations and sandier parts of the Eagle Ford and Bonham outcrops. This water percolates toward topographically low areas, where it is discharged into local creeks and streams or into Pat Mayse

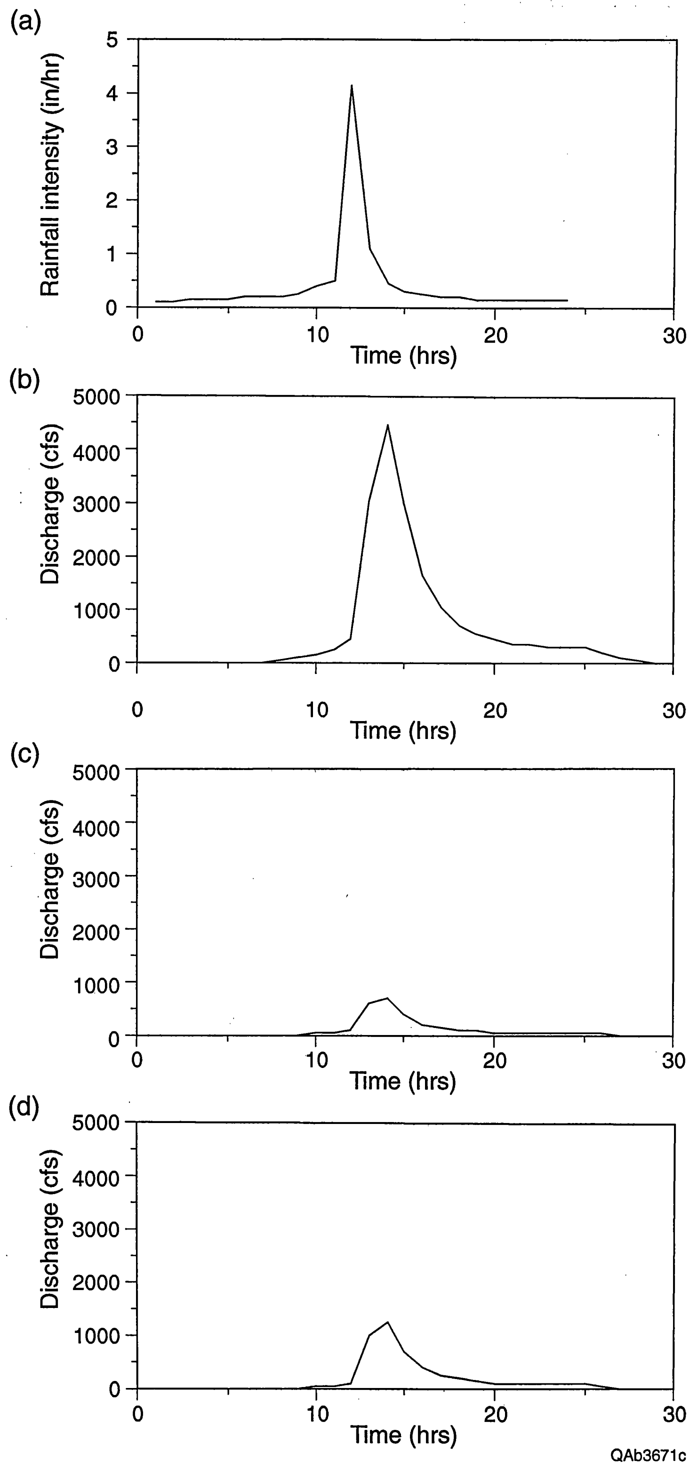


Figure 12. Flood hydrograph analysis of Camp Maxey, including (a) 100-yr 24-hr SCS Type II distributed rainfall intensity and the 100-yr flood hydrographs near the camp boundary for (b) a northwest tributary to Pat Mayse Lake (point A, fig. 10), (c) the stream that feeds into Lamar Lake (point B, fig. 10), and (d) a northern tributary to Pat Mayse Lake (point C, fig. 10).

Lake to the north or Hicks and Pine Creeks to the south. A small part of the local recharge may travel into the underlying Woodbine Formation.

Most surface runoff from Camp Maxey drains into first-order tributaries on the camp grounds, then to Pat Mayse Lake, and ultimately into the Red River. Floodplains resulting from a 100-yr storm are small and generally confined near stream beds.

