

***THE LOWER BLACK SQUIRREL,
CHICO, AND HAYNES CREEK BASIN,
EL PASO AND PUEBLO COUNTIES,
COLORADO***

by

John C. Romero

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**OFFICE OF THE STATE ENGINEER
DIVISION OF WATER RESOURCES**

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INTRODUCTION

ABSTRACT

The proposed lower Black Squirrel, Chico, and Haynes Creek basin consists of approximately 500 square miles in southeastern El Paso and northeastern Pueblo Counties. The basin, includes all of the drainage area of Chico Creek and Haynes Creek north of the U.S. Department of Transportation Test Center (DOT) highway and all of that part of the Black Squirrel Creek basin lying south of the current south boundary of the Upper Black Squirrel Creek Designated Ground Water Basin.

The topography of the proposed basin is flat to gently rolling and much of it is covered by extensive deposits of eolian sand and loess; internal drainage is common in most of the sand-dune covered areas. The basin is semi arid with an annual precipitation of approximately 12.6 inches. All of the basin is drained by Black Squirrel Creek, Chico Creek and its tributaries, and Haynes Creek. Black Squirrel and Chico Creeks are intermittent. Chico Creek has an 18 mile-long perennial reach due to the groundwater discharge as springs and seeps in the southern half of the basin. Livestock, alfalfa, sorghum, and hay millet are the basin's chief agricultural products.

Principal geologic formations in the basin are the Pierre Shale, Fox Hills Sandstone, Laramie Formation, the Arapahoe and Denver aquifers, older alluvium, and a vast expanse of eolian (wind) deposits. The Pierre Shale is the bedrock formation in the southern two thirds of the report area and forms the lower impermeable layer along all of the basin's spring/seep discharge areas. Two sandstones in the upper part of the formation have been identified and are known to yield water to wells. The overlying Fox Hills Sandstone, Laramie Formation (lower part), and Arapahoe and Denver aquifers are part of the well known Denver Basin bedrock aquifer system. ; The Pierre Shale and Denver Basin bedrock aquifers have been dissected by an ancient stream system whose buried channels and interchannel divides are now covered by material which forms the basins principal aquifer--the older alluvium, or the alluvial aquifer.

The older alluvium or alluvial aquifer consists of gravel, sand, and silt with interbedded clay. Thickness ranges from a feather edge to 140 feet. Saturated thickness ranges from 0 along the edges of the basin to slightly over 75 feet along the deepest parts of the main buried channel. All of the high capacity wells in the proposed basin are completed in these alluvial deposits. Office research and an aquifer test conducted during the preparation of this report indicates that the hydraulic conductivity of the alluvial aquifer ranges between 150 and 320 ft. per day. The groundwater in the buried channel system is moving southward, toward the Arkansas River. A significant quantity of the groundwater is discharged by springs and seeps along Chico Creek valley and its tributaries and by interception by phreatophytes in high water-table areas. Surface-water use within the proposed basin is confined to tributary valleys of Chico Creek where small reservoirs capture spring and seep discharge. A small quantity of the water is used (in conjunction with wells) for irrigation purposes.

Colorado Division of Water Resources records indicate that at least 13,684 acre feet of water per year has been permitted and/or decreed (records are incomplete). In 1991, however, only 2169 acre feet of water was withdrawn by the basin's non-exempt wells. The quantity of drainable groundwater in the proposed basin is estimated to be 1,101,597 acre feet from the alluvial deposits and 1,682,780 acre-feet from the basins known and potential bedrock aquifers.

Investigations of the Haynes Creek and the Pueblo Ordnance Activity area south of the DOT highway reveal that only 300 to about 1600 acre feet of groundwater reaches the Arkansas River floodplain. This represents about 1 to 6 percent of the total recharge to the proposed basin and serves to illustrate the significance of the evapotranspiration occurring in the spring and seep areas.

Suitability of the lower Black Squirrel, Chico, and Haynes Creek basin for groundwater basin designation will hinge on how the Ground Water Commission applies the two basic criteria for designated ground water: 1) groundwater not required for the fulfillment of surface decrees, and 2) groundwater not adjacent to a continuously flowing stream.....

PURPOSE AND SCOPE OF THE INVESTIGATION

In 1986, the Board of Land Commissioners began studies to locate, identify and quantify ground water which may be underlying approximately 125,000 acres of state-school trust lands located in south-central El Paso County and north-central Pueblo County. Early Land Board studies were specific to a parcel of land containing 8,000 acres in Township 16 South, Range 63 West immediately south of the Upper Black Squirrel Creek Designated Basin. The Land Board's research of this ground water was prompted by information contained in hearings to designate the area now defined as the Upper Black Squirrel Creek Basin. These hearings hinted of the presence of additional ground water along the Lower Black Squirrel Creek drainage, but no detailed information was available.

The 8,000 acre parcel was studied in the 1980's. Subsequent evaluations lead to the conclusion that a thorough analysis of ground water underlying state-school trust lands in the area will require the collection and evaluation of significantly more information and data, and that the area of investigation be extended to include elements of Chico and Haynes Creek, and the lower reaches of Black Squirrel Creek. It was suggested that the larger study area may meet designated basin criteria.

During the spring of 1991 the Colorado Division of Water Resources entered into an agreement with the Colorado State Board of Land Commissioners to conduct a water resources investigation of approximately 500 square miles in parts of eastern El Paso and Pueblo Counties, Colorado. The purpose of the investigation was twofold: 1) to evaluate groundwater resources underlying land administered by the Board of Land Commissioners (SLB), and 2) to evaluate the area with respect to its suitability for groundwater basin designationin this case an extension of the existing Upper Black Squirrel Creek Designated Ground Water Basin. The results of the investigation, therefore, will also be utilized by the Colorado Ground-Water Commission to evaluate the area's suitability for basin designation.

This report is intended to fulfill requirements set forth in 37-90-106, CRS 1973 of the Colorado Ground-Water Management Act. Findings which the Colorado Ground Water Commission consider are:

- a) The name of the aquifer within the proposed designated basin.
- b) The boundaries of each aquifer being considered.
- c) The estimated quantity of water stored in each aquifer.
- d) The estimated annual rate of recharge.
- e) The estimated use of the groundwater in the area.
- f) If the source is an area of use exceeding 15 years as defined in C.R.S. 37-90-103(6), the commission shall list those users who have been withdrawing water during the 15 year period, the use made of the water, the average annual quantity of water withdrawn, and the year in which the user began to withdraw water.

The investigation involved six phases of work, each overlapping with other phases. Phase 1 consisted of initial office research, collection of basic data, and designing a test hole and monitoring well construction program. Phase 2 consisted of extensive field investigations for the purposes of hydrogeologic mapping and acquisition of hydrologic data, and the flagging of test hole and monitor-well sites. Phase 3 consisted of the construction of 54 test holes and 7 steel-cased monitoring wells. During phase 4 all data collected for and generated by this investigation were evaluated, preliminary maps were prepared, and additional field studies were completed. Phase 5, the construction of a high capacity test well and conduction of an aquifer test, was completed in March 1992. Preparation of the final report represents phase 6.

LOCATION AND EXTENT OF THE PROJECT AREA

The area of investigation consists of approximately 500 square miles in southeastern El Paso and northeastern Pueblo Counties. About 60 percent of the area lies in El Paso County and 40 percent in Pueblo County (fig 1). Figure 1 illustrates how the inclusion of Chico and Haynes Creek basins extend the width of the south boundary of the present Upper Black Squirrel Creek Designated Ground Water Basin by approximately 15 miles. The northernmost extent of the area investigated is about two miles north of State Highway 94 along Coral Bluffs. The southernmost extent is at Chico Creek bridge on the DOT (Department of Transportation) highway. Maximum north-south extent of the area investigated is about 35 miles, maximum east-west extent is about 18 miles.

An additional 80 square miles south of the DOT highway were given a cursory examination in order to evaluate the relation between the project area and the Arkansas River. The area was examined in the field, U.S.G.S. photographic quadrangle maps were evaluated, and reports by Welder and Hurr (1971), Watts and Ortiz (1990), and the U.S.G.S. Pueblo Subdistrict Office (1991) were utilized.

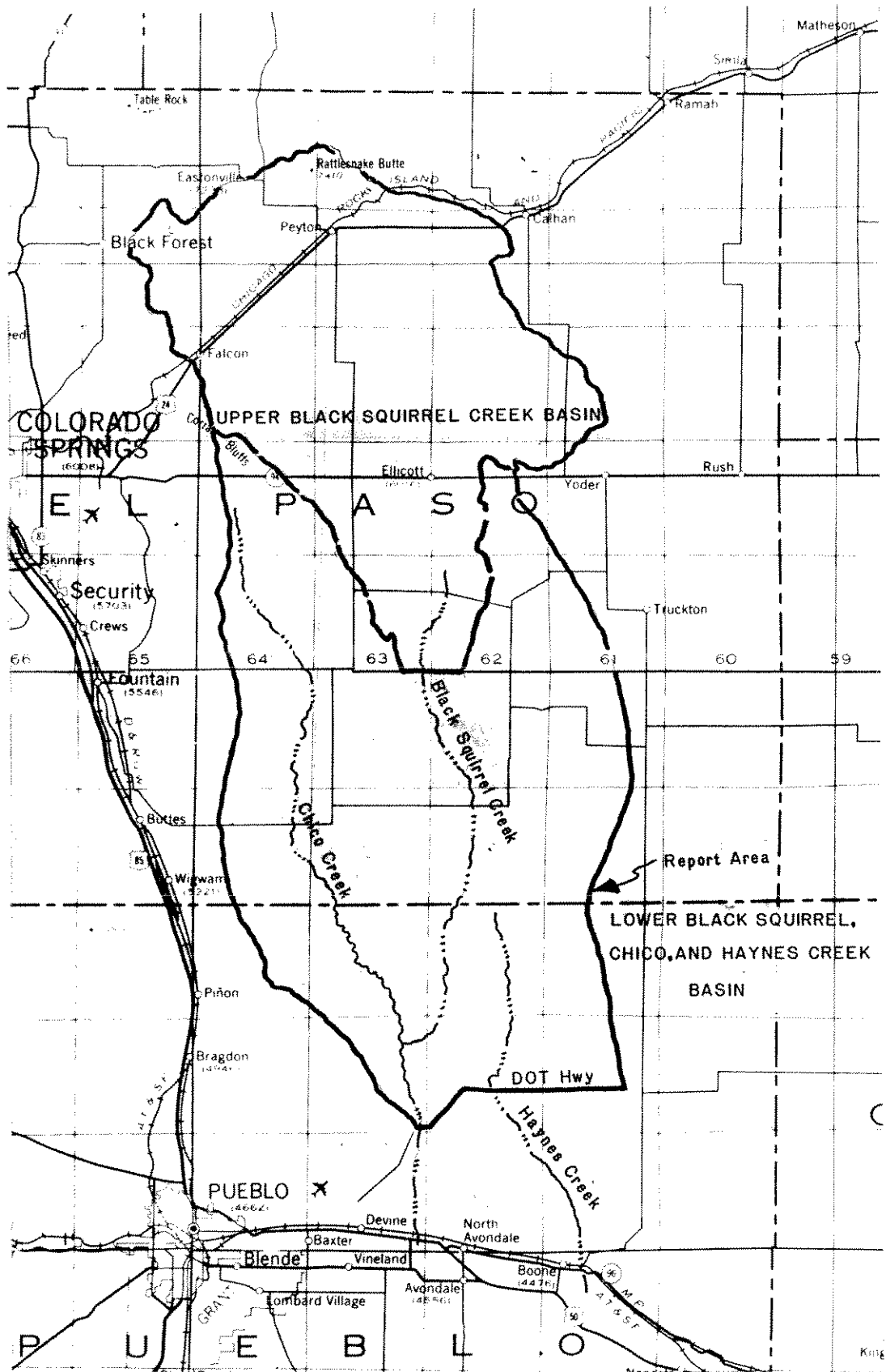


FIGURE 1. - Index map showing the location of the report area.

PREVIOUS INVESTIGATIONS

McGovern and Jenkins (1966), and Erker and Romero (1967) rendered detailed descriptions of the upper Black Squirrel Creek basin. Welder and Hurr (1971) examined the Pueblo Ordnance Facility, and Scott and others (1978) mapped the Pueblo 1° x 2° quadrangle. Kirkham and others (1988) examined the north-central part of the report area in detail and recognized the significance of the basins wetlands. The Denver Basin bedrock aquifers and potentiometric surfaces have been examined by Romero (1976, 1988) Robson and Romero (1981), Robson and others (1981), and Van Slyke and others (1988). The Colorado Division of Water Resources (1989) evaluated the Horse Creek basin the basin adjoining the report area on the east, and the U.S. Department of Agriculture, Soil Conservation Service (1979, 1981) mapped the soil species of the entire area.

ACKNOWLEDGEMENTS

Construction of all of the test holes and monitoring wells and the construction of the high capacity test well, and the conduction of 28-hour aquifer test was funded by the State Land Board. The Land Board also funded most general field expenses and funding for map and report preparation. Mr. Joseph Forney of the John Hancock Mutual Life Insurance Company furnished the author with pertinent agricultural data and allowed unrestricted access to Chico Basin Ranch. The author expresses gratitude to the many ranchers who allowed access to their property for test-well construction.

Messrs. Curtiss Turner, James Curliss, and Melvin Bird were responsible for giving the author a hydrogeologic tour of the land occupied by the Pueblo Ordnance Facility and furnished information on the Facility's water-use characteristics. Thanks is also extended to Gunars Spons of the U.S. Department of Transportation, Mark White of the Association of American Railroads, and to Frank Kipple of the Division II office of the Colorado Division of Water Resources.

GEOGRAPHY

TOPOGRAPHY AND DRAINAGE

The area of investigation lies within the Colorado Piedmont section of the Great Plains physiographic province. Topography is flat to gently rolling. Much of the area occupied by interstream divides, of Chico Creek-Black Squirrel Creek, and Black Squirrel Creek-Haynes Creek is covered by northwest to southeast trending stabilized sand dunes and interdune basins with no external drainage. The only significant stream dissections are those formed by Chico Creek, and Black Squirrel Creek south of Township 17 South. Haynes Creek is practically unidentifiable except at the south boundary of the Department of Transportation Test Center (DOT). Total relief of the area is approximately 2000 feet.

All of the project area is drained by Black Squirrel Creek, Chico Creek and its tributaries, and Haynes Creek. As noted above some interdune areas have no external drainage. Black Squirrel Creek is an intermittent stream with a normally dry sandy stream bed. It has a very short perennial reach east of Bar J H Ranch about 2000 feet upstream from its confluence with Chico Creek. Chico Creek is intermittent in the headwaters area but becomes

perennial two to three miles south of Hanover Road. The perennial characteristic is due to two phenomena. The first is the fact that two to three miles south of Hanover Road, the Chico Creek stream bed is cut into dense, relatively impermeable Pierre Shale and stream bed deposits are generally less than five feet thick. The second phenomenon involves discharge of groundwater along the alluvium - Pierre Shale contact along generally southwest - facing escarpments. Groundwater discharge occurs as seeps and springs with many of the latter discharging several gallons per minute. Spring discharge from a small Chico Creek tributary south of Chico Basin Ranch headquarters was measured at 214 gallons per minute. Ten to 15 miles of spring-seep discharge area has been identified. South of Bar J H Ranch, Chico Creek becomes intermittent with short perennial reaches. On October 9, 1991, Chico Creek flow at the south boundary of the project area was approximately 15 gpm.

Haynes Creek is intermittent and practically unidentifiable except along the south boundary of the project area at the DOT highway. Here the stream is identified by boggy terrain with phreatophytic grasses. This is believed to be the result of a perched water table which will be discussed in a later section of this report.

Both the Chico Creek and Haynes Creek drainages enter the Arkansas Valley floodplain six and nine miles respectively south of the DOT highway.

CLIMATE

Black Squirrel, Chico, and Haynes Creek basin is semi-arid with moderate winters and warm to hot summers. Average annual precipitation ranges from about 13.5 inches in the northern half of the basin to about 11.5 inches in the southern half. Some parts of the basin experience long dry spells between precipitations and many precipitations are 0.1 inch or less (National Oceanic and Atmospheric Administration). Normal seasonal distribution of precipitation for the entire basin is 9.1 inches for May - September and 3.5 inches for October - April. Most of the May - September precipitation occurs as thundershowers. Strong wind is common to the basin and often accompanies the thundershowers.

Such precipitation is sufficient only for native grasses and some small grains. Successful crop growth is dependent upon irrigation.

AGRICULTURE AND INDUSTRY

Livestock, alfalfa, sorghum, hay millet are the principal agricultural products of the basin. Most of the irrigated land is irrigated with water pumped from wells penetrating saturated alluvial deposits near the buried channel of Black Squirrel Creek. Limited irrigation is accomplished by diversions of impounded seep and spring water within major tributaries of Chico Creek.

Principal non-agricultural activities within the basin are the presence of small subdivisions and Falcon Air Force Base in the extreme northwestern part of the area, and the Department of Transportation Test Center (operated by the U.S. Railroad Administration) in the southeastern part of the area investigated.

The area is served by State Highway 94 (north part of area) and a number of paved and graveled county roads.

DRILLING AND AQUIFER TESTING PROGRAM

An extensive test hole-drilling program was initiated during the spring of 1991. The purpose of the program was twofold and involved two phases. Phase 1 was designed to determine whether or not a buried hydraulic barrier separated Black Squirrel Creek groundwater flow from Haynes Creek groundwater flow. If such a barrier existed, approximately 170 square miles of Haynes Creek basin could be eliminated from the study. Phase 2 was designed to strategically distribute test-hole drilling, with the funds remaining after completion of Phase 1. Both Phase 1 and 2 test holes were located as to best fill the vast information gap south of Meyers Road and generally east of Chico, Basin Ranch headquarters. Each hole was drilled to a depth sufficient to identify Pierre Shale bedrock.

A total of 54 test holes were completed during phases 1 and 2. Each was constructed using rotary drilling methods, equipped with slot perforated 2 inch PVC casing, gravel packed and allowed to stand for a 24 to 48 hour waiting period. At the end of the waiting period, a water level measurement was made. Shortly thereafter, the test wells were backfilled pursuant to methods approved by the Revised and Amended Rules and Regulations of the Board of Examiners of Water Well Construction and Pump Installation Contractors.

A total of seven steel-cased monitoring wells were constructed along the south boundary of the area of investigation (the DOT highway). Each was equipped with 6-5/8 inch steel casing, slot perforated 2.4 inch PVC, gravel packed, cemented, and furnished with a lock and cap pursuant to the Water Well Construction and Pump Installation Contractors Rules and Regulations.

The following paragraphs give the location, depth, elevation, and water level, for each monitoring well, and describes the lithologic characteristics encountered in each well. Registrations for the wells are on file at the Colorado Division of Water Resources, Denver office. Location, depths, and lithologic information on each of the 54 test holes are also filed at that office.

