Chapter 14

Hydrogeology of the Marathon Basin Brewster County, Texas

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Introduction

The Marathon Basin lies in the northeastern part of Brewster County in western Texas (fig. 14-1). The region, referred to as Trans-Pecos Texas in the literature, is in the westward-projecting part of the state that lies along the Rio Grande west of the Pecos River. Physiographically, the region is closer to Mexico and New Mexico than to the rest of Texas. It is a region of high plateaus, broad cuestas, rugged mountains, and gently sloping intermontane plains. Very little vegetation is present except in sheltered valleys and on the higher summits. This factor allows an uncluttered view of the bedrock geology.

Ephemeral streams, which are little more than dry gravel beds for the vast majority of the year, gather runoff from the mountains and flow across the plains during the summer rainy season. These include Maravillas Creek, San Francisco Creek, Dugout Creek, Pena Blanca Creek, Pena Colorada Creek, and Woods Hollow Creek, to name a few. Several springs that flowed in historical times have now ceased and very little year round surface water is present in the area. The basin includes about 760 mi^2 centered on the town of Marathon. The basin is bounded on the north and west by the Glass Mountains and Del Norte Mountains, respectively. On the east, the boundary is recognized at Lemons Gap between Spencer and Housetop Mountains (fig. 14-2). The southern extent of the basin basically ends at Maravillas Gap, where Maravillas Creek cuts through the southwest end of the Dagger Flat anticlinorium.

The Influence of Water on Area History

Water resources, particularly groundwater in the form of springs, have guided the history of the area. Most of Brewster County and specifically the Marathon Basin drain into the Rio Grande, although the northern part drains into the Pecos River. Soils are generally shallow and stony, with some loamy to sandy soils and clayey subsoils. Less than 1 percent of the land in the county is considered prime farmland. Vegetation at lower elevations in the county is drought resistant. Sparse grasses; desert shrubs such as ocotillo, lechuguilla, sotol, acacias, tarbrush, and creosote bush; some mesquite; and
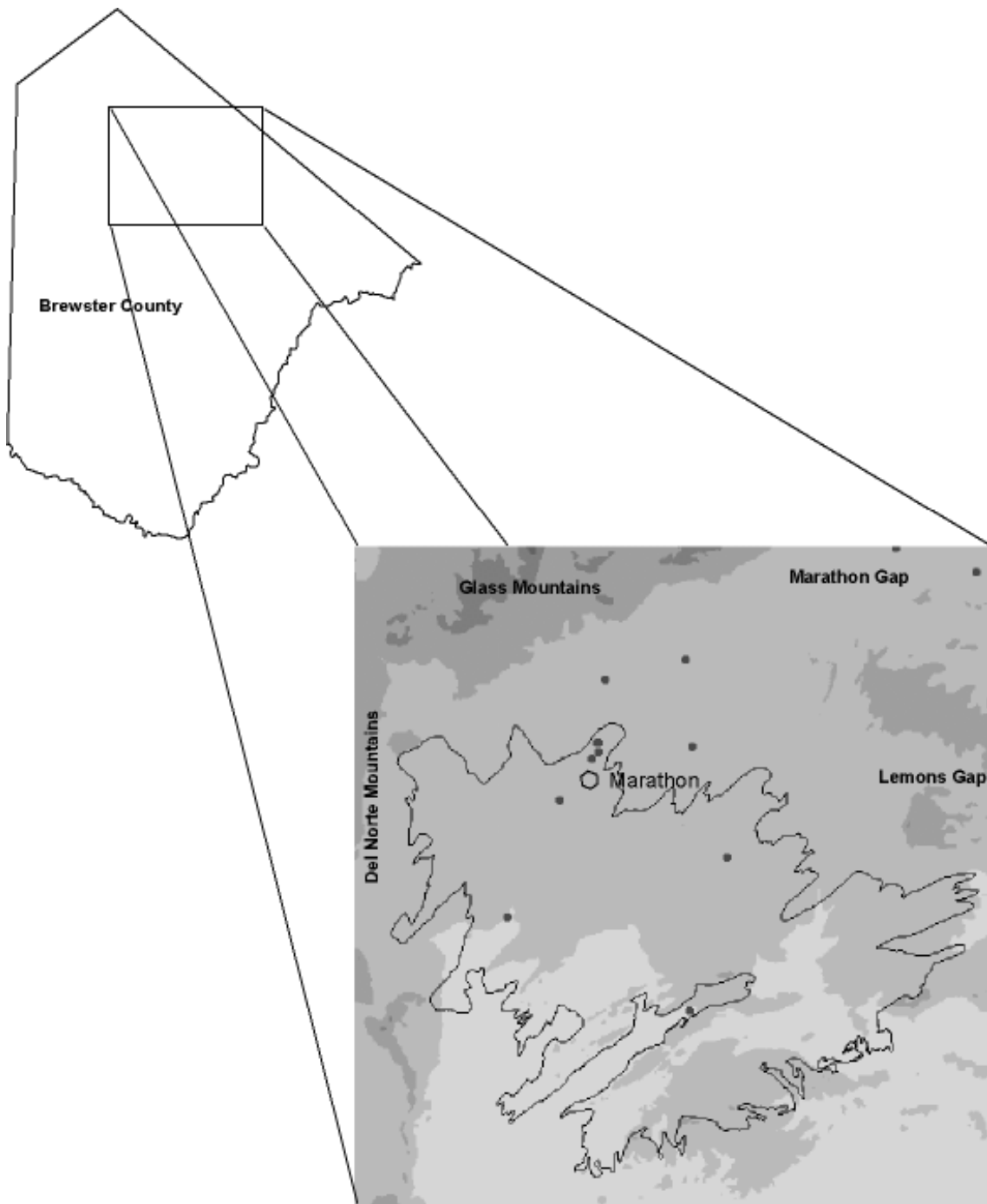
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Figure 14-1:   Location map of the Marathon Basin showing the Marathon Limestone
aquifer outline. Additional points indicate wells within the basin that
produce from Quaternary alluvium and terrace gravel.