The primary threat to ground-water resources and quality is surface contamination of recharge areas in the camp, whereas surface-water quality can be degraded by contamination or debris being swept into surface drainages during heavy rainfalls.

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Appendix 1

Well Survey around Camp Perimeter

Appendix 1. Well survey around camp perimeter.

Well #	Depth (ft)	Water level (ft BTOC)	Diameter (in)	Casing material	Land surface elevation (ft)	water level (ft BLS)
S001	-	-	-	-	-	-
S002	~50	38.2	8	clay pipe	525	35.37
S003	-	-	-	-	-	-
S004	-	-	-	-	-	-
S005	-	-	-	-	-	-
S006	-	-	-	-	-	-
S007	-	-	-	-	-	-
S008	-	-	-	-	-	-
S009	-	-	-	-	-	-
S010	-	-	-	-	-	-
S011	~100	-	-	-	-	-
S012	25	15.44	24	cement & stone	462	12.80
S013	-	-	-	-	-	-
S014	-	-	-	-	-	-
S015	-	-	-	-	-	-
S016	-	-	-	-	-	-
S017	-	-	-	-	-	-
S018	-	-	-	-	-	-
S019	-	-	-	-	-	-
S020	-	-	-	-	-	-
S021	21.6	21.56	36	brick	482	17.26
S022	-	-	-	-	-	-
S023	-	-	-	-	-	-
S024	-	-	-	-	-	-
S025	-	-	-	-	-	-
S026	30	~12	4	PVC	488	12 est.
S027	~55-60	-	6	PVC	488	-
S028	-	-	-	-	-	-
S029	-	-	-	-	-	-
S030	-	-	-	-	-	-
S031	-	-	-	-	-	-
S032	~25	7.69	4	PVC	484	7.36
S033	-	-	-	-	-	-
S034	-	-	-	-	-	-
S035	-	-	-	-	-	-
S036	-	-	-	-	-	-
S037	-	-	-	-	-	-
S038	-	-	-	-	-	-
S039	-	-	-	-	-	-
S040	-	-	-	-	-	-
S041	-	-	-	-	-	-
S042	-	-	~30	brick	-	-
S043	-	-	-	-	-	-
S044	-	-	-	-	-	-
S045	57.17	dry	4	iron	515	-
S046	260	-	-	-	-	-
S047	-	-	-	-	-	-
S048	-	-	-	-	-	-
S049	247	-	-	-	-	-
S050	255	~95	6	-	500 est.	95 est.
S051	-	-	-	-	-	-
S052	-	-	-	stone	-	-