Monitoring Well:	BCHM1		
Location:	SW 30,T.19S.,R.62W	Elevation:	4730 ft.
Total depth:	21 ft.	Water level:	19.9 ft.
Date drilled:	9/25/91	Date:	9/27/91

0-25 ft. pale brown - light yellowish brown loamy sand underlain by about 23 feet of very fine to medium clayey sand, grading to very coarse sand and fine gravel in the lower 15 feet, lower foot is fine gravel, some limonite staining; 25 - 28 ft. dense, dusky blue shale. Bedrock pick at 25 feet.

Monitoring Well:	BCHM2		
Location:	NWNW29,T.19S.,R.62W	Elevation:	4835 ft.
Total depth:	70 ft.	Water level:	41.4 ft.
Date drilled:	9/25/91	Date:	9/27/91

0-14 ft. pale brown to brownish yellow sandy loam 14-18 ft. very pale brown-whitish caliche, tight; 18-68 ft. medium to very coarse sand with thick interbeds of fine gravel, yellowish brown to brownish yellow; 68-75 ft. medium - dark bluish gray shale. Bedrock pick at 68 feet.

Monitoring Well:	BCHM3		
Location:	NENE21,T.19S.,R.62W	Elevation:	4842 ft.
Total depth:	83 ft.	Water level:	21.0 ft.
Date drilled:	9/25/91	Date:	9/27/91

0 - 23 ft. sandy loam, fine to medium eolian sand pale brown to light yellowish orange; 23-27 ft. indication of caliche, sandy, soft; 27-38 ft. very coarse gravelly sand with interbedded fine gravel; 38-43 ft. pale brown to yellowish brown clay; 45-53 ft. fine to medium sand with thin interbeds of clay; 53-78 ft. gravelly sand as above; 78-83 ft. dense, dark gray shale. Bedrock pick at 78 feet.

Monitoring Well:	BCHM4		
Location:	N 1/4 Cor 22,T.19S.R.62W	Elevation:	4826 ft.
Total depth:	57 ft.	Water level:	0.65 ft.
Date drilled:	9/25/91	Date:	9/27/91

0-4 ft. sandy loam; 4-10 ft. pale yellowish brown calcareous clay, stiff; 10-15 ft. light brownish yellow - gravelly sand; 15-20 ft. light bluish gray clay; 20-23 ft. fine to medium sand; 23-30 ft. grayish blue clay; 33-53 ft. fine to very coarse sand with interbedded fine gravel, to 1/4 inch; 53-55 ft. gravel as above, significant quantity of dark minerals renders a "salt and pepper" appearance, some limonite staining; 55-60 ft. dense, dark gray shale. Bedrock pick at 55 feet.

Monitoring Well:	BCHM5		
Location:	SWSE14,T.19S.,R.62W	Elevation:	4818 ft.
Total depth:	47 ft.	Water level:	27.9 ft.
Date drilled:	9/26/91	Date:	9/27/91

0-15 ft. fine to medium silty sand, pale brown to yellowish brown; 15-18 ft. clayey, silty, sand; 18-23 ft. fine sand; 23-28 ft. pale brown clay; 28-31 ft. sand, gravel; 31-39 ft. yellowish brown to olive clay; 39-44 ft. very coarse sand, gravelly, 1 ft. fine gravel on bottom; 44-55 ft. dense, dark gray shale. Bedrock pick at 44 feet.

Monitoring Well:	BCHM6		
Location:	SESW13,T.19S.,R.62W	Elevation:	4858 ft.
Total depth:	63 ft.	Water level:	dry
Date drilled:	9/26/91	Date:	9/27/91

0-21 ft. fine to medium silty sand with thin clay layers from 15 to 21 ft. light yellowish brown to brownish yellow; 21-25 ft. light olive gray clay rapidly changing to dense, dark bluish gray shale. Bedrock pick at 21 feet.

Monitoring Well:	BCHM7	Elevation:	4858 ft.
Location:	NESE24,T.19S., R.62W	Water level:	dry
Total depth:	63 ft.	Date:	9/27/91
Date drilled:	9/26/91		

0-29 ft. fine to medium silty sand, coarsening with depth; 28-29 ft. very coarse sand and gravel; 29-32 ft. dense light olive gray shale; Bedrock pick at 29 feet.

During March 1992, an aquifer test was conducted on the older alluvial deposits of the buried Black Squirrel Creek channel in section 13, T.16 South, Range 63 West. To conduct the test, a test well was constructed between Colorado Geological Survey monitoring wells CGS 4 and CGS 5a (fig. 2) ...wells drilled for the Kirkham and others study (1988). Observations during testing were conducted at the CGS wells, an observation well (No. 1) constructed 50 feet east of the test well, and at a water-supply well constructed 250 feet west of the test well.

The test well was constructed using reverse-rotary methods, equipped with 102 feet of 16 inch steel casing and 60 feet of well screen, gravel packed, and cemented pursuant to the Water Well Construction and Pump installation Contractor's Rules and Regulations. The test well was equipped with a submersible pump with electricity supplied by a portable electric generator. Water from the discharge pipe was conducted away from the test site by 180 feet of 8 inch irrigation pipe. One day before the aquifer test, the test well was developed for approximately seven hours. During this time, the metered discharge was allowed to vary between about 500 and about 1100 gallons per minute.

The aquifer test began at approximately 12 noon March 17, 1992 and extended for 27 hours. During that time the average discharge was 975 gallons per minute. Difficulties prevented drawdown measurements in the pumped well, therefore, aquifer characteristics had to be determined from measurements in observation Well No. 1. Drawdowns observed in Observation Well No. 1 were adjusted and plotted as required by the Cooper-Jacob method of determining aquifer transmissivity (Wilson, 1965). The following list summarizes pertinent data for the well observations.

Elevation (sea level datum)	5515 ft.
Total depth	160 ft.
Depth to Pierre bedrock	158 ft.
Initial water level	88.79 ft.
Final water level	101.96 ft.
Initial saturation	70 ft.
Length of observation	27 hrs.
Calculated transmissivity	22,110 ft. ² /d
Calculated hydraulic conductivity	316 ft./d

Expressed in Meinzer units the transmissivity is 165,000 gallons per day per ft. and the coefficient of permeability is 2360 gallons per day per square foot. Drawdown plots and all calculations are on file at the Colorado Division of Water Resources, Denver office.

R.63W. R.62W.

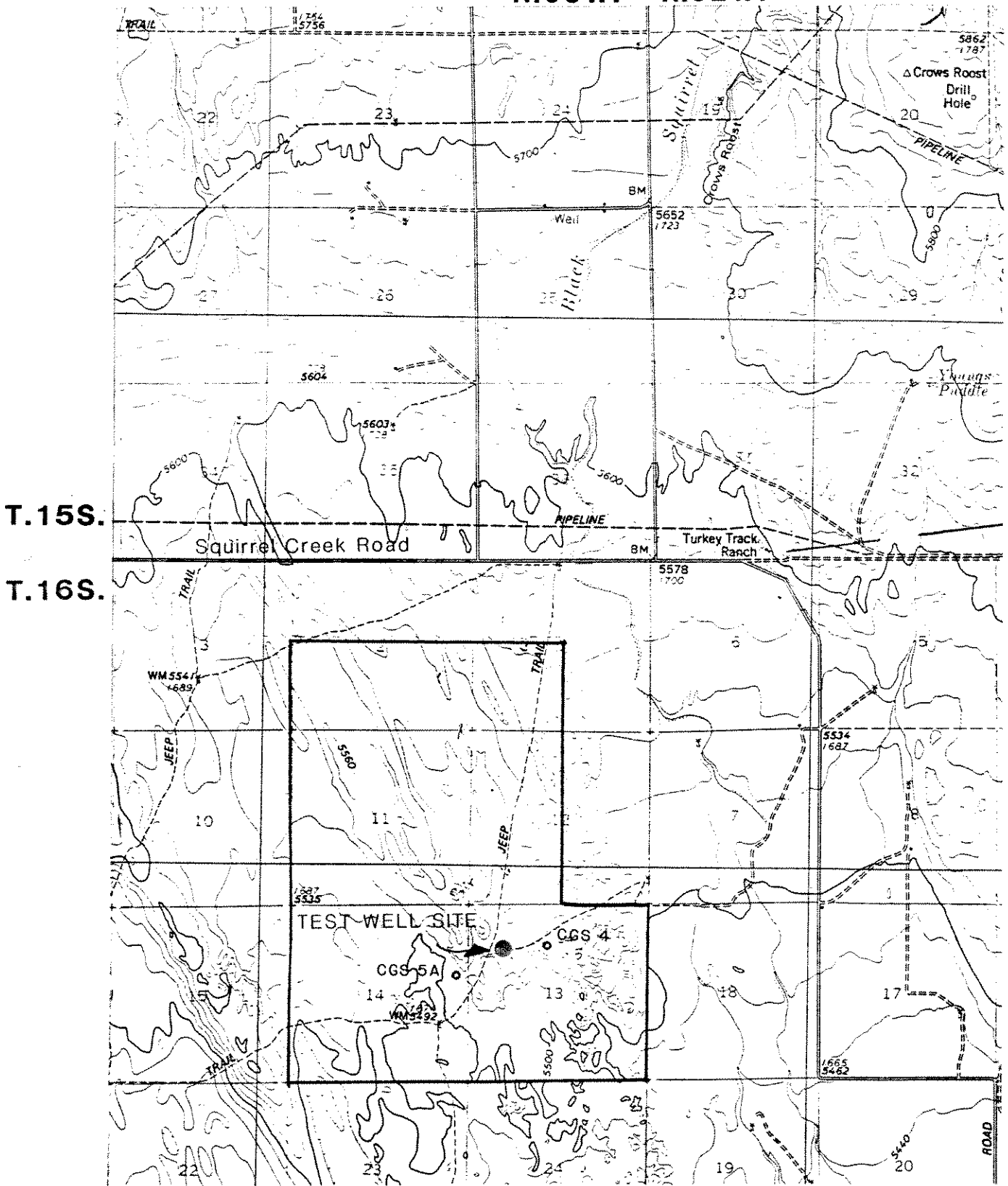


FIGURE 2.- Map showing the location of the test well.

GEOLOGIC FORMATIONS

SUMMARY OF REGIONAL GEOLOGY

The Black Squirrel, Chico, and Haynes Creek basin lies along and extends to about 22 miles south of the Denver groundwater basin. In the northern "ears" of the study area the surficial deposits are underlain by the generally northward-dipping Denver, Arapahoe, and Laramie-Fox Hills aquifers and the Laramie Formation. South of Squirrel Creek Road the Laramie-Fox Hills aquifer pinches out and the bedrock formation southward to the Arkansas River floodplain is the Pierre Shale. Except along the flanks of deep stream cuts, all of the bedrock strata are covered by alluvial and eolian (wind blown) deposits ranging in thickness from a feather edge to about 180 feet.

Stratigraphy of the surficial and bedrock units, along with their general aquifer properties are described in table 1. Figure 3 is a general geologic map of the basin and figures 4 through 6 are generalized north-south and east-west cross sections of the basin.

BEDROCK FORMATIONS

The oldest bedrock formation which underlies the surficial units in the basin is the Pierre Shale. The Pierre Shale underlies surficial deposits in all of the basin which lies south of the outcrop/subcrop of the base of the Laramie-Fox Hills aquifer. The Pierre Shale consists of 4,000 to 5,000 feet of medium to dark gray shale, claystone, siltstone, sandstone, and limestone of marine origin. Outcrop and subcrop colors are frequently olive gray and yellowish brown. Siltstone, sandstone, and limestone not only occur as thin interbeds throughout the entire formation, but also occur as distinct groups of strata. Kitley (1978) and Soister (1968) are among those investigators who have identified 3 to 5 or more major groups of strata within the Pierre Shale.

The uppermost 500 to 800 feet of the Pierre (frequently referred to as the upper transition member) is of particular interest because of the presence of distinct sandstone beds. The thickest of these lies approximately 250 feet below the Laramie-Fox Hills (L-F) aquifer. The sandstone is approximately 120 feet thick and forms a subcrop width of about 3000 feet (figs. 7,8, plate 1). A second sandstone lies at a depth of about 850 feet below the base of the upper sandstone with its outcrop-subcrop about three miles south of this upper sandstone (figs. 7, pl. 1). Both sandstones dip toward the north at a rate of 185-370 feet per mile. The sandstones are important because of their aquifer potential. Limited outcrop areas have prevented identification of other Pierre sandstones within the basin. The Pierre Shale is in transitional contact with the overlying Fox Hills Sandstone.

The Fox Hills Sandstone is composed of 175 to 275 feet of very fine to medium grained, locally ferruginous sandstone with thin to thick interbeds of siltstone and shale all of shallow marine (beach) origin. Siltstone predominates in the lower half of the formation. Ironstone concretions are common as are marine fossils, particularly in the lower part. Outcrop colors are yellowish gray to brown with olive gray in the lower half. Sandstone predominates in the upper one third of the formation. This sandstone is referred to as the Milliken Sandstone Member in many parts of the Denver Basin.

Overlying the Fox Hills Sandstone are 300 to 400 feet of shale and sandstone of the Laramie Formation. The lower 120 to 150 feet is composed of one or two generally 50 to 100 foot thick beds of medium-grained sandstone with 5 to 10 feet or more shale commonly separating the two. Outcrop colors range from white to medium yellowish gray sandstone olive gray to grayish brown shale. These lower Laramie sandstones form the upper two-thirds of the Laramie-Fox Hills aquifer. One of the most significant exposures of the L-F aquifer is at Crows Roost, in the Upper Black Squirrel Creek Basin, in Section 19, T.15S., R.62 W., approximately two miles northwest of Turkey Track Ranch.

The upper 180 to 250 feet of Laramie Formation is composed of medium to dark gray and occasionally olive gray shale with thin interbedded sandstone. The shale is commonly carbonaceous and up to three coal beds have been identified (Soister, 1968). The coal has been economically exploited in many areas of the Denver Basin. The Laramie Formation represents a transition between the marine deposition of the underlying Fox Hills Sandstone and continental deposition of the overlying Arapahoe Formation.

The Arapahoe Formation of the Colorado Division of Water Resources is equivalent to the Division's Arapahoe aquifer. This nomenclature, first introduced in 1976 and again in the early 1980's, has now been generally accepted by most investigators of Denver Basin bedrock aquifers. The Arapahoe aquifer is composed of 300 to 400 feet of interbedded shale and sandstone. In the southern part of the Denver Basin, the Arapahoe Formation sandstone to shale ratio is commonly 1:1 and it is not unusual for shale to predominate over sandstone in a ratio of 2:1. Arapahoe sandstone is generally medium to coarse grained, locally conglomeratic, quartzitic, and feldspathic. Outcrop colors range from light yellowish brown to reddish brown. Shales of the Arapahoe are commonly silty, with colors ranging from light yellowish gray to pale olive and olive brown.

Overlying the Arapahoe aquifer and separated from it by a 20 to 80 foot shale, are sandstones with interbedded shales of the Denver aquifer. Only the lowermost 100 feet of Denver aquifer are present in the area of investigation; about 100 feet in the extreme northwest and probably less than 50 feet in the extreme northeast (pl. 1). The Denver is exposed along Corral Bluffs where it is composed of light reddish brown sandstone with minor beds of medium olive gray to medium gray carbonaceous shale. Like the underlying Arapahoe aquifer, the Denver aquifer becomes more effective with increasing distance from the outcrop.

The Pierre, Fox Hills, Laramie, Arapahoe, and Denver strata dip toward the trough of the Denver Basin at angles generally ranging from 2 to 6 degrees.

SURFICIAL FORMATIONS

Except in outcrop areas, all of the bedrock strata are overlain by unconsolidated alluvial and eolian deposits which, in combination, range in thickness from a feather edge to about 180 feet. Kirkham and others (1988) recognize three distinct types of surficial deposits within their project area: 1) modern stream alluvium (Qal) in the present channel of Black Squirrel Creek; 2) eolian (wind blown) deposits (Qe); and older alluvial deposits (Qoa) underlying the eolian deposits. This author agrees with Kirkham and others, but extends (Qa1) identification to Chico Creek and its major tributaries, and the (Qoa) to the entire project area except where Pierre strata is exposed.

TABLE 1 - Stratigraphic units and their water bearing properties

	Series	Geologic Unit	Thickness (feet)	Physical Character	Water-bearing properties
		Modern stream alluvium	0-20	Unconsolidated sand, gravel, silt, and clay. Includes floodplain deposits immediately adjacent to the present stream channel.	Except for Chico Creek valley, lies above the water table and is not utilized for water. It allows precipitation and runoff to percolate to underlying strata.
		Eolian deposits	0-140	Unconsolidated very fine to medium sand, silt, and clayey, sandy silt. Thin interbeds of coarse sand have been reported. Wind deposited. Important because it allows rapid downward percolation of precipitation.	Not utilized for water as they generally lie above the water table.
		Older alluvium	0-140	Unconsolidated fine to very coarse sand and fine gravel with interbedded silt and clay. Grayish orange to reddish yellow, pinkish, whitish. Basal two feet iron oxide cemented with particle size to 4-6 inches.	The basins principal aquifer. Saturation up to about 75 feet. Well yields up to 900 to 1000 gpm.
Tertiary	Early Tertiary	Denver aquifer	0-100	Unconsolidated to consolidated light reddish brown sandstone with interbeds of carbonaceous shale. Only the lowermost 100 feet of the aquifer is present within the report area.	Yields 1 to 10 gpm to domestic and stock wells in the northern part of the report area.
		Atapahoe Formation	0-400	Unconsolidated to consolidated yellowish brown to reddish brown sandstone with interbeds of silty shale. Sandstones generally medium to coarse grained; locally conglomeratic, quartzitic. Total aquifer thickness averages 400 feet.	Locally high shale to sandstone ratios render the aquifer of marginal importance in the southern Denver Basin. Most wells in the report area yield 1-10 gpm.
		Laramie Formation	0-400	Upper half is generally consolidated medium to dark gray shale with thin interbeds of fine-grained sandstone. Coal beds common-particularly in lower part. Lower part consists of up to 150 feet of medium-grained sandstone which forms the upper part of the Laramie-Fox Hills aquifer (L-F aquifer).	Upper part not utilized. Lower sandstones from the upper or Laramie part of the Laramie-Fox Hills aquifer.
System		Laramie Fox-Hills aquifer	0-240	Generally consolidated white (top) to brown (base) medium to very fine grained sandstone with interbeds of siltstone and shale. Ironstone concretions common. Upper part may be carbonaceous. Thickness 0-240 feet.	A principal Denver Basin bedrock aquifer. Well yields to 200 gpm or more in deeper parts of the basin.
		Fox Hills Sandstone	0-275	Generally consolidated medium to very fine grained, locally ferruginous sandstone with interbeds of siltstone and shale. Siltstone predominates in the lower half. Ironstone concretions common. Yellowish gray to brown. Upper sandstone and siltstone forms lower part of the L-F aquifer.	Lower part not utilized unless significant siltstone beds are present. These are not always water yielding. Upper part forms the Fox Hills part of the L-F aquifer.
		Pierre Shale	0-5000	Generally consolidated medium to dark gray shale, claystone, siltstone, sandstone, and limestone. Shale and claystone predominates throughout the entire formation. Outcrop colors olive gray to yellowish brown.	Not utilized as an aquifer except in outcrop/subcrop areas where significant sandstones are present. Two such beds lie in the report area. The shallowest is about 200 feet below the L-F aquifer and is known to yield up to 90 gpm. The second outcrops along Meyers Road but needs more study.