Figure 14-2:   The entrance to the Marathon Basin on Hwy 90 at Lemons Gap. This
                 photo, taken looking to the west, shows a few of the low hills that are
                 surficial remnants of Paleozoic structures once buried beneath
                 Cretaceous sediments.

cactus are the dominant plants of this zone. At intermediate elevations vast grasslands
occur in mountain basins, with white oak, juniper, and piñon woodlands dominating the
slopes. Douglas fir, aspen, Arizona cypress, maple, Arizona pine, oaks, and madrone are
found at the higher elevations. The fauna in Brewster County includes the pronghorn
antelope, mule deer, white-tail deer, bobcat, mountain lion, desert bighorn sheep, black
bear, coyote, raccoon, badger, prairie dog, pack rat, kangaroo rat, skunk, ringtail cat,
porcupine, jackrabbit, cottontail, golden eagle, roadrunner, quail, dove, rock wren, white-
winged dove, mourning dove, Canyon Wren, painted bunting, zone-tailed black hawk,
and Colima warbler. Mineral resources include mercury, silver, lead, fluorspar,
nonceramic clay, and lignite coal. Of these, the most important to the historical
development of Brewster County was mercury. For most of the first half of the twentieth
century the Terlingua Mining District in southern Brewster County was among the
nation's leading producers.

The first European to set foot in what is now Brewster County may have been Álvar Núñez Cabeza de Vaca in 1535 (Casey, 1972). The presence in August 1583 of Antonio de Espejo's expedition, which probably passed the future site of Alpine via the Marathon Basin en route to La Junta de los Ríos, is more certain (Casey, 1972). Juan Domínguez de Mendoza is thought to have camped at Kokernot Spring, just northeast of Alpine, in 1684. But there was no extensive European presence in the Big Bend until the middle of the eighteenth century, when the Spanish began to explore the area in an effort to combat Indian raids into Mexico from the north (Gomez, 1990). In 1747, Governor Pedro de Rábago y Terán of Coahuila led an expedition into the Chisos Mountains, and, in 1772, Lt. Col. Hugo Oconór led an expedition to locate sites for forts along the Rio Grande. Oconór placed Capt. Francisco Martínez in command of the presidio at San Vicente, on the Comanche Trail on the Mexican side of the river. This was the first permanent European presence in the region (Gomez, 1990).