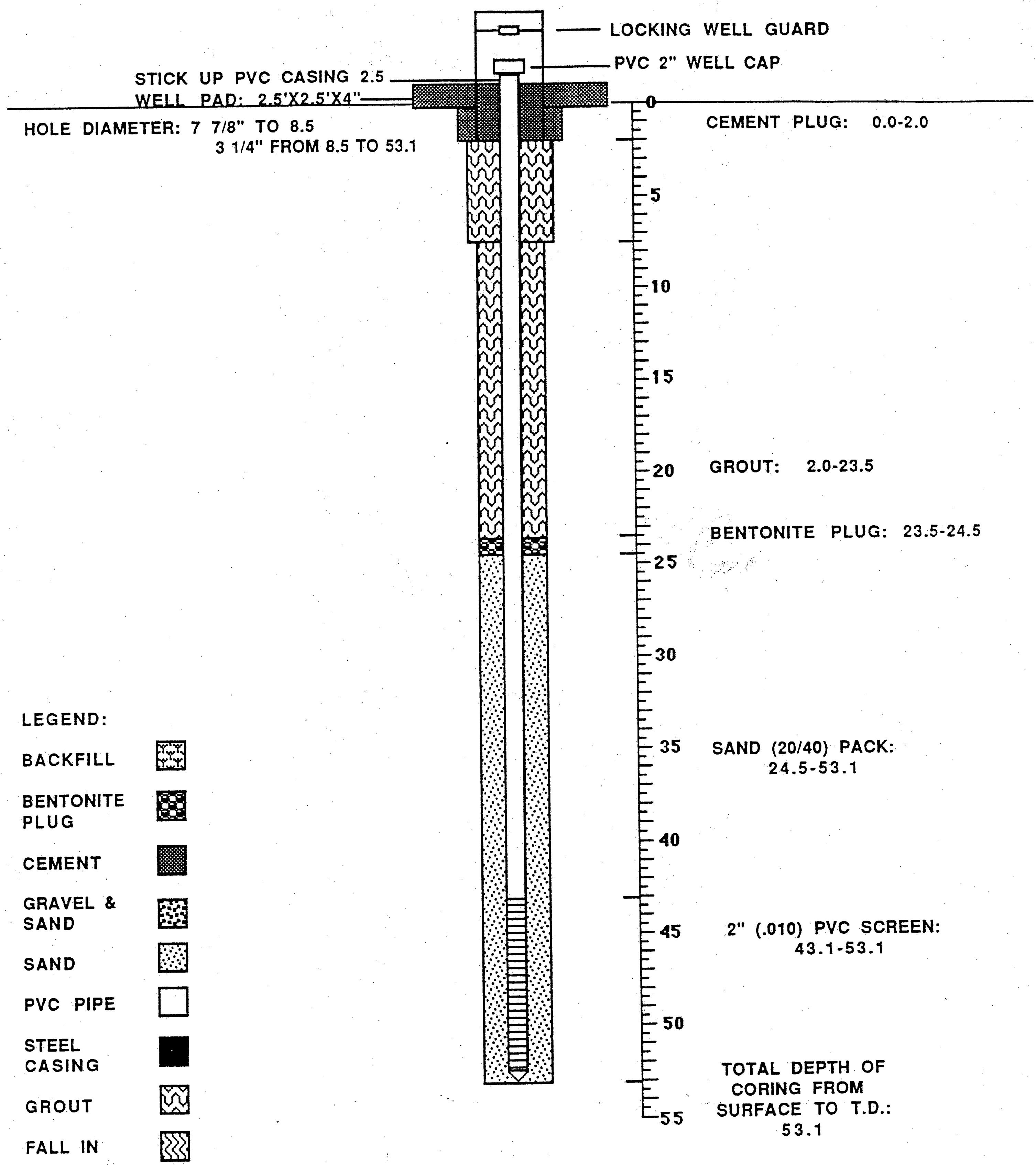
Appendix 1. Well survey around camp perimeter.

Well #	Depth (ft)	Water level (ft BTOC)	Diameter (in)	Casing material	Land surface elevation (ft)	water level (ft BLS)
S053	-	-	-	-	-	-
S054	-	-	-	-	-	-
S055	-	-	-	-	-	-
S056	-	-	-	-	-	-
S057	-	-	-	-	-	-
S058	-	-	-	-	-	-
S059	-	-	-	-	-	-
S060	-	-	-	-	-	-
S061	-	-	-	brick	-	-
S062	-	-	-	-	-	-
S063	>100	-	10	-	-	-
S064	126	~85-90	10	concrete	510	85-90 est.
S065	-	-	-	-	-	-
S066	-	-	-	-	-	-
S067	-	-	-	-	-	-
S068	-	-	-	-	-	-
S069	-	-	-	-	-	-
S070	-	-	-	brick	-	-
S071	-	-	-	-	-	-
S072	-	-	-	-	-	-
S073	-	-	-	-	-	-
S074	-	-	-	brick	-	-
S075	~275	-	-	-	-	-
S076	>200	-	-	-	-	-
S077	-	-	-	-	-	-
S078	>200	-	-	-	-	-
S079	-	-	-	-	-	-
S080	-	-	-	-	-	-
S081	-	-	-	-	-	-
S082	-	-	-	-	-	-
S083	-	-	-	-	-	-
S084	-	-	-	-	-	-
S085	-	-	-	brick	-	-
S086	-	-	-	-	-	-
S087	-	-	-	-	-	-
S088	-	-	-	brick	-	-
S089	-	-	-	-	-	-
S090	-	-	-	-	-	-
S091	-	-	-	brick	-	-
S092	-	-	-	-	-	-