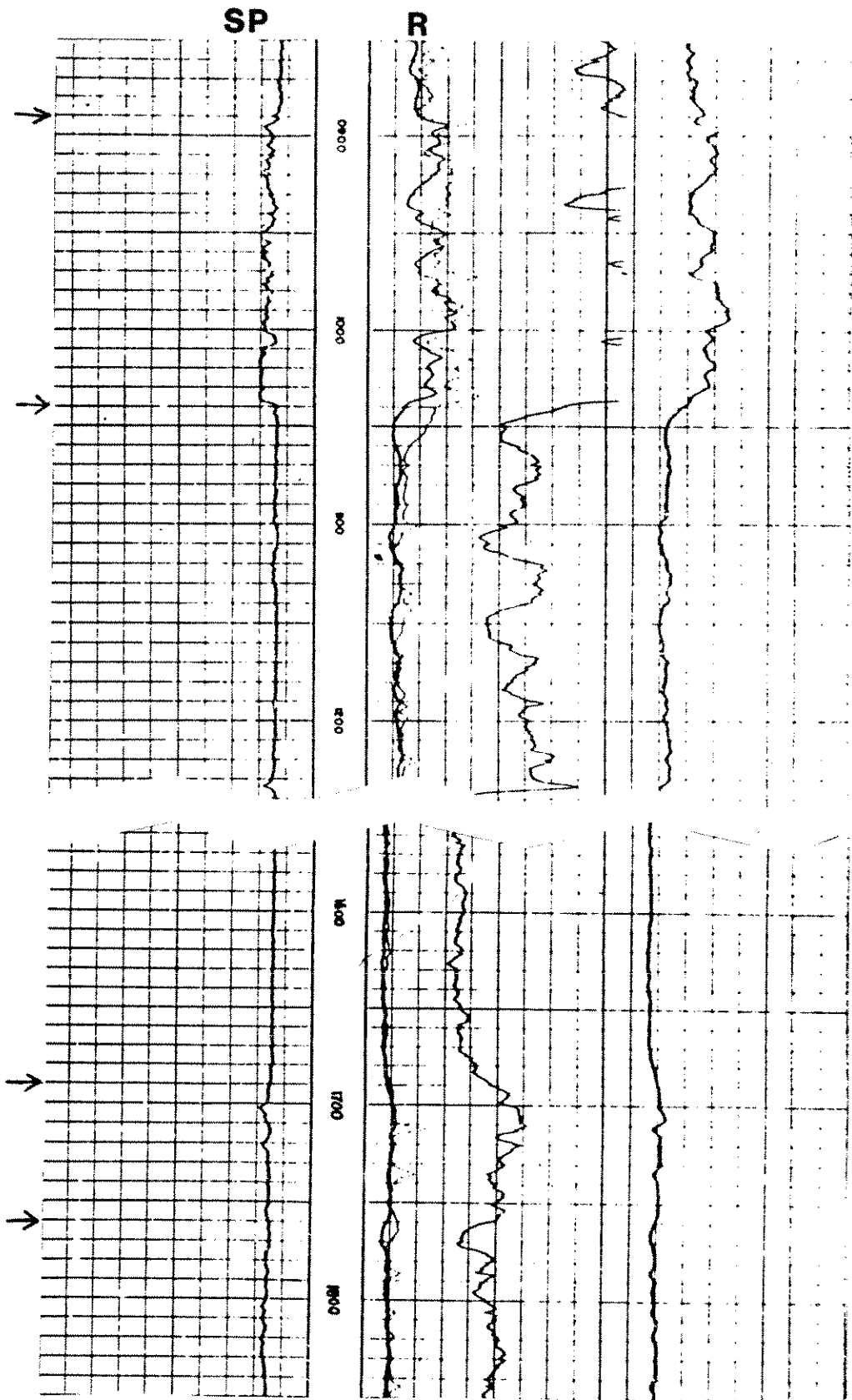


FIGURE 7. - Copy of a portion of a geophysical log in Section 3, T.15S., R.63 West showing the uppermost part of the Pierre shale with a prominent sandstone in the interval 890 - 1040 feet, and a less distinct sandstone at 1690 - 1760 feet.

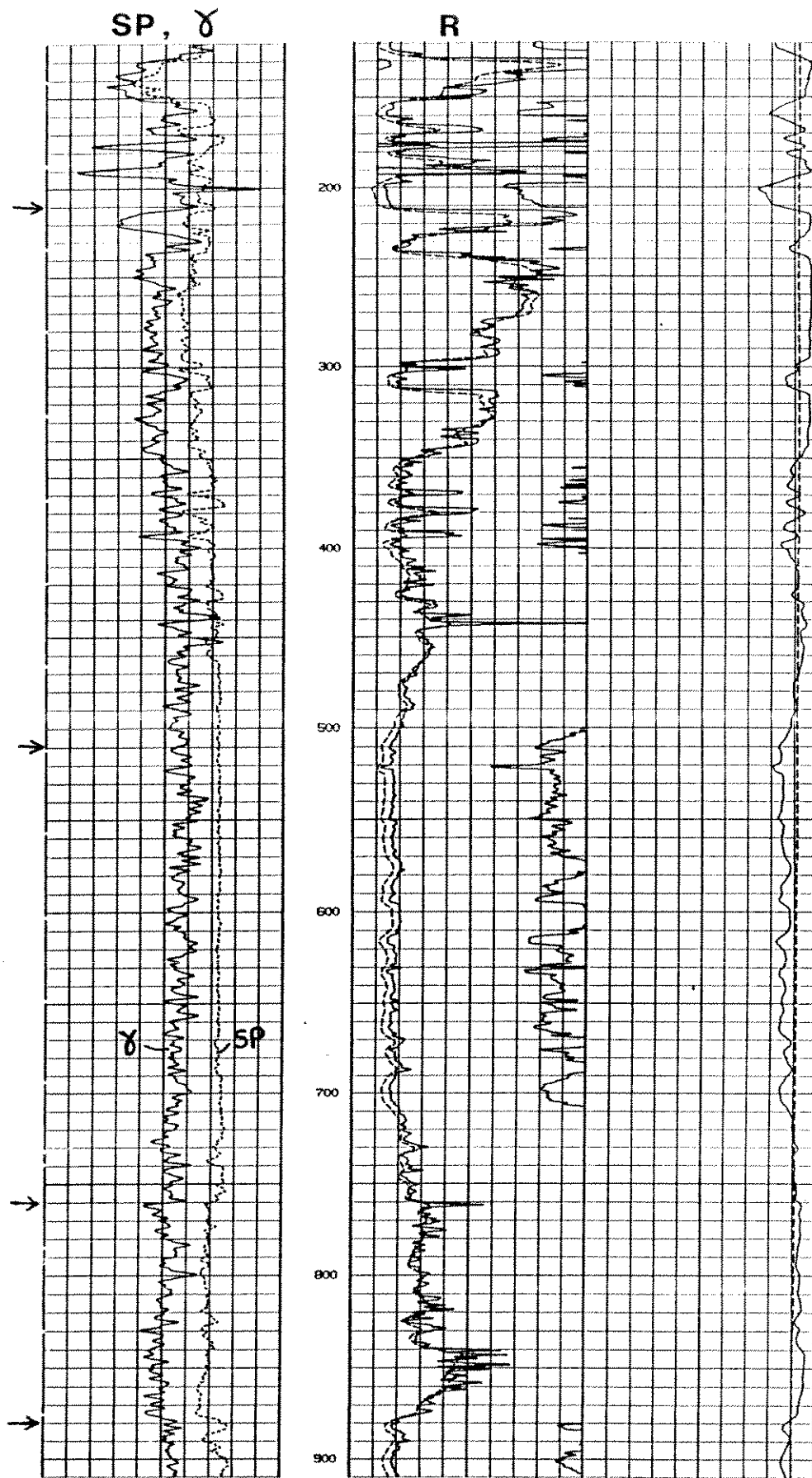


FIGURE 8. - Copy of a portion of a geophysical log of a water well in Section 30, T.14S., R.64 West showing the Laramie Fox Hills aquifer (210 - 510 ft.) and a prominent sandstone in the upper part of the underlying Pierre shale (760 - 880 ft.).

The older alluvium overlies all of the erosion surface of the Pierre Shale except where the latter is exposed along stream cuts. Thickness of these deposits ranges from a feather edge to 100-140 feet. Composition is fine to predominantly very coarse sand and fine gravel with a few 5 to 10 foot interbeds of clay. The sand and gravel is composed of generally subangular to medium rounded particles of quartz, feldspar, and other rock particles. Color is generally grayish orange to reddish yellow, and can be distinctly pinkish or whitish depending upon pink feldspar and quartz content. Particle size ranging from 1/4 to 3/4 inch is common. The clay interbeds are generally 3 to 10 feet thick, tight, and light to dark yellowish brown in color. The clay content in most of the holes was less than 15 percent. The basal two to four feet of the older alluvium is commonly a partially iron-cemented reddish orange sand and gravel with particle size ranging from very coarse sand to 4 to 6 inches. All of the study area's high capacity wells and about 180 domestic and stock wells are completed in the older alluvium.

Eolian deposits cover practically the entire area of investigation. A considerable percentage of the eolian deposits are in the form of generally stabilized sand dunes and narrow to wide interdune flats. All of the dunes are oriented in a northwest-southeast direction and some extend for a distance of several miles. They are locally quite hummocky and have no distinct external drainage. The dunes are composed of very fine to medium sand, silt, and clayey sandy silt. Both Kirkham and others (1988) and Soister (1968) report the presence of thin interbeds of coarse-grained sand and gravelly sand. Thickness of the eolian deposits ranges from a feather edge to 10 or 20 feet in interdune areas to 40-60 feet in most dune areas. It is possible that 120 to 140 feet of material occurs on the larger dune ridges.

The eolian deposits of the basin are important hydrogeologically because they serve as catchment material which allows for rapid downward percolation of precipitation to the underlying older alluvium.

Modern stream alluvium occupies the present channels of Black Squirrel, Chico, and (to a small extent) Haynes Creek. The alluvium is composed of sand, gravel, silt and clay derived from deposits within the basin (including Upper Black Squirrel Creek Basin). In this report, the term alluvium is extended to include floodplain deposits immediately adjacent to the present stream channel. Chico Creek alluvium is distinct throughout most of its entire length. Its width ranges from a few feet in the headwaters area to approximately 100 feet near the DOT highway at the south boundary of the basin. Black Squirrel Creek alluvium is distinct only in the northern half of the basin and near its confluence with Chico Creek. South of Squirrel Creek Road, Black Squirrel Creek diminishes in width from about 100 feet to less than 10 feet several miles south. In many areas, Black Squirrel Creek is only slightly recognizable, in others the channel is 30 to 40 feet wide. South of Township 18 South, Black Squirrel Creek is composed of a number of subchannels and has cut a floodplain nearly 3/4-mile wide. This feature is prominent on topographic maps. This flood plain is not covered by stream alluvium of the classic sense, but by sandy loam, and loamy sand which support medium to dense growths of saltbush, greasewood, sage and a number of other vegetation types. Thickness of both Black Squirrel and Chico Creek alluvium is believed to be less than 15 feet.

Haynes Creek does not have a distinct channel north of the DOT highway. It is recognizable only by virtue of the dense vegetation which grows along the base of the valley it occupies and only in the southern part of DOT Test Track area.

In this report descriptions of the eolian deposits and, to a slight degree, the modern stream alluvium have been simplified. For a detailed description of these deposits and associated soils, along with their physical properties, the reader is referred to U.S. Dept. of Agriculture, Soil Conservation Service, Soil Survey reports for El Paso County and the Pueblo area.

No wells are completed in the modern stream alluvium. Black Squirrel Creek alluvium is important because it allows precipitation and surface runoff to percolate to the older alluvium.

WATER RESOURCES

GROUNDWATER

Groundwater can be obtained from all of Black Squirrel Creek, Chico Creek, and Haynes Creek basin's bedrock aquifers and from the older alluvium (table 1). Bedrock aquifers are important in areas where surficial aquifers are dry or do not have sufficient saturation. A good example of such an area is in the northwestern ear of the proposed basin. In this area over 100 water wells have been constructed in bedrock strata. The older alluvium is the only aquifer in the basin with sufficient saturation to sustain high capacity irrigation wells. All of the basin's irrigation wells are south of Squirrel Creek Road, or south of T.15 South.

Table 2 is a list showing the distribution of exempt (low capacity) wells by aquifer.

TABLE 2 - Distribution of exempt wells in the Lower Black Squirrel, Chico, and Haynes Creek basin by aquifer (as of fall 1991).

<u>Aquifer/aquifers/formation</u>	<u>No. of Wells</u>
Older alluvium	155
Older alluvium and Pierre	27
Denver aquifer	49
Arapahoe aquifer	65
Arapahoe and Laramie	2
Laramie	10
Laramie-Fox Hills aquifer	14
L-F and Pierre	1
Pierre Shale, sandstones	79
Total as of fall 1991	402

Upper Pierre sandstones

Sandstones and siltstones of the Pierre Shale are known to yield small quantities of water throughout most of eastern Colorado - wherever the strata are relatively close to land surface and are sufficiently saturated with water. Two such sandstones occur within the project area. The uppermost of these lies at a depth of approximately 250 feet below the base of the Laramie-Fox Hills aquifer (fig. 7). This Pierre aquifer was first utilized by a well in the Jimmy Camp Creek drainage basin southeast of the City of Colorado Springs (fig. 8). The well completed in this sandstone yields 90 gpm of reportedly excellent-quality water. Geophysical logs of the sandstone reveal that it is approximately 120 feet thick and extends over a potential water-production area of at least 200 square miles. The lower sandstone outcrops along Meyers Road in section 4,T.17 South, Range 61 West (fig. 7, pl. 1). Colorado Division of Water Resources files reveal that approximately 80 small capacity water wells have been completed in the Pierre Shale, many in the two significant sandstones mentioned herein and the remainder in Pierre strata of marginal aquifer characteristics.

Laramie-Fox Hills aquifer

The Laramie-Fox Hills (L-F) aquifer is the oldest of the Denver Basin bedrock aquifer system. The L-F aquifer is composed of Milliken Sandstone Member and any significant siltstones lying directly below it, and the lower 120 to 150 feet of the overlying Laramie Formation. In some areas the lower Laramie is composed of one or two distinct sandstone beds "A" at the base, "B" above it (fig. 8). In some areas neither the A or B or Milliken Sandstone is distinct and the L-F aquifer forms a single distinct sandstone underlain by generally 100 feet of siltstone. Experience with the L-F aquifer in other parts of the Denver Basin reveals that the most productive part of the aquifer is from the sandstone part of the aquifer. Well discharges range from only a few gallons per minute along the periphery of the aquifer to 100 to 200 gpm in deeper parts of the Denver Basin.

The outcrop/subcrop pattern of the L-F aquifer is shown on plate 1. Generally northward dips range from 2 to 5 degrees. Recognized aquifer properties are as follows: hydraulic conductivity - 0.5 ft./d or 3.74 gallons per day per square foot; estimated specific yield is 15 percent. Robson (1987) discusses the Denver Basin aquifers with significant detail. Colorado Division of Water Resources files reveal that within the area of investigation, 14 water wells have been completed in the L-F aquifer. Practically all of these lie within the boundaries of outcrop/subcrop as shown on plate 1. In such areas well depths range from 100 to 400 feet. Because of the aquifers northward dip, wells which lie north of the outcrop/subcrop of the aquifer must be drilled to progressively deeper depths.

Arapahoe aquifer

The Arapahoe aquifer is Denver Basin's most important bedrock aquifer. It is noted for yielding large quantities of excellent quality water to wells throughout most of the central part of the Denver Basin. Plate 1 shows that only about 27 square miles of Arapahoe aquifer outcrops in the Black Squirrel, Chico, and Haynes Creek Basin....in the northwestern and northeastern "ears" of the project area. Colorado Division of Water Resources files

reveal that approximately 65 water wells have been completed in the Arapahoe aquifer. Practically all of the wells are completed in the northwestern part of the project area. Most lie within the boundaries of the base and top of the aquifer and all are low capacity. Depth to the top of the aquifer increases in a northward direction. Well depths in the outcrop/subcrop areas range from 200 to 600 feet.

Generally recognized aquifer properties are: hydraulic conductivity - 0.5 ft./d, or 3.74 gallons per day per square foot; estimated specific yield - 17 percent.

Denver aquifer

Three to four square miles of the Denver aquifer outcrops/subcrops in the extreme northwestern part of the Black Squirrel, Chico, and Haynes Creek basin (pl. 1). Because this part of the project area is heavily subdivided, no less than 49 wells are known to be registered to pump from the Denver aquifer. Records of completed wells reveal that depths range from 60 to about 400 feet and discharges range from less than 1 to 10 gallons per minute. Aquifer properties are as follows: hydraulic conductivity - 1.0 ft./d, or 7.48 gpd/ft.²; estimated specific yield - 17 percent.

Older alluvium aquifer

The most important aquifer in the Black Squirrel, Chico, and Haynes Creek basin is the older alluvium aquifer, hereafter called the alluvial aquifer. This aquifer overlies an erosion surface cut into the Pierre Shale. Plate 2 is a contour map of the Pierre erosion surface and shows the presence of an extensive channel system. This channel system is filled with 100 to 140 feet of the silts, sands, and gravels of the main aquifer. Studies have shown that the saturated thickness of the alluvium ranges from a feather edge to about 75 feet, with a direction of water flow toward the south. Results of the 27-hour aquifer test performed on the aquifer were used to estimate the aquifer's transmissivity and hydraulic conductivity. Values for these aquifer constants were given in an earlier chapter of this report but are repeated here. They are: Transmissivity - 22,110 ft.²/d; hydraulic conductivity - 316 ft./d. In Meinzer units: transmissivity - 165,000 gpd/ft.; coefficient of permeability - 2360 gpd/ft.².