For much of the nineteenth century, the presence of Comanche raiding parties on their way to and from Mexico, combined with the forbidding local topography, discouraged European exploration of the Big Bend. The first Mexican and American explorers of the area, who arrived after the Mexican War, found harsh country indeed. In the summer of 1859 a camel expedition under 2d Lt. Edward L. Hartz set out from Fort Davis to explore the Comanche Trail and recommend a possible site for a fort on the Mexican border to protect against Indian raids. Hartz went south through the Marathon Basin to Persimmon Gap and down Tornillo Creek to the Rio Grande. A year later, a second camel expedition under 2d Lt. William Echols also explored along the Rio Grande, with the same goal as the Hartz expedition's. Before a fort could be built, however, the outbreak of the Civil War put an end to the plans.

After the war, three interrelated factors led to white settlement of what later became Brewster County: the presence of the United States Army, the development of the cattle industry, and the arrival of the railroad, all of which happened more or less simultaneously. Taking advantage of the Civil War, Indian cattle-rustling raids via the Comanche Trail rose sharply during the early 1860's and greatly reduced the number of cattle in northern Mexico. The high prices consequently paid by Mexican ranchers for imported cattle convinced Central Texas cattlemen to chance the long drive across the Big Bend country.

The revival of trade between Texas and Mexico along what has been called the Chihuahua Trail brought freighters and other transients to the future Brewster County. Kokernot Spring, where Mendoza had camped 2 centuries earlier, became a principal stopping place on the trail, renamed Burgess Waterhole after pioneering freighter John D. Burgess, whose wagon train was attacked by Indians there. In response to such threats, officials at Fort Davis established Camp Peña Colorada a few miles south of the future site of Marathon in 1879 (fig. 14-3).

Burgess and other freighters such as August Santleben helped spread the word about the open rangeland available in the Big Bend, and in the 1870's many ranchers from other parts of the state made plans to come west and investigate the area. Among them was Beverly Greenwood, from the Del Rio area, who came in 1878 and spent several months

Figure 14-3:   Peña Colorada Springs, an oasis in the desert, was the site of Fort Peña
                 Colorada during the mid- to late nineteenth century. Indians used the
                 springs for thousands of years prior to European exploration. The
                 springs flow from gravel deposits, and the water comes to the surface
                 where Peña Colorada Creek crosses the very hard Caballos Novaculite.
                 Flow has been measured at 150 to 450 gpm (DeCook, 1961).

exploring northern Brewster County. Mayer and Solomon Halff were San Antonio
merchants who leased to the government the land on which Camp Peña Colorada was
located. Later they became the first men to ship cattle into what is now Brewster County,
along with John Beckwith, who in 1879 drove a herd of cattle to the vicinity of Peña
Colorado Springs. These men contracted to supply meat to Camp Peña Colorada.

The burgeoning cattle industry got a major boost in 1882 when the Galveston,
Harrisburg, and San Antonio Railway was built through the area. The gradual influx of
cattlemen suddenly became a veritable flood, as a number of surveyors who had come
with the railroad and the Texas Rangers who had been assigned to protect them, elected
to stay. Among them were such men as Alfred S. Gage, James B. Gillett, and Joseph D.
Jackson, who soon became the leading citizens of Brewster County. Initially, at least,
ranchers generally settled in the northern part of what is now Brewster County for ease of

shipping their cattle via the railroad. However, the Gage Ranch and the G4 Ranch, which started in the mid- to early 1880's, were the first major cattle operations in what is now southern Brewster County. Gage soon moved north to be nearer the railhead. Several towns sprang up along the rails, the most significant of which were Alpine, then called Murphyville, and Marathon.