Appendix 2

Detailed Well Schematics and Drilling Reports for Monitor Wells

WATER MONITOR SCHEMATIC
CAMP MAXEY #1
DRILL DATE: 11/11/95
NATIONAL GUARD PROJECT



Send original copy by certified mail to: TNRCC, P.O. Box 13087, Austin, TX 78711-3087 *Please use black ink.*

ATTENTION OWNER: *Confidentiality Privilege Notice on Reverse Side*

State of Texas
WELL REPORT

Texas Water Well Drillers Advisory Council
P.O. Box 13087
Austin, Texas 78711-3087
512-239-0530

Camp Maxey #1

1) OWNER Texas National Guard (Name) **ADDRESS** P.O. Box 5218 (Street or RFD) Austin (City) Tx (State) 78763 (Zip)

2) ADDRESS OF WELL:
County Lamar Camp Maxey Rt. 1 Box 169 (Street, RFD or other) Powderly (City) Texas (State) 75473-0169 (Zip) **GRID #** 17-12-5

3) TYPE OF WORK (Check):
☒ New Well ☐ Deepening ☐ Reconditioning ☐ Plugging

4) PROPOSED USE (Check): ☒ Monitor ☐ Environmental Soil Boring ☐ Domestic ☐ Industrial ☐ Irrigation ☐ Injection ☐ Public Supply ☐ De-watering ☒ Testwell
If Public Supply well, were plans submitted to the TNRCC? ☐ Yes ☐ No

5)
33° 47' 40"
95° 32' 31"
N

6) WELL LOG:
Date Drilling:
Started 11/11 19 95
Completed 11/11 19 95

DIAMETER OF HOLE

Dia. (in.)	From (ft.)	To (ft.)
7 7/8	Surface	8.5
3 1/4	8.5	53.

7) DRILLING METHOD (Check): ☐ Driven ☐ Air Rotary ☐ Mud Rotary ☒ Bored ☐ Air Hammer ☒ Cable Tool ☐ Jetted ☒ Other Augered

From (ft.)	To (ft.)	Description and color of formation material
		N/A ROCK BITTED

(Use reverse side if necessary)

8) Borehole Completion (Check): ☐ Open Hole ☒ Straight Wall ☐ Underreamed ☐ Gravel Packed ☐ Other
If Gravel Packed give interval . . . from ____ ft. to ____ ft.

CASING, BLANK PIPE, AND WELL SCREEN DATA:

Dia (in.)	New or Used	Steel, Plastic, etc. Perf., Slotted, etc. Screen Mfg., if commercial	Setting (ft.) From	Setting (ft.) To	Gage Casting Screen
2"	N	PVC Schedule 40 - 20'	2.5' Above Surface	43.1	.010
2"	N	PVC Schedule 40 - 10'	43.1	53.1	.010

9) CEMENTING DATA: [Rule 338.44(1)]

Cemented from 4" Above Surface ft. to 2.0 ft. No. of Sacks Used 3
____ ft. to ____ ft. No. of Sacks Used ____
Method used Hand Poured
Cemented by Drill Crew
Distance to septic system field lines or other concentrated contamination N/A ft.
Method of verification of above distance N/A

10) SURFACE COMPLETION

☒ Specified Surface Slab Installed [Rule 338.44 (2) (A)]
☒ Specified Steel Sleeve Installed [Rule 338.44 (3)(A)]
☐ Pitless Adapter Used [Rule 338.44 (3)(b)]
☐ Approved Alternative Procedure Used [Rule 338.71]

11) WATER LEVEL:

Static level ____ ft. below land surface Date ____
Artesian flow ____ gpm. Date ____

12) PACKERS: Type Depth

13) TYPE PUMP:
☐ Turbine ☐ Jet ☐ Submersible ☐ Cylinder
☐ Other ____
Depth to pump bowls, cylinder, jet, etc., ____ ft.

14) WELL TESTS:
Type test: ☐ Pump ☐ Bailer ☐ Jetted
Yield: ____ gpm with ____ ft. drawdown after ____ hrs.