Other investigators have conducted pump or aquifer tests on Upper Black Squirrel Creek and on the main stems of Rush and Horse Creeks, and Steels Fork (McGovern and Jenkins, 1966; Wilson, 1965; and Hydrokinetics, 1987). Coefficients of permeability from their tests range from 1100 to 1945 gpd/ft.². It is believed, therefore, that the permeability (or hydraulic conductivity) of the alluvial aquifer is best represented by a range of values with a low value of 1100 gpd/ft.² and a high value of 2360 gpd/ft.². The average is 1730 gpd/ft.², or in terms of hydraulic conductivity 232 ft./d. The forthcoming water-balance data in this report are based upon the average (tables 6,8).

Configuration and extent of the buried channel system -- The main channel is a continuation of the Upper Black Squirrel Creek basin buried channel first mapped by McGovern and Jenkins (1966) and later, in more detail by Erker and Romero in 1967. Kirkham and others (1988) mapped the main channel in considerable detail in their 13 square mile project area and in marginal detail south to the El Paso - Pueblo County line. Much of the data generated by Kirkham and others has been utilized in the preparation of plate 2.

Plate 2 shows that the total relief of the buried-channel system is approximately 1900 feet - the low elevation of 4700 feet above mean sea level at Chico Creek along the south boundary, and the high elevation of about 6600 feet above mean sea level at the extreme northwestern part of the basin near Coral Bluffs.

The main buried channel enters the project area from the south boundary of the Upper Black Squirrel Creek Ground Water Basin. At this point, the buried channel is approximately one mile west of the present surface channel of Black Squirrel Creek. Five miles farther south, the buried channel and surface channel are approximately two miles apart. Between the south boundary of Upper Black Squirrel Creek Basin and the DOT highway, the main buried channel is joined by seven small buried tributary channels --four of these entering the main channel from the east and three from the west.

Examination of plate 2 reveals the absence of a buried hydraulic divide which separates Black Squirrel Creek groundwater flow from Haynes Creek valley groundwater flow. In fact, the southernmost six miles of the main Black Squirrel Creek buried channel underlies Haynes Creek valley. Note that in Sections 17 and 20, T.18S., R.62 West, the main buried channel trends southeastward into Haynes Creek valley, whereas, the surface channel of Black Squirrel Creek begins to trend southwestward toward its confluence with Chico Creek south of Bar J H Ranch.

The main buried channel trends southward through the DOT facility, enters the Pueblo Ordnance Facility and continues southward toward the south-facing escarpment of the facility. The surface channel of Haynes Creek trends southeastward and appears to have only minor influence on the buried system.

The Chico Creek buried channel is distinct only in the southern half of the basin. In the northern half of the basin buried channels do occur, but three of these trend southeastward toward the Black Squirrel Creek buried channel. The buried channel which underlies Chico Creek is distinct only south of Section 25, T.16S., R.64 West. The large number of tributary channels entering Chico Creek from the west are nearly mirror images of the overlying surface topography. This is due to fact that the underlying Pierre Shale is either exposed or covered by only a thin veneer of surficial deposits. A large number of exposures of the Pierre along the east bank of Chico Creek reveal the alluvial deposits directly overlying the Pierre erosion surface and, more importantly, allow visual inspection of spring and seep discharge of groundwater along the alluvium - Pierre contact. From the DOT highway, the Chico Creek buried channel continues in a southward direction -- toward the Arkansas River.

Water table and movement of groundwater -- Plate 3 is a water table contour map of Black Squirrel, Chico, and Haynes Creek basins alluvial aquifer. The water-table contours of the map represent the inclusion of spot checked water-level data prepared by Kirkham and others (1988), water-level data from pre-existing well-completion reports on file at the Colorado Division of Water Resources Denver office, and water level measurements obtained from 64 test holes and monitoring wells constructed during the investigation.

Plate 3 shows that in general, water that percolates to the water table migrates in a southward direction and leaves the basin at the DOT highway. The plate also reveals that a substantial quantity of groundwater enters Chico Creek from the east. This groundwater emerges from the alluvial aquifer in the form of springs and seeps which occur within

tributary valleys, and along the westward facing stream banks and slopes of the intertributary divides. Kirkham and others (1988) refer to these areas as "spill over wetlands", and suggests that the wetlands are a result of spill over of southwestward - migrating groundwater. Recent investigations strongly indicate that the wetlands, perhaps more properly called spring/seep areas, are a result of interception of groundwater by the deeply cut channels of Chico Creek and at least five north and northeastward cutting tributaries. The spring/seep areas, therefore, owe their existence to Chico Creek downcutting.

A perched water-table system of unknown, but of limited extent, exists near the south boundary. During the construction of monitoring well BCH4, no less than 12 feet of clay was encountered in the upper 20 feet of hole--a six foot bed occurs in the interval 4 to 10 feet below land surface. This high clay bed accounts for the presence of a boggy area where Haynes Creek is crossed by the DOT highway. Groundwater in the underlying alluvium is under slight artesian pressure; the water level in the completed and properly cemented well rises to within about 0.5 ft. below land surface. This condition was not encountered during the construction of monitoring wells BCH3 and BCH5.

Water level fluctuations -- Evaluation of U.S. Geological Survey water level records (U.S. Geological Survey, 1989) and data provided by Mr. Joseph Forney (1991) reveal that in most alluvial wells, the water level has remained nearly constant or has risen 1 or 2 feet since the late 1910's. In the Upper Black Squirrel Creek Basin, the water level in most alluvial wells has been steadily declining (Colorado Division of Water Resources, 1992). It remains to be seen when declining water levels in the upper basin affect water levels in the lower basin (this report). Figure 9 illustrates hydrographs of selected wells in the lower basin.

SURFACE WATER

Black Squirrel and Haynes Creeks

With an exception of a short perennial reach east of Bar J H Ranch, Black Squirrel Creek is an intermittent stream--flowing only after thaw of heavy snowfall or in response to heavy thundershower activity. The short perennial reach of stream east of Bar J H Ranch is a result of a combination of proximity to the Pierre bedrock, high water table, and poorly drained, clayey soil, common in the lower reaches of Black Squirrel Creek.

Haynes Creek is a difficultly recognizable intermittent stream until it leaves the south boundary of the basin at the DOT highway. From that point southward the stream bed is boggy and heavily grassed over. The high water table south of the highway is the source of water for the Thatcher Reservoir system which lies between the DOT highway and the Pueblo Ordnance Facility.

Chico Creek

Chico Creek is intermittent in its headwaters area, but becomes perennial two to four miles south of Hanover Road. The stream remains perennial except in the lower reaches where intermittent phases occur....particularly late in the runoff season. The perennial nature of Chico Creek is due exclusively to spring/seep activity along the east bank of the creek and

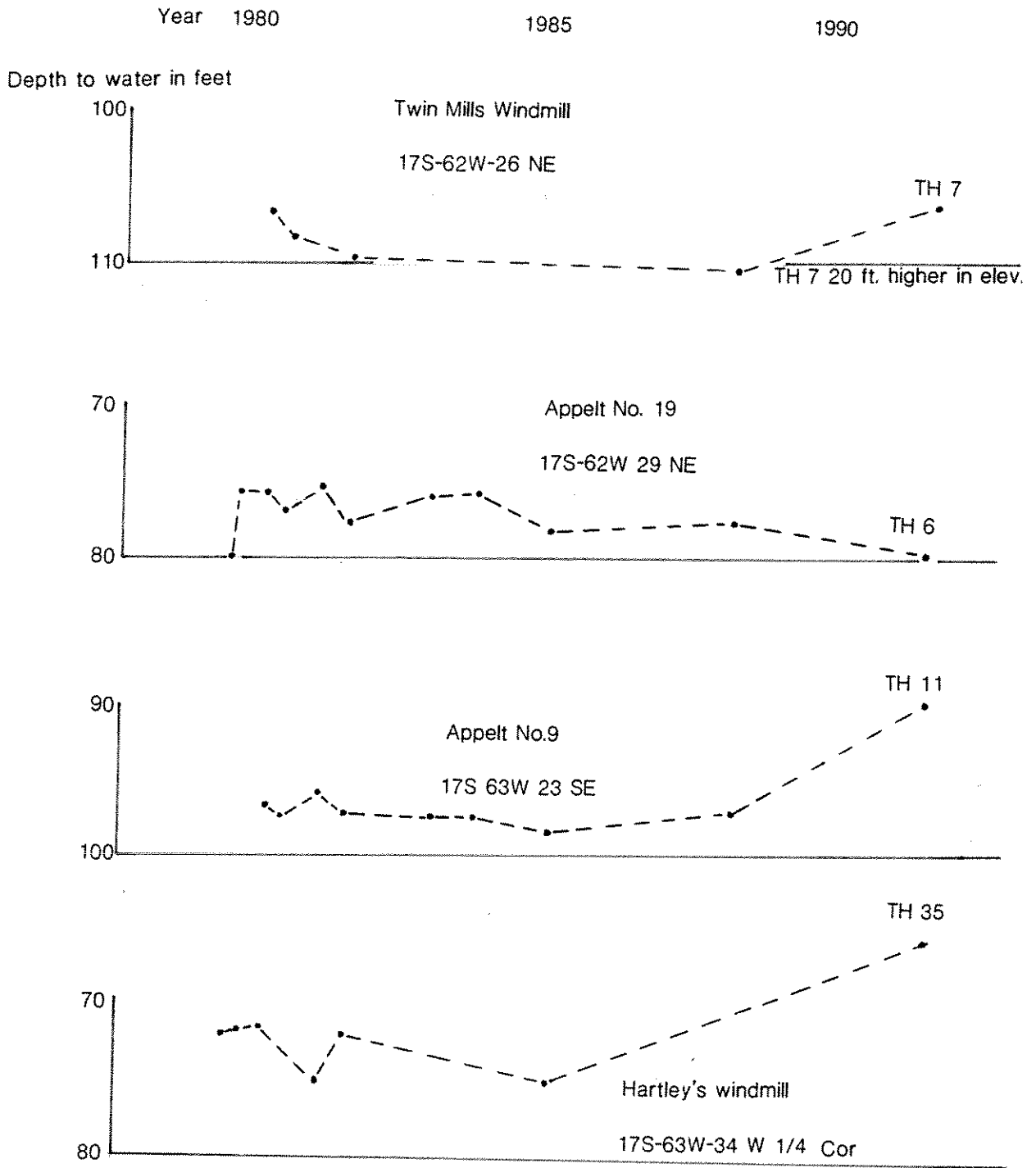


FIGURE 9. - Hydrographs of selected wells in the lower Black Squirrel, Chico, and Haynes Creek basin.

measurement sites and table 3 lists the value of each measurement. Flow measurements upstream from site 3 were difficult because of dense hydrophyte growth. Analysis of the within north and northeastward extending tributary valleys. Stream-flow measurements of Chico Creek were obtained from five sites on October 9, 1991. A flow measurement of one major tributary valley was made on the same date. Figure 10 shows the location of the six stream-flow measurements reveals the significance of evapotranspiration along Chico Creek and its tributaries. From site 5 southward, Chico Creek surface flow decreases. The first five miles of Chico Creek south of site 5, passes through some of the basin's most prolific spring and seep areas. Most of the spring and seep discharge, however, is consumed by phreatophytes, hydrophytes, and free-water surface evaporation. Chico Creek at site 3 is bounded on both sides by Pierre Shale and much of the creek in this area flows directly on shale; but the measured streamflow is only 0.036 cfs (16gpm).

TABLE 3 - Stream flow measurements on Chico Creek.

<u>Station</u>	<u>Flow Measurement</u>
Chico 1	0.033 cfs - 14.8 gpm
Chico 2	0.026 cfs - 11.2 gpm
Chico 3	0.036 cfs - 16.2 gpm
Chico 4	0.023 cfs - 10.3 gpm
Chico 5	0.189 cfs - 84.8 gpm
Tributary 6	0.477 cfs - 214.1 gpm

Flow measurement 6 was made at a culvert in one of the many Chico Creek tributaries affected by excessive spring and seep discharge. The 0.477 cfs (214 gpm) measured is entirely of spring and seep origin.

Seven reservoirs and one reservoir of marginal use have been constructed in tributary valleys of Chico Creek (fig. 10). Recorded reservoir capacities range from 5 to nearly 70 acre feet. The source of the impounded water is intercepted spring and seep discharge, and in the case of Holland Reservoir No. 1, supplemental water from Appelt Wells 20 and 20-2.

WATER USE

Groundwater Use

Withdrawal of water from the alluvial aquifer for non-exempt purposes during 1991 was determined after discussing irrigation withdrawals and other applications with well owners. Mr. Joseph Forney of Hancock Mutual Life Insurance Company (1991), reported that Chico Basin Ranch and affiliated property applied 1090 acre feet of water to approximately 775 acres in 1991. Approximately 982 acre feet was applied by direct application of water pumped from wells. Approximately 108 acre feet were applied as flood irrigation of 85 acres via Holland Reservoir No. 1.....the 108 acre feet first being pumped from Appelt Wells 20 and 20-1. The 1.27 acre feet of applied water per acre does not represent an average year because a large number of effective rainfall events during the growing season reduced

consumptive use (Forney, 1991). The other four active (1991) wells in the lower basin applied 1041 acre feet of water to 478 acres. In addition, Mr. Gunnar Spons (1992) of the U.S. Department of Transportation reported that in 1991 approximately 38.3 acre feet of water was withdrawn for miscellaneous purposes, including fire fighting, on DOT property. Summarizing for 1991, 2131 acre feet of pumped water was applied to 1253 acres of land for irrigation purposes, and 38 acre feet was applied for miscellaneous purposes on the DOT site. Total water withdrawn for the above described uses was 2169 acre feet.

Colorado Division of Water Resources well files reveal that 43 non exempt wells have been permitted in the lower basins' alluvial deposits for predominantly irrigation purposes. Appendix 1, which lists the basins registered non-exempt alluvial wells, shows that at least 11,892 acre feet of water per year has been permitted for irrigation purposes. This is over 4,000 acre feet more than the total water flow past the south boundary of the proposed lower basin. Most of the wells listed in Appendix 1 have been adjudicated in the Pueblo Water Court. These will be discussed in the adjudicated water rights section of this report.

Surface Water Use

All surface water used for beneficial purposes in the Lower Black Squirrel, Chico, and Haynes Creek basin is diverted from the reservoir system on Chico Creek tributaries. Information furnished by Mr. Joseph Forney (1991) indicates that approximately 110 acres of land are flood irrigated with reservoir water, and that the 85 acres of land flooded with Holland Reservoir No. 1 includes water pumped from Appelt Wells 20 and 20-2. Reservoirs "6" and "6-1/2" were used to flood irrigate 25 acres in 1991. Using the 1.27 acre feet per acre results in an application of 31.75 acre feet. Limited subirrigation downstream from the reservoirs also occurs. For 1991 the total quantity of diverted reservoir water (with the exception of Holland Reservoir No. 1) was approximately 32 acre feet.

The diversion of 32 acre feet of water from Reservoirs "6" and "6-1/2" does not represent an actual withdrawal of water. The only withdrawal or use of water from "6" and "6-1/2" diversions is the evapotranspiration over the 25 acres of flood-irrigated land. The estimated ET is 25 acres x 1.27 AF/ac x 80% consumptive use = 25.4 acre feet.

Adjudicated water rights

Appendix 2 is a list of adjudicated water rights in the Lower Black Squirrel, Chico, and Haynes Creek basin. It is based upon Colorado Division of Water Resources records on file at the Denver and Pueblo offices. The list should be considered preliminary since the Pueblo office records are undergoing a lengthy audit. Information given in the list includes water district, water right name, water source, structure type, location, appropriation date, decreed amount of water, acre feet of appropriation as listed in the decree or noted on it's associated well permit, well permit number, and a remarks column. On the list are 123 wells, 13 reservoirs, and 6 ditches; 4 of the reservoirs and 2 ditches have incomplete records. Total decreed withdrawal rate from the wells with records is 126 cfs or 56,550 gpm. Total decreed or permitted annual water application by the wells with records is 13,261 acre feet. Total decreed reservoir capacity of the 9 reservoirs with records is 100 acre feet. Appendix 2 includes a significant number of adjudicated wells of the domestic and stock type.

BASIN RECHARGE AND DISCHARGE

Basin Recharge

Recharge of groundwater to the alluvial deposits of the Lower Black Squirrel, Chico, and Haynes Creek basin originates as precipitation infiltration, groundwater inflow from the Upper Black Squirrel Creek Groundwater Basin, irrigation return, and groundwater discharge from Denver Basin bedrock aquifers.

Precipitation -- Groundwater recharge from the infiltration of precipitation was determined by consideration of seasonal precipitation distribution within the basin, and the effectiveness of precipitation as influenced by the season. Seasonal precipitation distribution maps have been published by the U.S. Department of Commerce (1931-1960; 1951-1980) and are discussed by Dolsken, McKee, and Richter (1984). Daubenmire (1959) discusses precipitation affectivity as influenced by season.

Investigations reveal that precipitation within the basin averages 12.5 inches per year; about 13.5 inches in the north half of the basin and about 11.5 inches in the south half. Most of the precipitation (70-75%) occurs within the period May through September. Infiltration past the upper soil horizons is estimated to be 3 percent during May - September and 8.5 percent during October through April. Infiltration during winter months is high due to the absence of hot wind and seasonal ET reduction. Precipitation recharge to aquifer systems underlying the upper soil horizons is estimated to be approximately 14,944 acre feet per year.

Groundwater inflow from the upper basin -- Plate 3 indicates that a significant quantity of groundwater from the Upper Black Squirrel Creek basin enters Lower Black Squirrel, Chico, and Haynes Creek basin just west of Turkey Track Ranch. Calculations for fall 1991 show that approximately 9600 acre feet of water per year enters the lower basin from Upper Black Squirrel Creek (fig. 11).

Irrigation return -- The total quantity of water applied for irrigation and related purposes from 11 irrigation wells, 2 DOT wells, and 3 reservoirs in 1991, was 2169 acre feet. Utilizing a figure of 20 percent return (R.W. Beck and Assoc., 1967; Woodward-Clyde-Sherard and Assoc., 1966), it is estimated that approximately 434 acre feet of water per year is recharged to the alluvial aquifer.

Denver Basin bedrock aquifers -- Potentiometric surface contour maps by Robson and Romero, 1981, and Robson and others, 1981, and Romero, 1988, reveal that water in Denver Basin bedrock aquifers migrates southward in a large area south of the Black Forest region of the Denver Basin. Discharge of groundwater from each bedrock aquifer was determined after evaluation of existing potentiometric surface maps, assigning a thickness of bedrock aquifer which is saturated and discharging to the alluvium, and use of the formula $Q = KA dh/dl$ where Q = discharge, K = hydraulic conductivity, A = cross sectional area of the discharging bedrock aquifer, and dh/dl = slope of the potentiometric surface.

Estimates of groundwater discharge from the bedrock aquifers to the lower basin are:

Laramie Fox Hills aquifer.	88 AF/yr.
Arapahoe aquifer	0
Denver aquifer	40

Available evidence indicates that in the area of investigation the Arapahoe aquifer might be in a state of transition between an aquifer discharging to the alluvium and an aquifer accepting recharge from the alluvium. Total recharge from the Denver Basin bedrock aquifers, therefore, is 128 acre-feet per year.