These two towns quickly became shipping points and important supply centers for the booming cattle industry. Five years after the coming of the railroad, in 1887, Brewster County was marked off from Presidio County, as were Jeff Davis, Buchel, and Foley Counties. Brewster County was named for Henry P. Brewster, Secretary of War under David G. Burnet. Buchel and Foley Counties were not organized and were attached to Brewster County for judicial purposes. The first Brewster County elections were held on February 4, 1887, when Murphyville was selected as county seat; on March 14 of that year a contract was let for the construction of the Brewster County courthouse and jail. In 1890 Brewster County had just 710 residents, while Buchel and Foley Counties had only 298 and 25 residents, respectively. By 1897 Buchel and Foley Counties had still not been organized, and in that year their territory was officially added to that of Brewster County, making the latter the largest county in Texas.

Cattle ranching and mining have never regained the prominence in Brewster County that they had in the late nineteenth and early twentieth centuries. The county population rose from 6,478 in 1940 to 7,309 in 1950; dropped to 6,434 in 1960; and climbed again, to an all-time high of 7,780, in 1970, before declining slightly to 7,573 in 1980. The number of people employed in agriculture, however, steadily declined, from 712 in 1930 to 507 in 1950 and only 202 in 1970. Similarly, the number of people employed in mining dropped from 206 in 1930 to 147 in 1940 and 11 in 1950. In subsequent years, when the mercury mines enjoyed a brief renaissance, that figure rose again, to 32 in 1970 and 80 in 1980.

In the early 1980's Brewster County was 53rd among United States counties in land area and one of the most sparsely populated in Texas. The largest ancestry groups were Hispanic and English, both at 43 percent. In 1990 the population was 8,681. The largest town, Alpine, had 5,637 residents. By 1999, the population of Brewster County had increased to 8,793, with most of that growth in Alpine. Given the dry climate, coupled with the magnificent scenery, the Brewster County economy has become increasingly dependent on tourism.

Physiography of the Basin

The Marathon Basin is in the Mexican Highlands physiographic province. The land surface consists of high plateaus, rugged peaks and sierras, and broad, shallow intermontane valleys. The Marathon area is situated on a structural uplift of the Ouachita fold belt. The crest has been eroded to a lower level than the flanks so that the central part is an irregular, circular basin surrounded by steep escarpments. The north and west basin margins formed by the Glass and Del Norte Mountains, respectively, consist chiefly of Permian and Cretaceous rocks that dip gently northward and westward. The relief on the
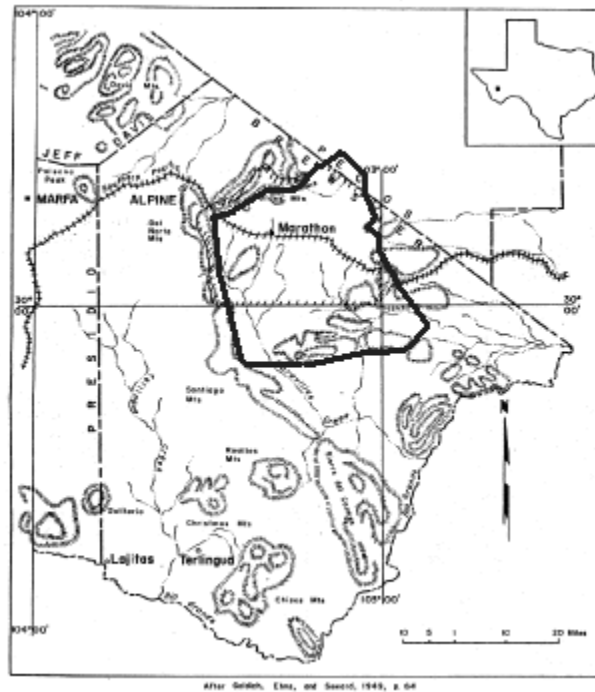
Figure 14-4:   Location map of the Marathon Basin showing physiographic features and basin boundary.

rather steep inward-facing escarpments is about 1,000 to 1,500 ft. The highest peak in these ranges has an altitude of slightly more than 6,000 ft MSL (fig. 14-4).