15) WATER QUALITY:
Did you knowingly penetrate any strata which contained undesirable constituents?
☐ Yes ☐ No
Type of water? ____ Depth of strata ____
Was a chemical analysis made? ☐ Yes ☐ No

I hereby certify that this well was drilled by me (or under my supervision) and that each and all of the statements herein are true to the best of my knowledge and belief. I understand that failure to complete items 1 thru 15 will result in the log(s) being returned for completion and resubmittal.

COMPANY NAME University of Texas/Bureau of Economic Geology (Type or Print) **WELL DRILLER'S LICENSE NO.** 3187-M

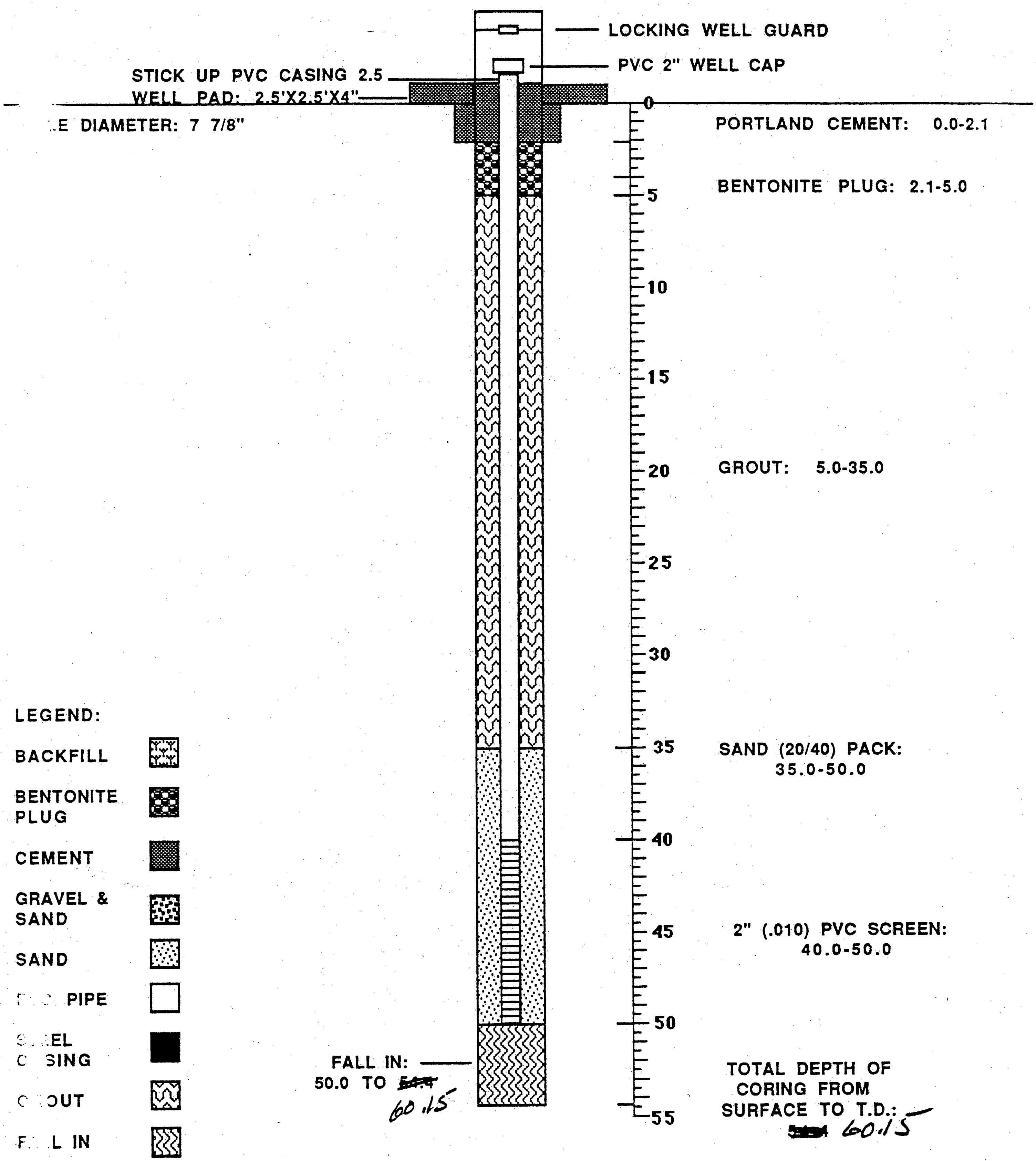
ADDRESS P.O. Box X University Station (Street or RFD) Austin (City) Texas (State) 78701 (Zip)

(Signed) James Doss (Licensed Well Driller) (Signed) Jordan Forman (Registered Driller Trainee)

Please attach electric log, chemical analysis, and other pertinent information, if available.