Basin Discharge

Discharge of water from the lower basin occurs as withdrawals by wells, groundwater and surface water outflow at the proposed south boundary of the lower basin (i.e. ...the DOT highway), and evapotranspiration. Preliminary investigations indicate that infiltration of precipitation to the bedrock aquifers and infiltration of water to the bedrock aquifers from overlying saturated alluvium does not represent an actual loss from the older alluvium aquifer. Any water unfiltered to the bedrock aquifer system will be returned as bedrock-aquifer discharge.

Non-exempt well withdrawals -- Withdrawal of water from the alluvial aquifer by 11 irrigation wells and two miscellaneous-use wells on DOT property during 1991 was 2169 acre feet. This includes groundwater pumped from Appelt Wells 20 and 20-1.

There are approximately 155 exempt water wells completed in the lower basin's alluvial deposits. Registered yield from these wells ranges from 1 to 40 gallons per minute. Although an evaluation of the basin's domestic and stock wells was not undertaken, it is possible that 200 to 400 acre feet or more of water per year is consumed by exempt well uses.

Groundwater and surface-water outflow -- The proposed south boundary of the Lower Black Squirrel, Chico, and Haynes Creek basin is nearly 10 miles in length and is composed of western and eastern parts. The western part is composed of Chico Creek and its floodplain and buried channel; its eastern boundary is the Pierre bedrock escarpment one mile east of the Chico Creek bridge (fig. 11). Flow measurements made in the fall of 1991 show that the Chico Creek surface - flow rate was approximately 25 acre feet per year and the groundwater flow rate in the underlying older alluvium was approximately 65 acre feet per year.

The eastern part of the south boundary is nine miles in length and extends from the Pierre-bedrock escarpment eastward to the Haynes Creek/Kramer Creek drainage divide. Measurements made in the fall, 1991 show that groundwater flow in the underlying alluvium is approximately 7578 acre-feet per year. Total water flow out of the lower basin, therefore, is 7668 acre feet per year.

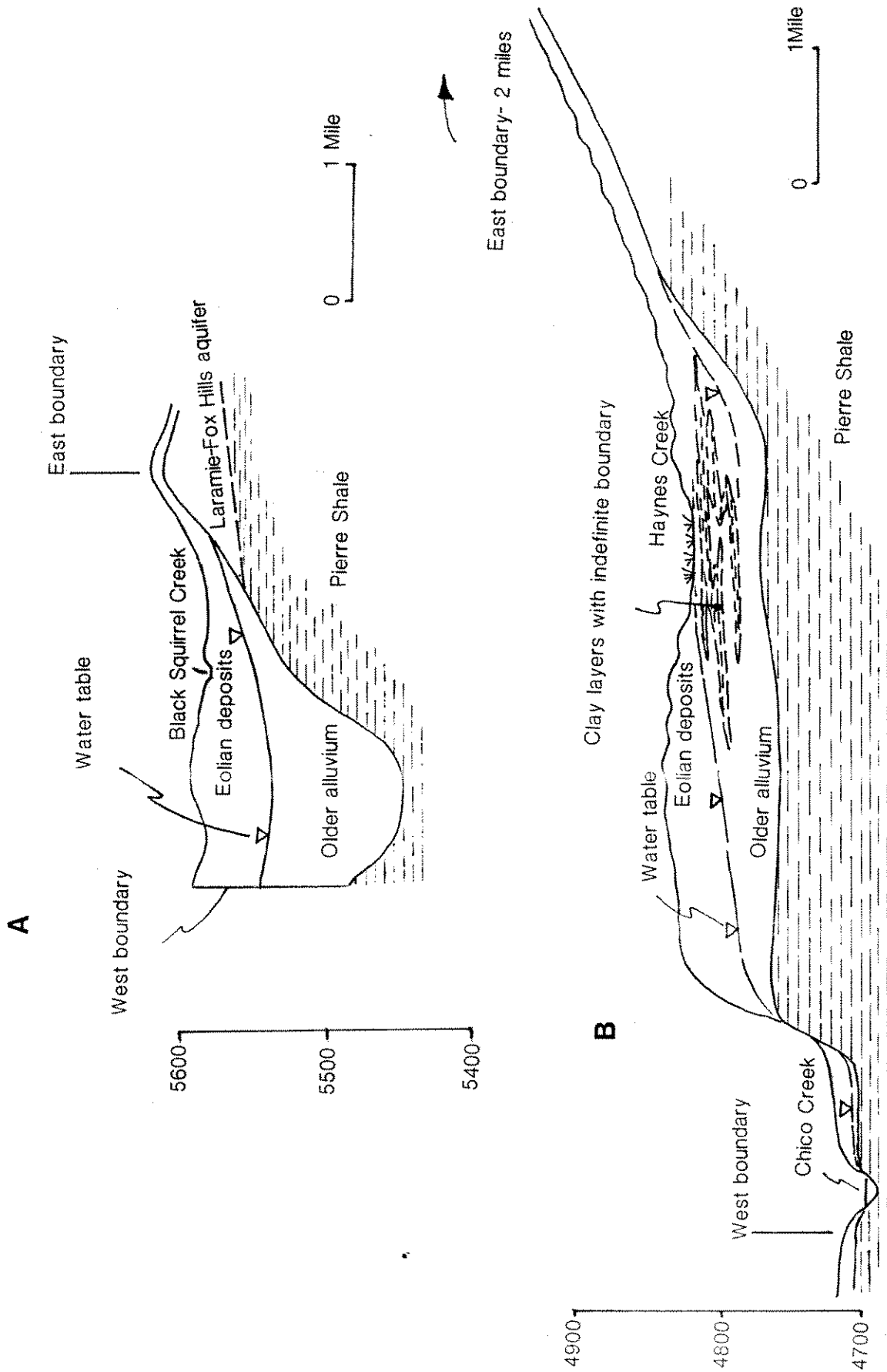


FIGURE 11. - A, cross section along the south boundary of the Upper Black Squirrel Creek Ground Water Basin. B, cross section along the proposed south boundary of the lower Black Squirrel, Chico, and Haynes Creek basins. Figures are elevations above sea level in feet.

Evapotranspiration -- Evapotranspiration (ET) includes the evapotranspiration of applied water on land irrigated by Reservoirs "6" and "6-1/2" which is 31.75 acre feet x 80% consumptive use = 25.4 acre feet, and evapotranspiration not related to irrigation.

The only significant unknown in the lower basin's water balance is non-irrigation related ET. Water-level change information from the south half of the basin indicates that no significant change occurred over the period August 1979 through April 1988 (Forney, 1992., fig. 9). Basin discharge, therefore, is adjusted to equal basin recharge. Non-irrigation related ET was determined by estimating free-water surface evaporation losses from the basin's seven reservoirs and the flowing reach of Chico Creek, and assigning a number to phreatophyte and hydrophyte losses so that basin discharge equals basin recharge.

The 36.5 acres of water surface in the reservoirs underwent 152 acre feet of evaporation; using an evaporation rate of 50 inches per year (Farnsworth, Thompson, and Peck, 1982). The approximately 96,000 feet of Chico Creek stream flow with stream width ranging from 2.5 to 7 feet resulted in 50 acre feet of evaporation; the evaporation rate for a moving water surface was set at seven percent greater than that of a still water surface (Meyer, 1942). A series of subtractions resulted in an estimate of 15,244 acre feet per year of non-irrigation related evapotranspiration of which 15,042 acre feet is due to water consumption by phreatophytes and hydrophytes in high water table areas and in the spring and seep areas. Table 4 is the basin's completed water balance data.

TABLE 4 - Water budget data for the Lower Black Squirrel, Chico, and Haynes Creek basin.

<u>RECHARGE</u>	
	<u>AF/yr.</u>
Precipitation	14,944
GW inflow from Upper Blk. Sqr. Basin	9,600
Irrigation return & return from DOT wells	434
Denver Basin BR aquifers	
Denver aquifer	40
Arapahoe aquifer	-
Laramie-Fox Hills aquifer	88
TOTAL RECHARGE	25,106
<u>DISCHARGE</u>	
Groundwater applied by non-exempt wells	2,169
Chico Creek surface flow past south boundary	25
Groundwater flow past south boundary	7,643
Evapotranspiration on land irrigated by Res "6" & "6-1/2"	25
Non-irrigation related evapotranspiration	
Reservoir free water surface evaporation	152
Stream-surface evaporation	50
Phreatophytes, hydrophytes & spring/seep areas	15,042
TOTAL DISCHARGE	25,106

The term phreatophyte refers to a plant that habitually obtains its water supply from the zone of saturation, either directly or through the capillary fringe (Robinson, 1958). Closely related to phreatophytes in the spring and seep areas are hydrophytes. These are plants which grow in water or at least have their roots continuously immersed in water (Robinson,

1958) and are common only in wetland environments. Wetlands are lands which are transitional between terrestrial and aquatic systems where the water table is usually at or near the land surface.....(Cowardin, et al, 1979). The spring and seep areas and the wetlands thereby produced, and high water-table areas form the most significant hydrologic feature of the entire basin. This is because of the excessive predominantly non-beneficial consumptive use of water which occurs within their boundaries. Table 6 shows that evapotranspiration in these areas is approximately 9 times the consumptive use by crops irrigated within the lower basin in 1991.

The area of phreatophyte and hydrophyte growth within Chico, Lower Black Squirrel, and Haynes Creek basin was estimated by examining U.S. Geological Survey photographic quadrangle maps and outlining areas believed to be covered by phreatophytes and hydrophytes. Limited field comparisons were also conducted. The planimeted acreage of the outlined areas is 3494. There is a strong probability that this figure is low by 10 to 20 percent due to inaccuracies in identifying all of the phreatophyte and hydrophyte infested areas, particularly within the floodplain of Lower Black Squirrel Creek. The area of phreatophyte and hydrophyte growth, therefore, ranges between 3494 and 4193 acres, or more realistically.....between 3500 and 4200 acres. Dividing 15,042 acre feet by 4200 acres and 3500 acres result in a consumptive use ranging from 3.6 to 4.3 acre feet per acre. This range is reasonable considering the presence of extensive wetlands in the spring-seep discharge areas.

GROUND WATER STORAGE

Saturated thickness of the alluvial aquifer

Plate 4 is a saturated thickness contour map of the Lower Black Squirrel, Chico, and Haynes Creek basin for fall 1991. The heavy dashed lines represent equal thickness of saturated alluvium. Contour interval is 25 feet. Saturations range from 0 along the flanks of the basin to over 75 feet along the main buried channel. Note that about 80 percent of the basin contains saturations of less than 50 feet. The zero saturation boundary on the west side of the basin has been mapped with a higher degree of accuracy than its eastern counterpart. This is because downcutting of Chico Creek and its tributaries has exposed underlying bedrock strata thus facilitating identification of boundaries of saturated alluvium. The eastern side of the basin does not have an actively downcutting stream and most of it is covered by thick eolian deposits.

When used in conjunction with the bedrock-contour and water-table maps, the saturated thickness map can be used to locate future well sites with the highest long-term production potential.

Quantity of gravity - drainable groundwater

The quantity of gravity - drainable groundwater in the alluvial aquifer was determined by planimetering the saturation contours of plate 4, determining the volume of saturated material, and multiplying by specific yield. The assigned specific yield of the alluvium, is 20 percent. The quantity of gravity - drainable groundwater in the alluvium is estimated to be 1,101,597 acre feet.

Groundwater storage in the bedrock aquifers

The estimated quantity of gravity - drainable groundwater in the established Denver Basin bedrock aquifers is based upon evaluation of maps by Van Slyke and others (1988), application of assigned specific yields, and very limited knowledge of the location of the potentiometric surfaces near outcrop areas. The estimated quantity of gravity - drainable groundwater in the two Pierre sandstones discussed in this report is based upon geophysical log evaluations, assigned specific yield, and limiting the northern extent of the lower sandstone to that distance wherein the depth to the top is approximately 1000 feet below land surface. Table 5 lists the known and potential aquifers and gives pertinent statistical data for each.

TABLE 5 - Quantity of gravity drainable groundwater in the bedrock aquifers.

<u>Aquifer</u>	<u>Assigned Area (acres)</u>	<u>Assigned Sat'd (ft)</u>	<u>Drainable Sy</u>	<u>Drainable Water(AF)</u>
Denver	2,560	65	0.17	28,288
Arapahoe	3,520	100	0.17	59,840
Laramie-Fox Hills	28,160	200	0.15	844,800
Upper Pierre ss	54,400	75	0.15	612,000
Lower Pierre ss	30,400	50	0.10	152,000

Approximately 932,928 acre feet of groundwater is available from established Denver Basin aquifers and 764,000 acre feet from the two Pierre sandstones. The total gravity-drainable water from the bedrock system is 1,696,928 acre feet.

CHARACTERISTICS OF THE BASIN SOUTH OF THE DOT HIGHWAY

That part of the basin lying south of the DOT highway was examined and mapped in order to determine the relationship between the basin and the Arkansas River. The area of this investigation is approximately 92 square miles and extends southward to the north edge of the Arkansas River floodplain. Included in the study area are approximately 40 square miles of the Pueblo Ordnance Facility.

During this investigation, it was found that the surface flow of Chico Creek ceases about two miles south of the DOT highway bridge. Dry streambed conditions were found to extend southward, beyond U.S. Highway 50. About one-half mile south of DOT highway, Haynes Creek begins to flow intermittently and continues to do so for about two miles. The flow, which was not measured, is attributed to perched water table conditions in this part of the basin and discussed in an earlier chapter of this report. The creek bed is relatively wide, grassy, and is the recipient of spring and seep discharge. In the same general area are three adjudicated reservoirs: Thatcher Reservoirs 1, 2, and 3. Reservoir No. 1 is the collection reservoir for the system; water is distributed to 2 and 3 via the Lankford Ditch and two laterals. All reservoirs are used for watering livestock along their shorelines and Reservoir No. 2 is also used for the irrigation of 140 acres of grassland east of the reservoir; water being delivered by pumping through a pipeline and applied by sprinkler heads. Mr. John Thatcher Jr. reports that some livestock water is pumped from the system to stock tanks two miles or more east of Haynes Creek (there are no aquifers in the area).

Approximately one-half mile southeast of the Pueblo Ordnance Activity east boundary, Haynes Creek channel is cut directly into Pierre shale and the creek becomes perennial for approximately four miles. Haynes Creek flow ranges from about one gallon per minute just southeast of the ordnance activity boundary to approximately 15 to 20 gallons per minute northeast of Boone. The increase in flow is attributed to groundwater accretions originating as seeps and springs along the escarpment west of Haynes Creek.

The escarpment occurs along the alluvium - Pierre contact and extends southward to the Arkansas River where it forms the north bank of the Arkansas River floodplain. The west branch of the escarpment extends westward along the south boundary of the Pueblo Ordnance Activity, turns north near Chico Creek and continues northward past the DOT highway. The escarpment is significant because it has exposed, or nearly exposed, the alluvium - Pierre contact and allows groundwater flowing along the contact to surface as springs and seeps. Spring and seep discharge occurs along 2 to 3 mile long lengths of escarpment. The discharge areas are 200 to 300 feet wide, boggy, and heavily grassed over. Groundwater is also discharging along the deeply incised banks of Boone Creek which flows through the southeastern part of the ordnance activity.

The planimetered area of spring and seep discharge and their accompanying phreatophytes and hydrophytes is 1800 acres. This figure might be low by 10 to 20 percent due to inaccuracies in identifying all growth areas. The area of phreatophyte and hydrophyte growth, therefore, ranges between 1800 acres and 2160 acres. Vegetation within these area includes sedges, rushes, wheatgrass, bluegrass, witchgrass, cattails, and occasional cottonwood trees and willows. In addition to phreatophytes and hydrophytes, are five reservoirs with a total of approximately 43.9 acres of free water surface and approximately 2 acres of free water surface along the flowing part of Haynes Creek.

Non beneficial evapotranspiration by phreatophytes and hydrophytes is estimated to range between 6480 and 7780 acre feet per year. Evaporation of water by free water surfaces (five reservoirs and a perennial reach of Haynes Creek) is estimated to be approximately 192 AF per year.

Water used by the Pueblo Ordnance Activity in 1991 was obtained from eight (8) wells completed in the alluvial deposits. Approximately 460 acre feet was withdrawn and used for irrigation, drinking and sanitation, and industrial purposes.

Table 6 shows the approximate distribution of water discharge and water recharge for the Haynes Creek and Pueblo Ordnance Activity area south of the DOT highway. The area west of the escarpment along the west side of the ordinance activity is not included. The purpose of the table is to show how much non beneficial evapotranspiration occurs along the escarpment and give an estimate of how much groundwater actually reaches the Arkansas Valley floodplain. Examination of table 6 indicates that about 200 acre feet to about 1500 acre feet of water per year reaches the floodplain. This represents about 1 percent to about 6 percent of the groundwater recharge to the lower Black Squirrel, Chico, and Haynes Creek basin, or between 0.02 percent (0.0002) and 0.14 percent (0.0014) of the upper basins gravity-drainable storage.

TABLE 6 - Water balance data for the Haynes Creek and Pueblo Ordnance Facility area south of the DOT highway.

<u>RECHARGE</u>		<u>AF/yr.</u>
Precipitation infiltration		1,103
Inflow from upper basin		7,578
Thatcher Res. #2 irrigation return		62
Pueblo Ordnance Facility		
Irrigation return		53
Drinking & sanitation return		160
Industrial return		<u>13</u>
TOTAL RECHARGE		8,969
 <u>DISCHARGE</u> 		
Surface-water evaporation		
Reservoirs		183
Haynes Creek		9
Phreatophytes, hydrophytes, etc., @3.6 AF/ac	(6,480) ¹	(7,780) ²
Thatcher Res. #2 irrigation application		308
Pueblo Ordnance Facility		
Irrigation withdrawals		266
Drinking & sanitation withdrawals		177
Industrial use withdrawals		17
TOTAL DISCHARGE	(7,440)¹	(8,740)²

¹) 1800 acres present

²) 2160 acres present

The 173 acre feet of the Pueblo Ordnance Activity's drinking, sanitation, and industrial use return water is discharged into Boone Creek; which drains into the Arkansas River floodplain.

It can be mathematically shown that phreatophyte and hydrophyte evapotranspiration rates exceeding 3.7 acre feet per acre per year result in (with the exception of 173 acre feet of Pueblo Ordnance Activity return) zero discharge from the Pueblo Ordnance Activity escarpment to the Arkansas River floodplain.

CONCLUSIONS

The five water-yielding formations in the lower Black Squirrel, Chico, and Haynes Creek basin are upper Pierre sandstones, the Laramie-Fox Hills, Arapahoe, and Denver aquifers, and the older alluvium or alluvial aquifer. The Laramie-Fox Hills, Arapahoe, and Denver aquifers are members of the Denver Basin system of bedrock aquifers. These aquifers are semi consolidated to consolidated and, except in deeper parts of the Denver Basin, yield small quantities of water to domestic and stock wells.