The basin is composed of a series of shallow valleys and comparatively flat erosional surfaces separated by northeastward-trending, low, abrupt ridges. The valley floor in the basin varies in altitude from about 3,500 ft in the south to a high of 4,500 ft in the north along the base of the Glass Mountains. Relief within the basin is not great, the summits of the ridges being generally only about 300 to 700 ft higher than the adjacent valleys. The highest peak within the basin is Horse Mountain (southeast section) at 5,010 ft MSL.

Climate

The mean annual temperature at Marathon is about 62° Fahrenheit (°F). The observed extremes vary from a high of about 110°F in the summer months to a low of below 0 in the winter. The mean monthly temperature varies from less than 46°F in December to more than 75°F in July and August.

According to records of the U.S. Weather Service, the long-term annual precipitation at Marathon is 13.59 inches. Most precipitation occurs during the summer months (fig. 14-5), largely in torrential rainstorms of irregular areal distribution.

Long Term Mean Monthly Precipitation
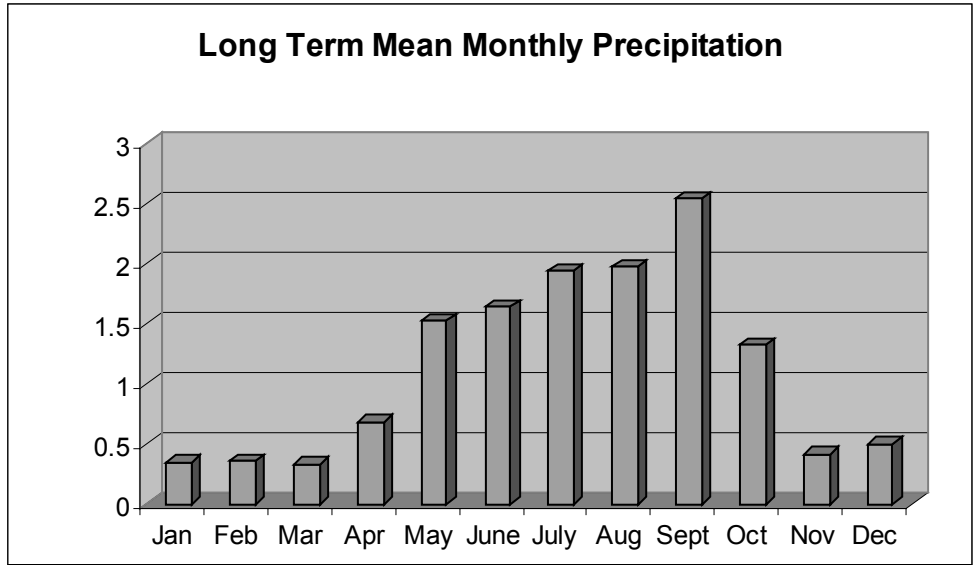
Figure 14-5:   Annual precipitation distribution at Marathon, Brewster County, Texas
                1946–1997. The value of the y-axis is inches.

The hot summers and low humidity contribute to high evaporation rates in the basin. The nearest long-term evaporation station is located at Balmorhea, 60 mi northwest of Marathon. Pan evaporation has been measured at about 70 inches per year, or over four times the mean annual precipitation at Marathon.

Marathon Basin Drainages

The largest part of the Marathon area drains to the south owing to a southward slope. Maravillas, San Francisco, and some smaller creeks flow into the Rio Grande. The tributaries of Maravillas Creek include Dugout, Pena Colorada, Monument, Wood Hollow, and Hackberry Creeks. They drain the central and western sides of the basin. The eastern side of the basin is drained by San Francisco Creek, with its main tributary being Pena Blanca Creek. The northern extent of the basin is drained by Big Canyon, which flows generally eastward to the Pecos River.

These drainages and the unnamed tributaries to them are the principal recharge sources for the water-producing formations within the basin and the spring flow that issues from various points within the basin.