TNRCC-0199 (Rev. 11-01-94) TNRCC COPY

WATER MONITOR SCHEMATIC
CAMP MAXEY #2A
DRILL DATE: 11/11/95
NATIONAL GUARD PROJECT



Send original copy by certified mail to: TNRCC, P.O. Box 13087, Austin, TX 78711-3087 *Please use black ink.*

ATTENTION OWNER: *Confidentiality Privilege Notice on Reverse Side*

State of Texas WELL REPORT

Texas Water Well Drillers Advisory Council
P.O. Box 13087
Austin, Texas 78711-3087
512-239-0530

Camp Maxey #2A

1) OWNER Texas National Guard (Name) ADDRESS P.O. Box 5218 (Street or RFD) Austin (City) Tx (State) 78763 (Zip)

2) ADDRESS OF WELL: County Lamar Camp Maxey Rt. 1 Box 169 (Street, RFD or other) Powderly (City) Texas (State) 75473-0169 (Zip) GRID # 17-12-8

3) TYPE OF WORK (Check):
☒ New Well ☐ Deepening
☐ Reconditioning ☐ Plugging

4) PROPOSED USE (Check): ☒ Monitor ☐ Environmental Soil Boring ☐ Domestic
☐ Industrial ☐ Irrigation ☐ Injection ☐ Public Supply ☐ De-watering ☒ Testwell
If Public Supply well, were plans submitted to the TNRCC? ☐ Yes ☐ No

5)
33° 46' 57"
95° 32' 38"
N

6) WELL LOG:
Date Drilling:
Started 11/7 19 95
Completed 11/11 19 95

DIAMETER OF HOLE

Dia. (in.)	From (ft.)	To (ft.)
7 7/8	Surface	7.2
3 1/4	7.2	60.15

7) DRILLING METHOD (Check): ☐ Driven
☐ Air Rotary ☒ Mud Rotary ☒ Bored
☐ Air Hammer ☒ Cable Tool ☐ Jetted
☐ Other

From (ft.)	To (ft.)	Description and color of formation material
0.0	7.2	Red & grey clay
7.2	30.0	Red clay, large rocks, gravel, some fractures
30.0	43.7	Light tan clay with sand & black mottled clay
43.7	48.6	Light tan clay with sand mottled with grey clay
48.6	53.5	Washed out sand
53.5	60.15	Large pebbles, tan clay, grey shale, brown clay

(Use reverse side if necessary)

8) Borehole Completion (Check): ☐ Open Hole ☒ Straight Wall
☐ Underreamed ☐ Gravel Packed ☐ Other
If Gravel Packed give interval . . . from ______ ft. to ______ ft.

CASING, BLANK PIPE, AND WELL SCREEN DATA:

Dia (in.)	New or Used	Steel, Plastic, etc. Perf., Slotted, etc. Screen Mfg., if commercial	Setting (ft.) From	Setting (ft.) To	Gage Casting Screen
2"	N	5 - 2" x 10' PVC riser	2.5' Above Surface	40.0	.010
2"	N	2 - 2" x 10' PVC riser	40.0	50.0	.010

9) CEMENTING DATA: [Rule 338.44(1)]
Cemented from 4" Above Surface ft. to 2.1 ft. No. of Sacks Used 3
______ ft. to ______ ft. No. of Sacks Used ______
Method used Hand Poured
Cemented by Drill Crew
Distance to septic system field lines or other concentrated contamination N/A ft.
Method of verification of above distance N/A

10) SURFACE COMPLETION
☒ Specified Surface Slab Installed [Rule 338.44 (2) (A)]
☒ Specified Steel Sleeve Installed [Rule 338.44 (3)(A)]
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11) WATER LEVEL:
Static level ______ ft. below land surface Date ______
Artesian flow ______ gpm. Date ______

12) PACKERS: Type Depth

13) TYPE PUMP:
☐ Turbine ☐ Jet ☐ Submersible ☐ Cylinder
☐ Other ______
Depth to pump bowls, cylinder, jet, etc., ______ ft.