By far the most important aquifer of the group is the older alluvium. The older alluvium occupies an ancient channel system cut into the Pierre Shale in the southern two-thirds of

the basin and into Fox Hills, Laramie, and Arapahoe strata in the northern third of the basin. The saturated thickness of the alluvium or alluvial aquifer ranges from 0 to slightly over 75 feet and is sufficient to support well discharges ranging from a few gallons per minute to approximately 1000 gallons per minute.

Colorado Division of Water Resources records indicate that at least 11,892 acre feet of water per year has been permitted and/or decreed in the basin for irrigation purposes (records are incomplete). In 1991, however, only 2169 acre feet of water was withdrawn by the basin's non-exempt wells.

Calculations for the calendar year 1991 indicate that 25,106 acre feet of water is recharged to the basin and an equal quantity is discharged. Of the quantity discharged 7,668 acre feet is ground and surface water flow past the south boundary (at the DOT highway) and 15,042 acre feet is consumed by phreatophytes in spring and seep areas.

Preliminary calculations reveal that approximately 70 percent or more of the water recharged to the area south of the DOT highway and east of Chico Creek is consumed by evapotranspiration along the Pueblo Ordinance Activity escarpment.

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APPENDIX 1

Non-exempt well list

LOCATION TWN RNS SEC	QTR	PERMIT NUMBER	USE	DATE OF 1st USE	WATER LEVEL	PUMP RATE	TOTAL DEPTH	ACRES IRRIG	ACRE FEET PER YEAR	REMARKS	15 YEAR EX USE
T13S R64W 15	SWNW	15949 RF	C	03/15/71	220	4	660	0	0	Ka	X
T14S R64W 09	SESE	33732 -F	M	/ /	0	0	0	0	0	New Permit (K1f)	EX
T14S R64W 09	SESE	21534 -F	D	12/31/01	0	50	165	0	5	One permit expired. TKd	X EX
T14S R64W 14	NWNW	29925 -F	M	/ /	0	0	0	0	0	K1f	EX
T14S R64W 15	NWSE	31889 -F	M	/ /	0	0	0	0	0	New Permit	EX
T14S R64W 15	SWNW	27481 -F	C	07/11/84	270	11	841	0	0	New Permit. Ka	
T14S R64W 22	NENW	31891 -F	M	/ /	0	0	0	0	0	K1f	EX
T14S R64W 22	NESE	31890 -F	M	/ /	0	0	0	0	0	K1f	EX
T14S R64W 27	NWSW	16129 -F	D	03/20/73	136	18	310	0	0	K1f	X
T15S R63W 33	SWNW	13997 -F	I	08/01/13	90	112	215	0	0	K1f,Kp	X
T15S R63W 34	NWNE	22990 RF	I	12/13/34	53	15	111	0	1	Ref.to cond.of approval	X
T16S R62W 06	NWNE	22989 -F	I	01/01/35	0	112	0	15	183		X
T16S R62W 18	SWSW	11449 -F	I	02/13/67	72	800	174	320	525		X
T16S R62W 19	NESW	19099 -F	I	12/01/72	84	580	142	120	270		X
T16S R62W 30	SWNE	19100 -F	I	05/10/76	90	200	133	120	120		X
T16S R63W 01	NENW	13999 -F	I	12/13/35	35	112	61	30	182		X
T16S R63W 03	NESW	13998 -F	I	12/31/13	38	112	75	30	182		X
T16S R63W 09	SESE	22992 -F	I	12/31/50	0	112	0	15	183		X
T16S R63W 12	SESE	22993 -F	I	12/31/20	0	112	0	15	183		X
T16S R63W 14	NESE	22994 -F	I	12/31/20	0	112	0	15	183		X
T16S R63W 20	SESE	22995 -F	I	12/31/13	0	112	0	15	183		X
T16S R63W 23	SWSW	22996 -F	I	12/31/13	0	112	0	15	183		X
T16S R63W 25	SESE	22997 -F	I	12/31/18	0	112	0	15	183		X

Explanation - I, irrigation; M, municipal; C, commercial; D, domestic; N, industrial; S, stock; O, other; BR, bedrock aquifer; pumping rate in gallons per minute; total depth in feet; X, in use in excess of 15 years prior to

APPENDIX 1 (continued)

LOCATION TWN R3G SEC	BTR SEC	PERMIT NUMBER	USE	DATE OF 1st USE	WATER LEVEL	PUMP RATE	TOTAL DEPTH	ACRES IRRIG	ACRE FEET PER YEAR	REMARKS	15 YEAR EX USE
T188 R63W 26	SESE	11121 -F	I	12/01/56	133	829	185	80	396		X
T168 R63W 33	SNNW	22991 -F	I	12/31/13	0	1120	0				X
T168 R63W 35	SWNE	13756 -F	I	05/26/69	98	1050	160	160	780		X
T178 R61W 17	SNNW	22999 -F	I	04/30/65	0	5	0				X
T178 R61W 18	NESW	35179 -F	S	05/26/89	74	35	105				
T178 R62W 05	NNSW	18848 -F	I	06/01/76	81	700	147	120	315		X
T178 R62W 22	SWNE	23000 -F	I	09/21/64	0	5	0				X
T178 R62W 29	SWSE	23001 -F	I	04/21/67	62	900	155	200	2990		X
T178 R62W 30	SESW	23002 -F	I	12/31/30	0	10	0				X
T178 R62W 30	SWNE	27158 -F	I	/ /	0	0	0		640		X EX
T178 R62W 30	SWSW	27157 -F	I	/ /	0	0	0		640		X EX
T178 R63W 02	NENE	22998 -F	I	12/31/13	0	112	0	15	183		X
T178 R63W 10	NESE	5816 -F	I	10/01/64	73	1020	126	80			X
T178 R63W 10	NESW	11089 -F	I	02/08/67	71	550	116			Refer to 23003RF	X
T178 R63W 10	NESW	23003 RF	I	09/21/64	76	650	132	130	325	Refer to 23003RF	
T178 R63W 11	SENW	4369 -F	I	08/05/63	93	1260	151	240			X
T178 R63W 11	SWSW	6990 -F	I	04/19/65	80	1550	140	160			X
T178 R63W 22	SESE	23004 -F	I	12/31/42	0	10	100	100			X
T178 R63W 24	SENW	23005 -F	I	12/31/63	0	10	0				X
T178 R63W 28	SESE	23009 -F	I	09/21/64	0	20	0				X
T178 R63W 29	NESW	23006 RF	D,S	12/31/42	10	15	50	10	1	Refer to 23006RF	X
T178 R63W 29	NWSE	23007 -F	I	12/31/42	0	90	50	10	146		X
T188 R62W 04	SWSW	23010 -F	I	12/31/20	0	65	125				X
T188 R62W 07	SENW	23011 -F	I	12/31/63	0	10	0				X
T188 R62W 09	SWSW	23012 -F	I	09/21/64	0	20	0				X
T188 R62W 29	NNW	16328 -F	N	/ /	0	0	0				EX
T188 R62W 29	NWSW	23013 -F	I	09/21/64	62	450	150	180			X
T188 R63W 03	SWSW	20558 -F	I	09/21/64	4	485	41		1150		X
T188 R63W 04	NENE	14791 -R	I	10/20/54	18	400	0				X
T188 R63W 04	NESE	20559 -F	I	09/21/64	3	570	28		790		X
T188 R63W 10	NESW	20561 -F	I	09/21/64	3	265	22		430		X

APPENDIX 1 (continued)

LOCATION			QTR	PERMIT	USE	DATE OF	WATER	PUMP	TOTAL	ACRES	ACRE	REMARKS	15 YEAR EX
TWN	RNG	SEC		NUMBER		1st USE	LEVEL	RATE	DEPTH	IRRIG	FEET		USE
											PER		
											YEAR		
T18S	R63W	10	S4NW	20560 -F	I	09/21/64	3	325	19		505		X
T18S	R64W	12	NWNE	4536 -F	I	07/23/63	10	1350	56	300			X
T19S	R62W	03	NENW	15829 -F	N	12/31/72	0	850	0		40		X
T19S	R62W	03	NENW	20730 -F	D	08/31/71	39	140	0			Supl. For 15829-F	X

APPENDIX 2

Adjudicated water rights

WD	WATER RIGHT NAME	SOURCE	STRU TYPE	LOCATION TWN R6G SEC	APPRO. DATE	cfs (d)	ACFT (d/p)	PERMIT NUMBER	REMARKS
10	HOLLAND DITCH NO.1	SB	D	T S R W	/ /	0.5000	180.00		90 Acres:
10	HOLLAND DITCH NO.2	SB	D	T S R W	/ /	0.5000	160.00		78 Acres
10	BALSER WELL NO.1	GW	WELL	T14S R64W 16	06/15/29	0.0780	0.00	36315	
10	BALSER WELL NO. 2	GW	WELL	T14S R64W 16	05/19/65	0.0400	0.00	23875	
10	ACKERMAN NO.3 WELL	BSC	WELL	T15S R63W 34	12/13/13	0.2500	0.00	22990 -F	
10	BOHART NO.4	BSC	WELL	T16S R61W 06	02/21/12	0.0900	0.00		
10	BOHART NO. 6	BSC	WELL	T16S R61W 06	02/21/12	0.0330	0.00		
10	WELL NO.4	Kp	WELL	T16S R61W 08	12/31/58	0.0300	0.00	90132	P# 90132 or 90133 ?
10	WELL NO.3	Kp	WELL	T16S R61W 08	12/31/58	0.0100	0.00		
10	WELL NO.6	Kp	WELL	T16S R61W 18	12/31/58	0.0100	0.00	90135	P# 90136
10	WELL NO.10	Kp	WELL	T16S R61W 20	12/31/58	0.0300	0.00	90139	
10	WELL NO. 9	Kp	WELL	T16S R61W 20	12/31/58	0.0100	0.00	90139	
10	WELL NO.12	Kp	WELL	T16S R61W 21	12/31/58	0.0300	0.00	90141	
10	WELL NO.11		WELL	T16S R61W 29	12/31/58	0.0300	0.00		
10	WELL NO. 13	Kp	WELL	T16S R61W 32	12/31/58	0.0200	0.00		
10	WELL NO.14	Kp	WELL	T16S R61W 32	12/31/58	0.0200	0.00		
10	WELL NO.2	Kp	WELL	T16S R61W 33	12/31/67	0.0300	0.00	29727	
10	WELL NO.3	GW	WELL	T16S R62W 05	08/13/62	0.0340	0.00	12566	
10	ACKERMAN NO.2 WELL	BSC	WELL	T16S R62W 06	12/13/35	0.2500	183.00	22989 -F	
10	BOHART NO.5	BSC	WELL	T16S R62W 06	02/06/42	0.0220	0.00	57661	
10	WELL NO. 2	GW	WELL	T16S R62W 07	06/18/64	0.1900	0.00	20385 -F	
10	BOHART WELL NO.3	Kp		T16S R62W 10	10/15/40	0.0090	0.00	57654	
10	BOHART NO.2			T16S R62W 12	08/20/58	0.0180	0.00		
10	BOHART NO.15			T16S R62W 13	02/21/12	0.0270	0.00		

Explanation - WD, water district; BSC, Black Squirrel Creek; SB, Spring Branch; GW, groundwater; W, well; D, ditch; R, reservoir; cfs (d), cubic feet per second as decreed; AF (d/p), acre feet of water per year per decree or well permit; cond., conditional part of decree

APPENDIX 2 (continued)

WD	WATER RIGHT NAME	SOURCE	STRU TYPE	LOCATION TWN R62W SEC	APPRO. DATE	cfs (d)	ACFT (d/tp)	PERMIT NUMBER	REMARKS
10	BOHART NO.8			T16S R62W 15	10/10/71	0.0330	0.00		
10	WELL NO. 1	GW	WELL	T16S R62W 18	02/13/67	1.7600	576.00	11449 -F	
10	HATTON WELL NO.2	BSC	WELL	T16S R62W 19	12/01/72	1.2900	270.00	19099 -F	120 Acres
10	BOHART NO.7			T16S R62W 21	06/03/41	0.0440	0.00	58163	
10	WELL NO.8	Kp	WELL	T16S R62W 24	12/31/58	0.0300	0.00	90137	P# 1712?
10	WELL NO.7		WELL	T16S R62W 24	12/31/58	0.0300	0.00		
10	WELL NO.1		WELL	T16S R62W 24	12/31/58	0.0300	0.00		
10	BOHART NO.12	Kp	WELL	T16S R62W 26	12/31/21	0.2200	0.00	58160	P# 58160 or 58519?
10	BOHART NO. 13	Kp	WELL	T16S R62W 26	12/31/21	0.0110	0.00		
10	BOHART NO.14			T16S R62W 26	07/23/68	0.0220	0.00		
10	ACKERMAN NO.24 WELL	BSC	WELL	T16S R62W 30	09/05/67	4.0000	0.00		4 cfs conditional
10	HATTON WELL NO. 1	BSC	WELL	T16S R62W 30	12/01/72	0.4400	120.00	19100 -F	120 Acres
10	ACKERMAN NO.6 WELL	BSC	WELL	T16S R63W 01	12/13/35	0.2500	182.00	13999 -F	
10	ACKERMAN NO.5 WELL	BSC	WELL	T16S R63W 03	12/31/13	0.2500	182.00	13998 -F	
10	ACKERMAN WELL NO.21	BSC	WELL	T16S R63W 03	09/05/67	0.0200	10.00		
10	ACKERMAN NO.7 WELL	BSC	WELL	T16S R63W 09	12/31/50	0.2500	183.00	22992 -F	
10	ACKERMAN NO. 8 WELL	BSC	WELL	T16S R63W 11	12/31/20	0.2500	183.00	22993 -F	
10	ACKERMAN NO.9 WELL	BSC	WELL	T16S R63W 14	12/31/20	0.2500	183.00	22994 -F	
10	ACKERMAN WELL NO.10	BSC	WELL	T16S R63W 20	12/31/13	0.2500	183.00	22995 -F	
10	ACKERMAN WELL NO.11	BSC	WELL	T16S R63W 23	12/31/13	0.2500	183.00	22996 -F	
10	ACKERMAN WELL NO.22	BSC	WELL	T16S R63W 23	09/05/67	0.0200	10.00		
10	ACKERMAN NO.12 WELL	BSC	WELL	T16S R63W 25	02/13/18	0.2500	183.00	22997 -F	
10	ACKERMAN WELL NO.23	BSC	WELL	T16S R63W 25	09/05/67	0.0200	10.00	0	
10	WELL NO. 1	GW	WELL	T16S R63W 26	12/01/56	1.3300	425.00	11121 -F	
10	ACKERMAN NO.4 WELL	BSC	WELL	T16S R63W 33	12/31/13	0.2500	0.00	22991 -F	
10	13756-F		WELL	T16S R63W 35	05/26/69	2.3300	0.00	13756 -F	
10	O.K. WELL	BSC	WELL	T17S R61W 17	04/30/65	0.0100	0.00	22999 -F	
10	SCOTT WELL	BSC	WELL	T17S R61W 18	12/31/63	0.0100	7.00	36426	
10	WELL 12565	BSC	WELL	T17S R62W 04	08/14/62	0.0440	0.00	12565	
10	WELL 18848-F	BSC	WELL	T17S R62W 05	09/26/74	2.2200	0.00	18848 -F	
10	NO.11	BSC	WELL	T17S R62W 09	04/30/49	0.0330	0.00	58165	
10	APPELT NO.10 WELL	BSC	WELL	T17S R62W 19	09/21/64	4.0000	0.00		4 cfs Cond.

APPENDIX 2 (continued)

BLACK SQUIRREL CREEK DESIGNATED BASIN EXPANSION JUNE 1992

NO	WATER RIGHT NAME	SOURCE	STRU TYPE	LOCATION TWN RNS SEC	APPRO. DATE	cfs (d)	ACFT (d/p)	PERMIT NUMBER	REMARKS
10	APPELT NO.13 WELL	BSC	WELL	T17S R62W 20	09/21/64	4.0000	0.00		4 cfs Cond.
10	APPELT NO. 12 WELL	BSC	WELL	T17S R62W 20	09/21/64	4.0000	0.00		4 cfs Cond.
10	APPELT NO.11 WELL	BSC	WELL	T17S R62W 20	09/21/64	4.0000	0.00		4 cfs Cond.
10	NORTHWEST WELL	BSC	WELL	T17S R62W 22	09/21/64	0.0100	0.00	23000 -F	
10	TWIN MILLS WELL	BSC	WELL	T17S R62W 26	12/31/17	0.0400	0.00	37806 FR	
10	TWIN MILLS NO.2	BSC	WELL	T17S R62W 26	12/13/17	0.0400	0.00	36422	
10	APPELT WELL NO. 19	BSC	WELL	T17S R62W 29	09/21/64	4.0000	0.00		2.45 CFS Cond.
10	APPELT NO. 15 WELL	BSC	WELL	T17S R62W 30	08/30/66	4.0000	640.00	27157 -F	4 cfs Cond.
10	APPELT NO. 17 WELL	BSC	WELL	T17S R62W 30	09/21/64	4.0000	0.00		4 cfs Cond.
10	OLD NEGRO WELL	BSC	WELL	T17S R62W 30	12/31/30	0.0200	0.00	23002 -F	
10	APPELT NO.16 WELL	BSC	WELL	T17S R62W 30	09/21/64	4.0000	640.00	27158 -F	160 Acres: 4cfs Cond.
10	WHALEN WELL	BSC	WELL	T17S R62W 33	04/30/65	0.0400	30.00	36423	
10	WELL NO.1		WELL	T17S R63W 01	12/31/47	0.1101	0.00		
10	ACKERMAN NO. 13 WELL	BSC	WELL	T17S R63W 02	12/31/13	0.2500	183.00	22998 -F	
10	WELL NO.2		WELL	T17S R63W 02	12/31/47	0.1101	0.00		
10	WELL NO.3		WELL	T17S R63W 03	12/31/65	0.1101	0.00		
10	WELL NO.2	BSC	WELL	T17S R63W 04	12/20/66	0.4400	0.00	29567	
10	APPELT NO. 2 WELL	BSC	WELL	T17S R63W 10	09/21/64	4.0000	325.00	23003 RF	W.BAKER Irr. 1.1 Abs./2.9 Cond
10	APPELT NO. 1 WELL	BSC	WELL	T17S R63W 10	09/21/64	4.0000	0.00		West Baker Test: 4cfs Cond.
10	No. 5816-F	SW	WELL	T17S R63W 10	09/24/64	2.2700	726.00	5816 -F	80 Acres
10	APPELT NO.5 WELL	BSC	WELL	T17S R63W 11	09/21/64	4.0000	0.00		4 cfs Cond.
10	APPELT NO.4 WELL	BSC	WELL	T17S R63W 11	09/21/64	4.0000	0.00	4369 F	E.Baker.1.8 cfs.cond.
10	APPELT NO.3 WELL	BSC	WELL	T17S R63W 11	09/21/64	4.0000	0.00		4 cfs Cond.
10	EAST BAKER NO.1	BSC	WELL	T17S R63W 11	12/31/59	0.1100	0.00	95598	N.Baker House: 0.077 cfs Cond.
10	NO.6990-F	BSC	WELL	T17S R63W 11	04/19/65	3.4400	1110.0	6990 -F	Circle 3 Irrig.
10	PEASE	BSC	WELL	T17S R63W 12	04/17/69	0.0180	0.00	37345	
10	BAKER	BSC	WELL	T17S R63W 14	06/06/61	0.1000	0.00	8844	S.Baker House.Dec.loctn.error
10	WELL NO, 1	BSC	WELL	T17S R63W 14	05/25/61	0.0890	0.00	8711	
10	CHASE-CHISMAN	BSC	WELL	T17S R63W 15	09/27/71	0.0330	0.00	48744	
10	PAUL CHISMAN		WELL	T17S R63W 15	04/11/69	0.0560	0.00		
10	HOLMES WELL	BSC	WELL	T17S R63W 22	12/31/42	2.0200	0.00	23004 -F	100 Acres, 2.0 cfs cond.
10	APPELT NO.6 WELL	BSC	WELL	T17S R63W 22	09/21/64	4.0000	0.00		3.78 Cfs Cond.