General Geology of the Marathon Basin

The consolidated rocks exposed in the basin range in age from Paleozoic Cambrian to Cenozoic Tertiary. Intrusive igneous rocks occur in scattered areas, but extrusive rocks crop out only along the rim of the Del Norte Mountains to the west (King, 1937).

The Paleozoic rocks in the basin have a total thickness of about 21,000 ft. The majority of this thickness is composed of Pennsylvanian and Permian strata. Prior to the deposition of the Permian, the underlying rocks in the Marathon area were strongly folded and faulted, producing a series of northeastward-trending anticlinoria and synclinoria (King, 1937). Permian rocks, which are restricted to the south flank of the Glass Mountains and the northeast end of the Del Norte Mountains, lie unconformably on the folded and faulted surface of older rocks (Tauvers, 1988). The area was subjected to erosion prior to the deposition of the Cretaceous rocks, which resulted in the truncation of the folded and faulted rocks of the basement. Cretaceous sediments, measuring about 1,200 ft, were deposited on this erosional surface. The resulting Cretaceous surface was uplifted to form the Marathon Dome, which in turn was eroded to form a topographic basin (King, 1980). Finally, during the early part of the Tertiary period, igneous rocks intruded the Cretaceous strata (King, 1980).

Quaternary sediments mantle the present-day stream valleys and form alluvial-fan deposits at the base of the escarpments up to 125 ft thick. These units are generally very thin and serve as a catchment area for rainfall that then enhances recharge to the underlying Paleozoic rocks.

Principal Water-Bearing Units of the Marathon Basin

Marathon Limestone

The Marathon Limestone is the most productive aquifer in the Marathon area. DeCook (1961) noted that 92 wells, most in the town of Marathon, had yields from this formation that varied from a few gallons per minute (gpm) to over 300 gpm. The aquifer can best be characterized as a highly fractured limestone aquifer. Groundwater in the Marathon Limestone generally occurs under water-table conditions, but is locally (i.e., the City of Marathon) under artesian pressure and may rise a few feet above the point where it is first encountered.

The Marathon Limestone, which is Ordovician, crops out in the Marathon anticlinorium and at the northeast end of the Dagger Flat anticlinorium. The City of Marathon is situated at the north end of the Marathon anticlinorium, and wells in the city are completed in the Marathon Limestone. The thickness of the Marathon Limestone decreases from north to south, ranging from 800 to 900 ft at Marathon to about 350 ft at Dagger Flat. The Marathon Limestone is a dark-gray, flaggy limestone with gray to greenish clayey shale streaks. Sandstone and conglomerate are interbedded with the

limestone and shale. The Marathon Limestone is underlain by the Cambrian Dagger Flat Sandstone, which does not produce water.

Approximately 100 domestic and industrial wells existed in the City of Marathon in 1956. A number of these wells were completed in shallow alluvial deposits, but the majority were drilled into the Marathon Limestone. Groundwater levels measured for the Marathon Limestone at the time indicated a high of 70 ft below the surface in the southwest part of Marathon compared with a low of 150 ft below the surface on the northeast side of town. There is not much basinwide information on the water levels in the Marathon Limestone. The plethora of wells in the city of Marathon has been replaced for the most part by two municipal wells operated by the Marathon Water Supply and Sewage Corporation.

In 1956, water levels on the north side of Marathon were 150 to 154 ft below surface level. In 1969, the City of Marathon well 52-55-104 was drilled to a depth of 468 ft and the water level was found to be 152 ft below the surface. An offset well drilled in 1974 (well 52-55-105) had a water level of 125 ft below the surface. These wells have measured yields of 85 and 55 gpm, respectively. According to a limited survey of the City of Marathon during July of 2001, it appeared that most houses and businesses were connected to the municipal supply.

Alsate Shale

The Alsate Shale overlies the Marathon Limestone and crops out in the Marathon and Dagger Flat anticlinoria. The Alsate Shale, which consists of thin-bedded limestone; indurated, greenish shale; lenses of black chert; conglomerate; siltstone; and quartzose sandstone, is not known to yield water in the Marathon area.