14) WELL TESTS:
Type test: ☐ Pump ☐ Bailer ☐ Jetted
Yield: ______ gpm with ______ ft. drawdown after ______ hrs.

15) WATER QUALITY:
Did you knowingly penetrate any strata which contained undesirable constituents?
☐ Yes ☐ No
Type of water? ______ Depth of strata ______
Was a chemical analysis made? ☐ Yes ☐ No

I hereby certify that this well was drilled by me (or under my supervision) and that each and all of the statements herein are true to the best of my knowledge and belief. I understand that failure to complete items 1 thru 15 will result in the log(s) being returned for completion and resubmittal.

COMPANY NAME University of Texas/Bureau of Economic Geology (Type or Print) WELL DRILLER'S LICENSE NO. 3187-M

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(Signed) James Doss (Licensed Well Driller) (Signed) Jordan Forman (Registered Driller Trainee)

Please attach electric log, chemical analysis, and other pertinent information, if available.

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Appendix 3

Data Dictionary for GIS Coverages

GIS DATA DICTIONARY

Several layers of spatial hydrologic and hydrogeologic data were input to the Bureau of Economic Geology GIS system. Maps were digitized using a Calcomp digitizing table, under the ArcEdit module of GIS ArcInfo, on a Sparc500 Workstation. When possible, the data from the paper originals of the U.S. Geological Survey (USGS) 1:24,000-scale, 7.5-minute topographic maps were either transferred on Mylar or digitized during one session to minimize the distortions related to environmental factors. The digital data base, regardless of the original projection, will be delivered in the Universal Transverse Mercator (UTM) coordinate system, with the following parameters:

Ellipsoid: Clarke 1866

Horizontal Datum: NAD27

Units: meters

Zone 14

The digital data represent the following.

Digital Elevation Models (DEM) were acquired from MicroPath at 1:24,000 scale, where available (View, Buffalo Gap, Paris, Lake Bastrop, Elgin East, McDade, Graford East, Mineral Wells East, Mineral Wells West, and Whitt), or were created from digital elevation contours and streams using the Grid module of ArcInfo (Topogrid). The cell size for DEMs is 30 m, with a horizontal accuracy of ±3 m and a vertical accuracy of ±10 m. The DEMs were used to delineate watersheds of interest.

Watersheds represent polygon coverages encompassing the drainage areas. They were outlined from DEMs for Camp Swift, Camp Mabry, Camp Barkeley, and Fort Wolters or were defined from USGS topographic quads and then transferred to a digital format. Possible inaccuracy might be related to human error and imperfections of the digitizing equipment. Given the USGS-stated positional accuracy of ±40 ft for its 7.5-minute quads, and the inadvertent positional shifts that may have been introduced during the digitizing process, it can be estimated that the positional accuracy of most features will be approximately ±50 ft.

Floodplains are polygon coverages, digitized from USGS topographic quads, with the aforementioned accuracy estimate.

Well locations are point coverages, digitized from USGS topographic quadrangles; they include existing and recently drilled wells, with an internally assigned well name (number) as an item in the Point Attribute Table (PAT). They include wells on and around the camps.

Soil maps are generalized soil maps at 1:250,000 scale compiled by the U.S. Department of Agriculture Soil Conservation Service. They contain polygons describing groups of soil types and attached attribute tables with extensive sets of numerical values, including their hydrologic properties, which were used to specify the percentage of the map unit occupied by soils in each hydrologic group. The digital data were obtained from the Texas Natural Resources Information System (TNRIS) ftp site.

Water levels represent water-level contours, which, owing to scarcity of control points and the inherent interpolation problems of the software, were hand drawn and then digitized from Mylar overlays.