APPENDIX 2 (continued)

WD	WATER RIGHT NAME	SOURCE	STRU TYPE	LOCATION TWN RNS SEC	APPRO. DATE	cfs (d)	ADFT (d/p)	PERMIT NUMBER	REMARKS
10	APPELT NO.7 WELL	BSC	WELL	T17S R63W 22	09/21/64	4.0000	0.00		4 cfs Cond.
10	APPELT WELL NO.8	BSC	WELL	T17S R63W 22	09/21/64	4.0000	0.00		4 cfs Cond.
10	APPELT NO.9 WELL	BSC	WELL	T17S R63W 23	09/21/64	4.0000	0.00		4 cfs Cond.
10	NEW NEGRO WELL	BSC	WELL	T17S R63W 24	12/31/63	0.0200	0.00	23005 -F	
10	APPELT NO. 14 WELL	BSC	WELL	T17S R63W 24	09/21/64	4.0000	0.00		4 cfs Cond.
10	H.O.P. NO.1 RESERVOIR	SB	R	T17S R63W 28	06/01/80	0.0000	0.00		Cap.30,000 cu.ft. Year=1880
10	H.O.P. NO.3 RESERVOIR	SB	R	T17S R63W 28	06/01/92	0.0000	0.00		Cap.25,000 cu.ft. Year=1892
10	H.O.P. NO.2 RESERVOIR	SB	R	T17S R63W 28	06/01/88	0.0000	0.00		Cap. 25,000 cu. ft.Year=1888
10	WELL K	BSC	WELL	T17S R63W 28	09/21/64	0.0400	0.00	23009 -F	
10	H.O.P.DITCH NO.2	SB	D	T17S R63W 29	07/01/75	2.0000	0.00		Feeder for H.O.P.RES.1,2 & 3
10	H.O.P. No.1 DITCH	SB	D	T17S R63W 29	06/01/81	2.0000	0.00		Ditch #2 on Spg.Branch
10	HOLMES CAMP WELL	BSC	WELL	T17S R63W 29	12/31/42	0.2000	1.00	23006 RF	SB
10	HOLMES CAMP NO.3	BSC	WELL	T17S R63W 29	12/31/42	0.2000	0.00	31654	0.167 cond.
10	GUEST HOUSE WELL	BSC	WELL	T17S R63W 29	12/31/42	0.2000	146.00	23007 -F	SB, Decree loctn.in error
10	GUEST HOUSE NO.2	BSC	WELL	T17S R63W 29	12/07/68	0.2000	0.00	37544	0.167 cfs cond.
10	APPELT JR. WELL	BSC	WELL	T17S R63W 29	12/31/42	0.2000	146.00	23008 -F	SB
10	H.O.P. RESERVOIR	SB	R	T17S R63W 32	12/28/02	0.0000	69.00		Cap. 3 Mcf.Res.#5 on Spg.Br.
10	CURITON RESERVOIR	SB	R	T17S R63W 32	03/15/03	0.0000	0.00		Cap.300,000 cu.ft.Comb.w/HDP
10	CHISMAN-HARTLEY	BSC	WELL	T17S R63W 34	09/28/71	0.0270	0.00	46402	
14	J.H. HOLLAND #3	BSC	R	T 5 R W	/ /	0.0000	5.00		Cap. 217,300 cu.ft.
14	QUARTER CORNER WELL	BSC	WELL	T18S R61W 18	09/21/64	0.0100	0.00		0.01 cfs Cond.
14	CAMP WELL	GW	WELL	T18S R62W 04	12/31/20	0.1700	0.00	23010 -F	0.04 cfs Cond.
14	LONG BRANCH WELL	BSC	WELL	T18S R62W 07	12/31/63	0.0200	0.00	23011 -F	
14	SOUTH CAMP WELL	BSC	WELL	T18S R62W 09	09/21/64	0.0400	0.00	23012	
14	APPELT NO.23	BSC	WELL	T18S R62W 28	09/21/64	4.0000	0.00		4 cfs Cond.
14	NORTH ANTELOPE WELL	BSC	WELL	T18S R62W 28	09/21/64	0.0400	0.00	34600	Permit No, per note on Permit
14	APPELT NO.21	BSC	WELL	T18S R62W 29	09/21/64	4.0000	0.00	23013 -F	3.1 cfs Conditional
14	APPELT NO.22	BSC	WELL	T18S R62W 29	09/21/64	4.0000	0.00		4 cfs Cond.
14	HEADQUARTERS WELL NO.1	GW	WELL	T18S R63W 03	12/31/42	0.1300	0.00	31516	0.097 cfs Cond.
14	HEADQUARTERS WELL 2	BSC	WELL	T18S R63W 03	04/01/65	0.4500	0.00		
14	APPELT NO. 20 WELL	BSC	WELL	T18S R63W 03	09/21/64	4.0000	0.00		Four APD's: 3.98 cfs.cond.
14	APPELT NO.20-1	GW	WELL	T18S R63W 03	09/21/64	1.6000	1150.0	2055B -F	APD for AP20 1.58 cfs.cond.

APPENDIX 2 (continued)

NO	WATER RIGHT NAME	SOURCE	STRU TYPE	LOCATION TWN RNS SEC	APPRO. DATE	cfs (d)	ACFT (d/p)	PERMIT NUMBER	REMARKS
14	PIPELINE WELL	BSC	WELL	T18S R63W 03	04/01/65	0.1300	0.00	0	
14	UNNAMED WELL	GW	WELL	T18S R63W 04	12/31/57	0.8500	280.00	0	R.Chissman
14	APPELT 20-2	GW	WELL	T18S R63W 04	09/21/64	1.1000	790.00	20559 -F	APD for AP20 1.1 cfs Cond.
14	SMITH NO.1 RESERVOIR	SB	R	T18S R63W 05	03/01/03	0.0000	0.00	0	Cap. 133,333 cfs;Res #6 SpgBr.
14	SMITH NO.1 DITCH	SB	D	T18S R63W 05	03/01/95	1.0000	0.00	0	Ditch No.3 on Spring Branch
14	SMITH NO. 2 DITCH	SB	D	T18S R63W 05	04/15/02	1.0000	0.00	0	Ditch No. 4 on Spring Branch
14	SMITH NO. 2 RESERVOIR	SB	R	T18S R63W 05	04/07/02	0.0000	6.00	0	Cap. 266,666 cu.ft.
14	J.H. HOLLAND #2	BSC	R	T18S R63W 09	/ /	0.0000	0.00	0	
14	APPELT 20-3	GW	WELL	T18S R63W 10	09/21/64	0.7000	505.00	20560 -F	APD For AP20: 0.7 cfs Cond.
14	APPELT NO. 20-4	GW	WELL	T18S R63W 10	09/21/64	0.6000	430.00	20561 -F	APD for AP20 0.6 cfs Cond.
14	J.H. HOLLAND #1	BSC	R	T18S R63W 10	/ /	0.0000	8.00	0	Cap.366,200 cu.ft.
14	SCHOOL HOUSE	GW	WELL	T18S R63W 15	12/31/20	0.0400	0.00	95599	
14	TOLLE & DITCH #1	BSC	R	T18S R63W 15	/ /	0.0000	0.00	0	
14	UNNAMED RESEAUOIR	BSC	R	T18S R63W 22	/ /	0.0000	0.00	0	Reservoir 6 ?
14	MAY RANCH RESEAUOIR	BSC	R	T18S R63W 23	/ /	0.0000	0.00	0	Reservoir 6 1/2 ?
14	DOT MAIN WELL NO.1	GW	WELL	T19S R62W 03	08/17/71	0.0000	40.00	15829 -F	
14	DOT BACK UP WELL	GW	WELL	T19S R62W 03	08/31/71	0.0000	0.00	20730 -F	Supplemental for 15829-F
14	SOUTH ANTELOPE WELL	BSC	WELL	T19S R62W 06	04/30/65	0.6400	0.00	24267	
14	SOUTH CHICO WELL	BSC	WELL	T19S R62W 19	09/21/64	0.0400	29.00	36426	
14	BAR J-B Well	BSC	WELL	T19S R63W 11	12/31/17	0.0300	22.00	36424	Correct name is Bar JH
14	WELL NO.5	GW	WELL	T16S R61W 17	12/31/56	0.0300	0.00	90134	
14	APPELT NO.18 WELL	BSC	WELL	T17S R62W 29	04/21/67	4.1000	2990.0	25001 -F	2.45 Absolute, 1.65 Cond.(cfs)

Figures from Pocket

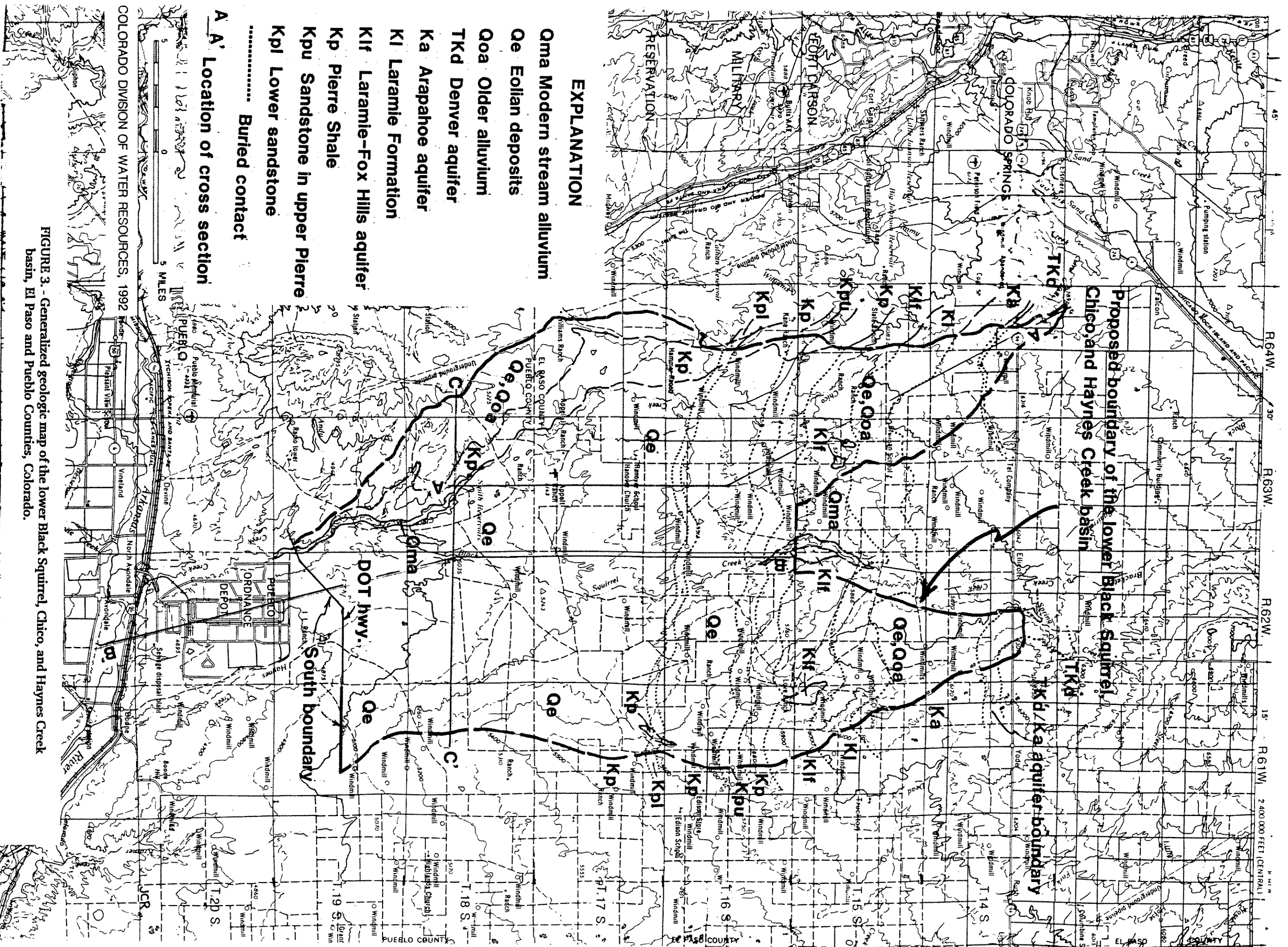


FIGURE 3. - Generalized geologic map of the lower Black Squirrel, Chico, and Haynes Creek basin, El Paso and Pueblo Counties, Colorado.

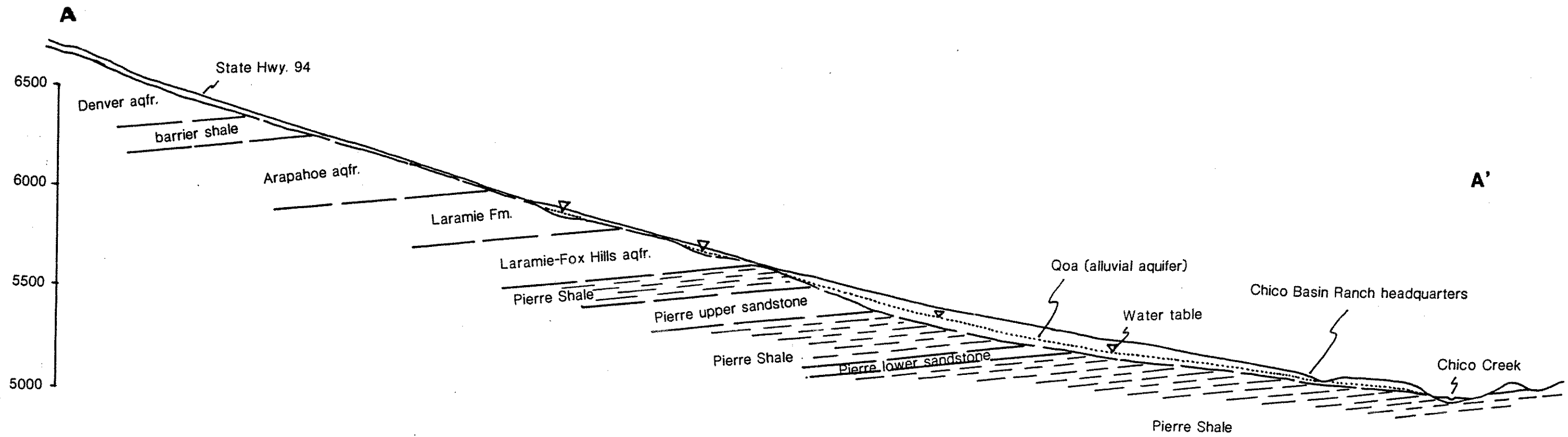


FIGURE 4. - Generalized north-south cross section of the basin extending through the Chico Basin Ranch head-quarters. Scale is approximate; horizontal scale is 2 miles per. inch, figures are elevations above sea level in feet.

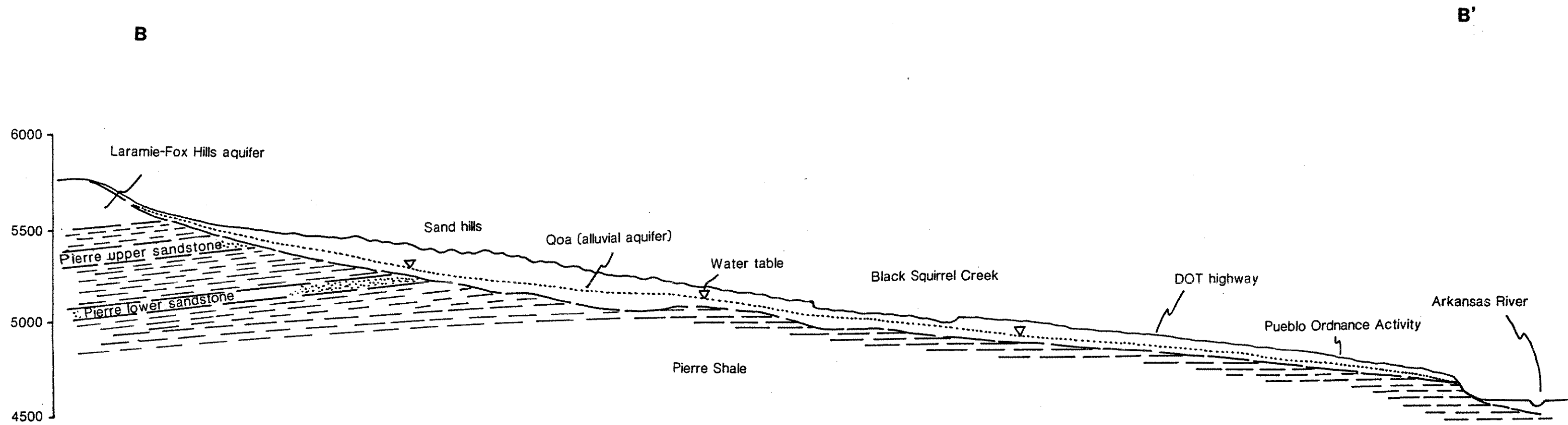


FIGURE 5. - Generalized north-south cross section of the basin extending through the Pueblo Ordnance Activity. Scale is approximate; horizontal scale is 2 miles per inch, figures are elevations above sea level in feet.