Fort Pena Formation

The Fort Pena Formation, which unconformably overlies the Alsate Shale in the Marathon area, forms low hogbacks roughly parallel to more prominent ridges formed by much younger novaculite. This formation is chiefly an alternating sequence of limestones and shales that yield water to some wells in the area. However, judging by the lithology, only small yields should be expected from the Fort Pena Formation.

Woods Hollow Shale

The Woods Hollow Shale is poorly exposed in the Marathon area. It consists principally of light-gray-green to tan, slightly calcareous shale interbedded with laminated sandy limestone and fine-grained sandstone. It is assumed that wells are not completed in this formation.

Maravillas Chert

The Maravillas Chert crops out primarily on the inner steep slopes of hogbacks formed by the overlying Caballos Novaculite. The Maravillas Chert is not known to contribute water to any wells in the area. However, it is a highly fractured formation and does convey water that emerges as springs along contacts with the underlying Woods Hollow Shale and the overlying Caballos Novaculite.

Caballos Novaculite

The Marathon Limestone is basal Ordovician and the Maravillas Chert is considered the top of the Ordovician; whereas, the Caballos Novaculite is considered basal Devonian. The Caballos Novaculite is the principal ridge-forming formation in the Marathon area, making up the ridges or hogbacks that enclose the Marathon and Dagger Flat anticlinoria (fig. 14-4). The novaculite is not known to yield water to wells in the Marathon area, but springs issue from joints and fissures in the weathered parts of the formation.

Pennsylvanian Formations

From oldest to youngest, the Tesnus, Dimple Limestone, Haymond, and Gaptank Formations are representative of the Pennsylvanian System in the Marathon Basin. All of these formations, with the exception of the Haymond, yield small quantities of water to stock wells in the area.

Permian Formations

The Wolfcamp, Leonard, Word, and Capitan Formations are all Permian formations with no water production except for two wells in the Wolfcamp Formation and five wells in the Word Formation. These are all stock wells with very low yields.

The Cretaceous rocks that border the basin and the Tertiary rocks that are intrusives in the basin are not important sources of groundwater in the Marathon area.

Groundwater Occurrence and Movement

The geologic structure in the Marathon Basin controls the occurrence, availability, and movement of all groundwater. The Marathon aquifer is composed of the Gaptank, Dimple, Tesnus, Caballos, Maravillas, Fort Pena, and Marathon Limestone Formations (Ashworth and Hopkins, 1995). The Marathon Limestone, which is the principal and most productive aquifer in the area, is found primarily in the Marathon and Dagger Flat anticlinoria, where upfolding has brought the formation to relatively shallow depths. In these areas, groundwater occurs under water-table conditions. In contrast, in the synclinorial belts where the Marathon Limestone is downfolded, younger rocks are generally tapped for groundwater. In those areas where the Marathon aquifer is overlain by relatively impermeable strata, groundwater is confined and is under artesian pressure.

Figure 14-1 shows the extent of the Marathon aquifer as delineated by Ashworth and Hopkins (1995). This delineation coincides with the surface outcrop of Ordovician rocks such as the Marathon Limestone, which is the primary groundwater-producing formation in the basin. However, numerous wells, primarily for stock, have been completed in the Quaternary alluvial and terrace sands, gravels, and silts that occur throughout the basin. The occurrence of these wells coincides with the entire basin configuration as seen in figure 14-4.

In general, groundwater in the Marathon Basin moves southward and southeastward toward the Rio Grande. This movement reflects the surface topography and the general drainage pattern of the area. Although data are not available to map the water table accurately, information gleaned from wells in the City of Marathon, in addition to spring information at Pena Colorada and other springs and spring-fed creeks, leads to the conclusion that subsurface flow is toward the south and southeast. This fact is probably not true in the immediate vicinity of the City of Marathon, where city wells have most likely drawn down water levels.

Groundwater is at relatively shallow depths in most of the Marathon Basin. Most wells are less than 250 ft deep. According to DeCook (1961), the depth to water for 205 wells in the area was less than 150 ft below the land surface, and in 72 wells it was less than 50 ft.