Cultural features include roads and generalized streams at 1:24,000 scale, at various extents around the camp. They were obtained from the TNRIS ftp site and are the latest version of Texas Department of Transportation (TxDOT) urban maps. These files were originally digitized from USGS 7.5-minute quadrangles. Updates are made periodically using TxDOT highway construction plans, aerial photographs, official city maps, and field inventory. These files contain most of the features found on 7.5-minute quads, except for items such as contour lines, fence lines, jeep trails, electrical transmission lines, oil and gas pipelines, and control data monuments.

The county map files are based on the following map projection system:

TEXAS STATEWIDE MAPPING SYSTEM (NAD27)

Projection: Lambert Conformal Conic

Ellipsoid: Clarke 1866

Datum: North American 1927

Longitude of Origin: 100 degrees west (-100)

Latitude of Origin: 31 degrees 10 minutes north

Standard Parallel #1: 27 degrees 25 minutes north latitude

Standard Parallel #2: 34 degrees 55 minutes north latitude

False Easting: 3,000,000 ft

False Northing: 3,000,000 ft

Unit of Measure: feet (international)

Positional Accuracy: These digital maps were created primarily for the purpose of producing county/urban published maps. Certain features, particularly railroads and streams, have been displaced in congested areas so as to insure map readability at county map scales.

Miscalculation of false northing and easting required reprojection of the DGN digital files, at the correct values (914,400 ft), in order to obtain the perfect overlay with several preexisting county and quadrangle files.

CAMP MAXEY

Base maps: the USGS 7.5′ topographic quadrangles, Paris and Pat Mayse East, are in the State Plane coordinate system, North Central Zone (5351), datum NAD27, units in feet.

Coverage name	Coverage type	Initial projection	Final projection	Source	Accuracy	Description
Quadutm	Polygon	UTM	UTM	TNRIS digital files	±100 ft	1:24000 scale topographic quadrangles: Paris
Lamarcnty	Polygon	UTM	UTM	TNRIS digital files	±100 ft	Outline of Lamar County
Offcamprdutm	Arc	Texas State Plane	UTM	TXDOT digital county files	±50 ft	Highways and off-camp well locations
Arcamprdutm	Arc	Texas State Plane	UTM	TXDOT digital county files	±50 ft	Highways near the camp
Oncamproads	Arc	Texas State Plane	UTM	Digitized from USGS 7.5′ topographic quads	±40 ft RMS = 0.002	Roads and trails in the camp
Boundutm	Polygon	State Plane North Central Zone	UTM	Texas Parks and Wildlife digital files	unknown	Camp boundary
Streamsutm	Arc	State Plane North Central Zone	UTM	Digitized from USGS 7.5′ topographic quads	±40 ft	Streams and rivers in the contributing watersheds
Lakesutm	Polygon	State Plane North Central Zone	UTM	Digitized from USGS 7.5′ topographic quads	±40 ft	Lakes in camp and in watersheds
Marshutm	Arc	State Plane North Central Zone	UTM	Digitized from USGS 7.5′ topographic quads	±40 ft	Outline of areas with marshes and low elevation terrain around lakes
Wshedutm	Polygon	State Plane North Central Zone	UTM	Digitized from USGS 7.5′ topographic quads	±40 ft	Watersheds corresponding to stream segments
Fplainutm	Polygon	State Plane North Central Zone	UTM	Digitized from USGS 7.5′ topographic quads	±40 ft RMS = 0.005	Floodplains
Fpstreamutm	Arc	State Plane North Central Zone	UTM	Digitized from USGS 7.5′ topographic quads	±40 ft RMS = 0.004	Stream orders and cross sections used for the HEC-RAS model
Soilsutm	Polygon	Texas State Plane	UTM	STATSGO digital database	unknown	1:2,500,000-scale distribution of soils in the watersheds
Mxswellsutm	Point	State Plane North Central Zone	UTM	Digitized from USGS 7.5′ topographic quads	±40 ft RMS = 0.004	Location of off-camp wells
Mxcwellsutm	Point	State Plane North Central Zone	UTM	Digitized from USGS 7.5′ topographic quads	±40 ft RMS = 0.002	Location of on-camp wells
Wlevels	Arc	State Plane North Central Zone	UTM	Digitized from USGS 7.5′ topographic quads	±40 ft RMS = 0.005	Digitized water-level contour maps