Groundwater Recharge

Groundwater reservoirs in the Marathon area are recharged principally by infiltration of rainfall and stream runoff. Some underflow from outside the basin can be expected. The amount of recharge from precipitation is determined by the duration, intensity, and type of precipitation, the thickness of the vegetative cover, the porosity and permeability of the soil and underlying rocks, and the areal extent of the precipitation event.

A large part of the precipitation takes place in the summer months, when the evaporation rate is highest (fig. 14-5). Thus, only a small part of the precipitation escapes evaporation and becomes recharge. Runoff from the summer torrential downpours emerges from the steep slopes of the basin boundary areas, spreads out over the alluvial fans, and percolates into the coarse material forming the fans. If precipitation at Marathon is considered to be representative of the entire 760-mi^2 basin, the annual precipitation of nearly 13.6 inches is equal to about 550,000 acre-ft of water per year. Estimations of less than 5-percent recharge in the neighboring Alpine area (Littleton and Audsley, 1957) give rise to about 25,000 acre-ft of recharge in the Marathon area.

Recharge from underflow is only likely from the east, and any water entering the basin from this direction would most likely move southwestward, along San Francisco Creek.

Groundwater Discharge

Groundwater is discharged from the basin via spring flow, evapotranspiration, underflow southward to the Rio Grande and pumpage from wells. Good estimates for spring flow and pumpage exist, but the other parameters can only be grossly estimated.

The amount of spring discharge was approximately 880 acre-ft in 1957 and 902 acre-ft in 1976. An undetermined, but probably large, part of the groundwater moves out of the Marathon Basin as underflow through the alluvium and permeable Paleozoic rocks. These preferential pathways include the stream valleys of Maravillas, Woods Hollow, Hackberry, and San Francisco Creeks, in addition to other minor drainages.

An additional quantity of water is removed via evapotranspiration. This varies with the season, with the summer months being the greatest with the highest temperatures. Discharge by direct evaporation occurs at several places along Pena Colorada Creek, Maravillas Creek, and other streams where the water table is at or near the land surface.

Groundwater is also discharged through pumpage of wells in the basin. In 1957, about 280 wells were known in the area. The total withdrawal was probably less than 400,00 gallons per day or 450 acre-ft per year. This amount is less than 2 percent of estimated natural recharge. Although the number of wells has been reduced owing to the Marathon Water Supply Corporation, the amount of pumpage has probably increased in the basin as a result of increased tourism and expanding development.

Water Quality

The water quality of the groundwater in the Marathon Basin is generally good. Sampling of water from well 52-55-104 started in 1972, and samples have been taken and analyzed through 1998. Total dissolved solids (TDS) have averaged between 525 and 550 mg/L, chloride—115 mg/L, nitrate—11.5 to 12 mg/L, sulfate—84 mg/L, and sodium 72—mg/L. The TDS is a little high but still within acceptable limits (Ashworth and Nordstrom, 1989).

Some reports of contamination by oil, gas, and saline water have been noted, but it appears that these zones can be sealed off and uncontaminated water production achieved.

Conclusions

The Marathon Basin contains two principal aquifers, the Marathon Limestone and the Quaternary alluvium near the streams and escarpments. The Marathon Limestone yields large quantities of good-quality water in the Marathon and Dagger Flat anticlinoria. In the synclinorial areas, production is generally from shallower producers.

Yields in the basin are low because most wells are for stock purposes. Larger yields could be achieved in numerous places through proper completion techniques.

Precipitation contributes about 25,000 acre-ft of recharge per year. Discharge is about 900 acre-ft/yr from springs, 450 acre-ft/yr from pumpage, and an unknown amount from underflow and evapotranspiration.

Water quality is generally good, although the water is hard. Some oil pollution exists and should be isolated.

Recommendations

The Marathon Basin is a very undeveloped area of the State of Texas. Studies need to be conducted to expand databases throughout the basin. Well records, drillers' logs, geophysical logs, and field examinations of existing wells need to be gathered and analyzed. Water-level measurements need to be made throughout the basin. Pumping tests should be conducted to establish aquifer parameters.

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