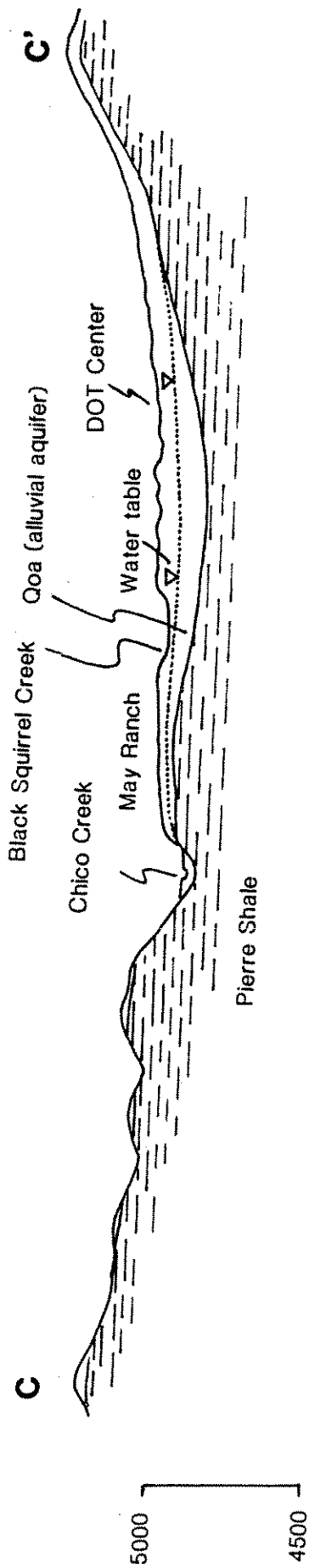


FIGURE 6. - Generalized east-west cross section through the basin extending through May Ranch and the DOT test center. Scale is approximate; horizontal scale is 2 miles per inch, figures are elevations above sea level in feet.

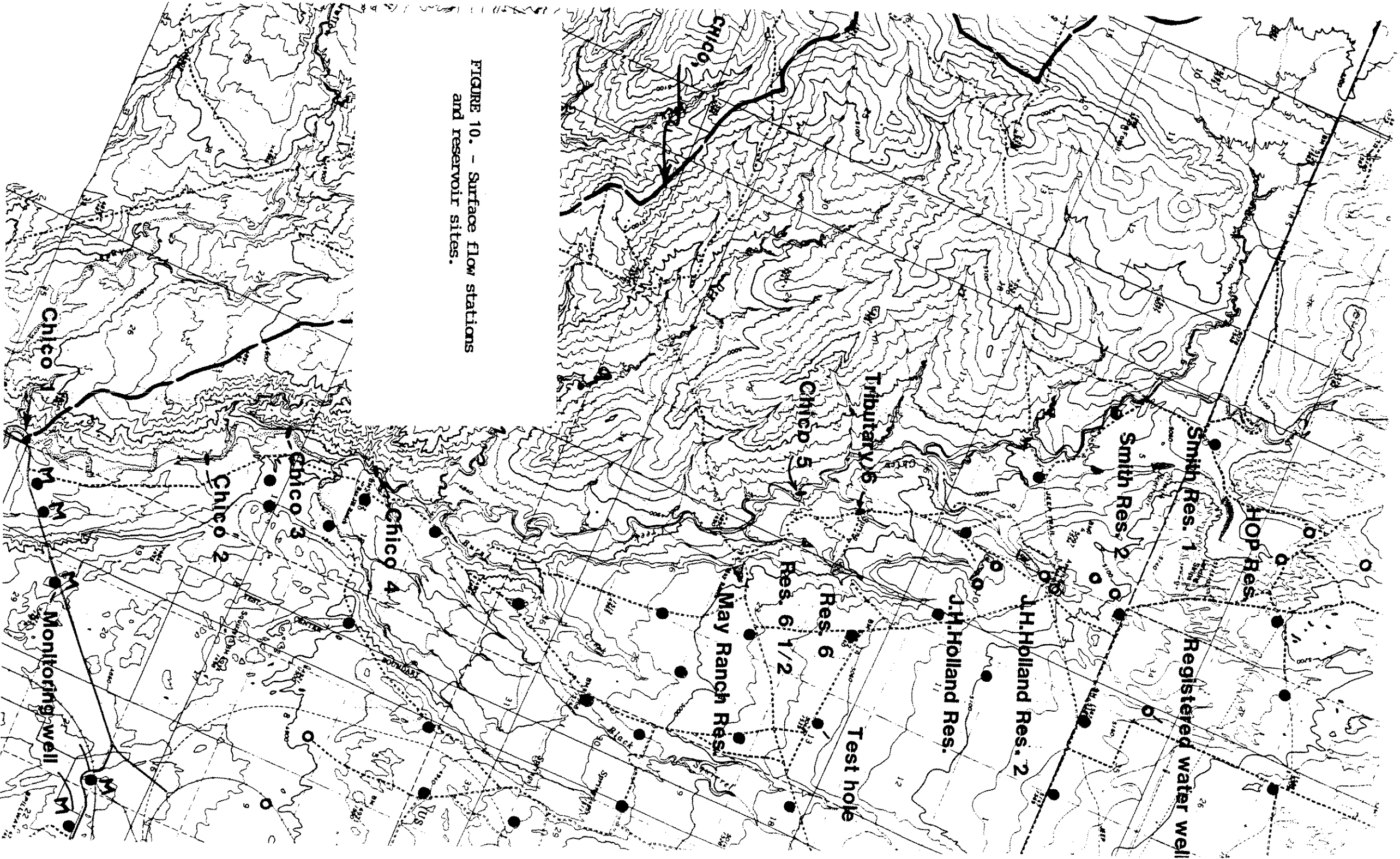


FIGURE 10. - Surface Flow stations and reservoir sites.

R.64W. R.63W.

R.63W. R.62W.

R.62W. R.61W.

T.13S.
T.14S.

T.13S.
T.14S.

T.14S.
T.15S.

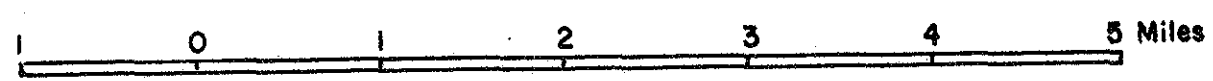
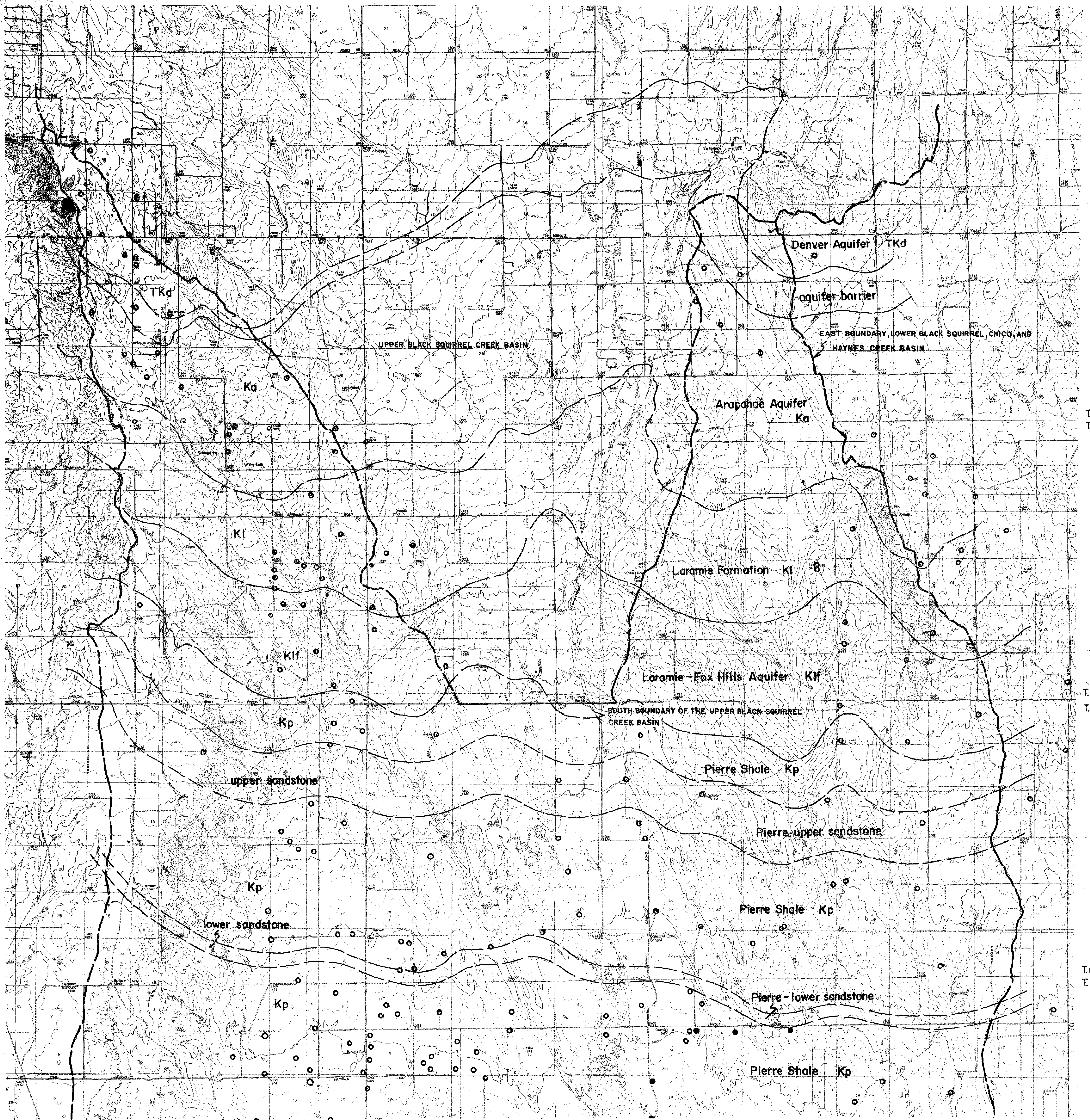
T.14S.
T.15S.

T.15S.
T.16S.

T.15S.
T.16S.

T.16S.
T.17S.

T.16S.
T.17S.



OUTCROP-SUBCROP MAP OF THE LOWER BLACK SQUIRREL,CHICO,AND HAYNES CREEK BASIN'S BEDROCK AQUIFERS

R.64W R.63W

R.63W R.62W

R.62W R.61W

T.13S
T.14S.

T.13S
T.14S

T.14S.
T.15S.

T.14S.
T.15S.

T.15S.
T.16S.

T.15S.
T.16S.

T.16S.
T.17S.

T.16S.
T.17S.

T.17S.
T.18S.

T.17S.
T.18S.

T.18S.
T.19S.

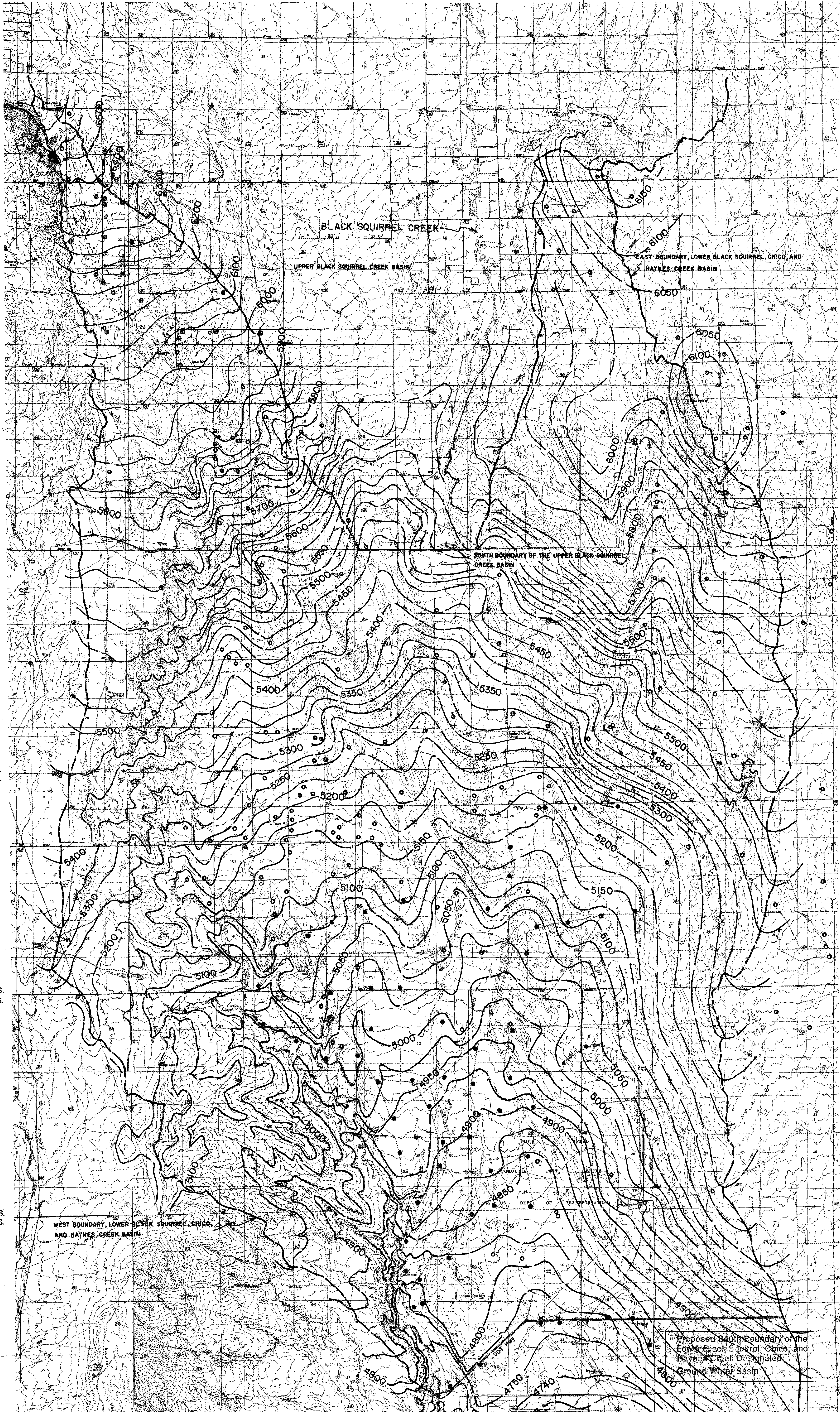
T.18S.
T.19S.

T.19S.
T.20S.

T.19S.
T.20S.

T.20S.
T.21S.

T.20S.
T.21S.

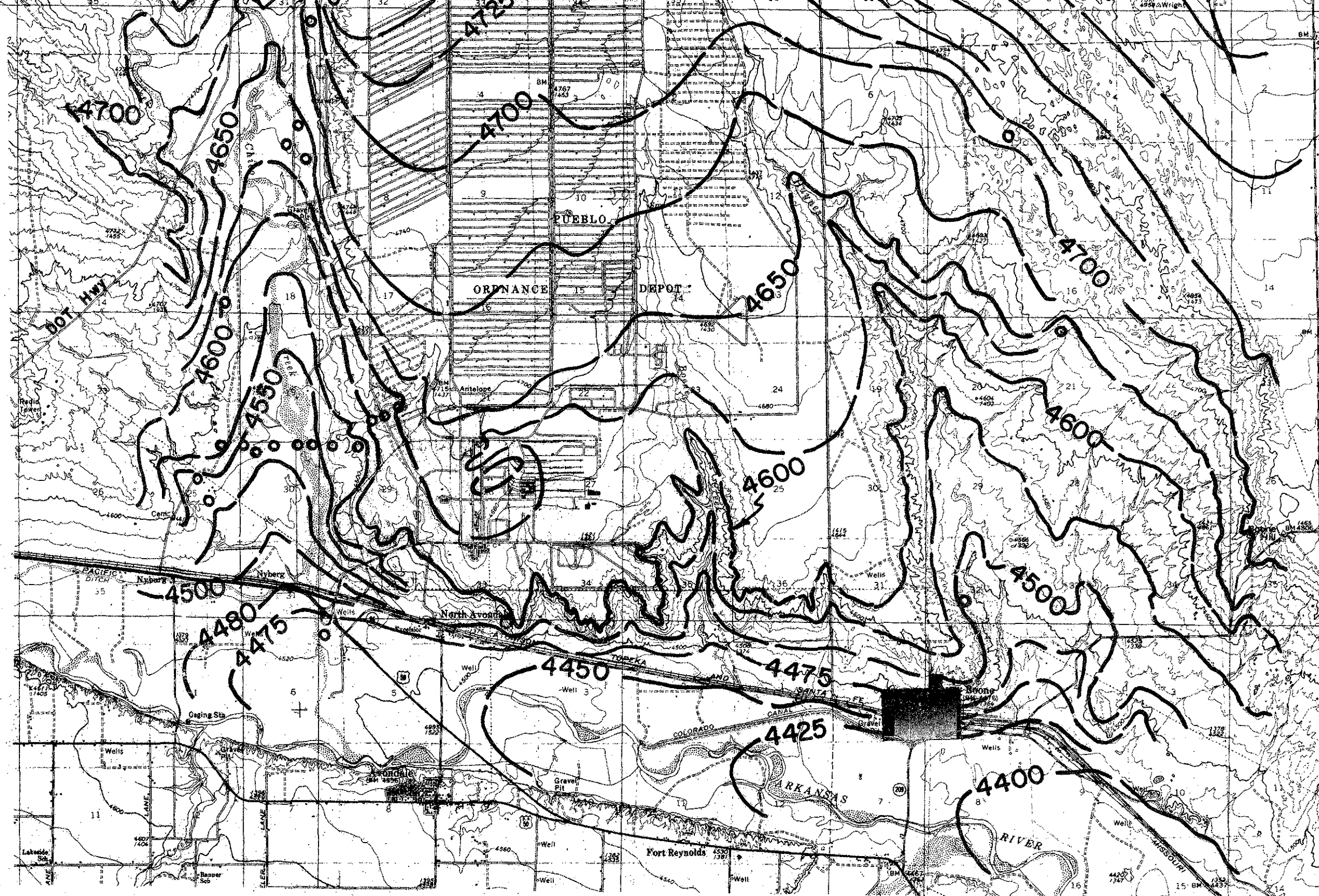


MAP OF THE LOWER BLACK SQUIRREL, CHICO, AND HAYNES CREEK BASIN, SHOWING THE CONFIGURATION OF THE BEDROCK SURFACE

Explanation

- ● Date point
- Test hole
- M Monitoring hole
- 4700— Bedrock contour, 25 and 50 foot intervals

0 1 2 3 4 Miles



R.63W R.62W

R.64W R.63W

R.63W R.62W

R.62W R.61W

T.13S.
T.14S.

T.13S.
T.14S.

T.14S.
T.15S.

T.14S.
T.15S.

T.15S.
T.16S.

T.15S.
T.16S.

T.16S.
T.17S.

T.16S.
T.17S.

T.17S.
T.18S.

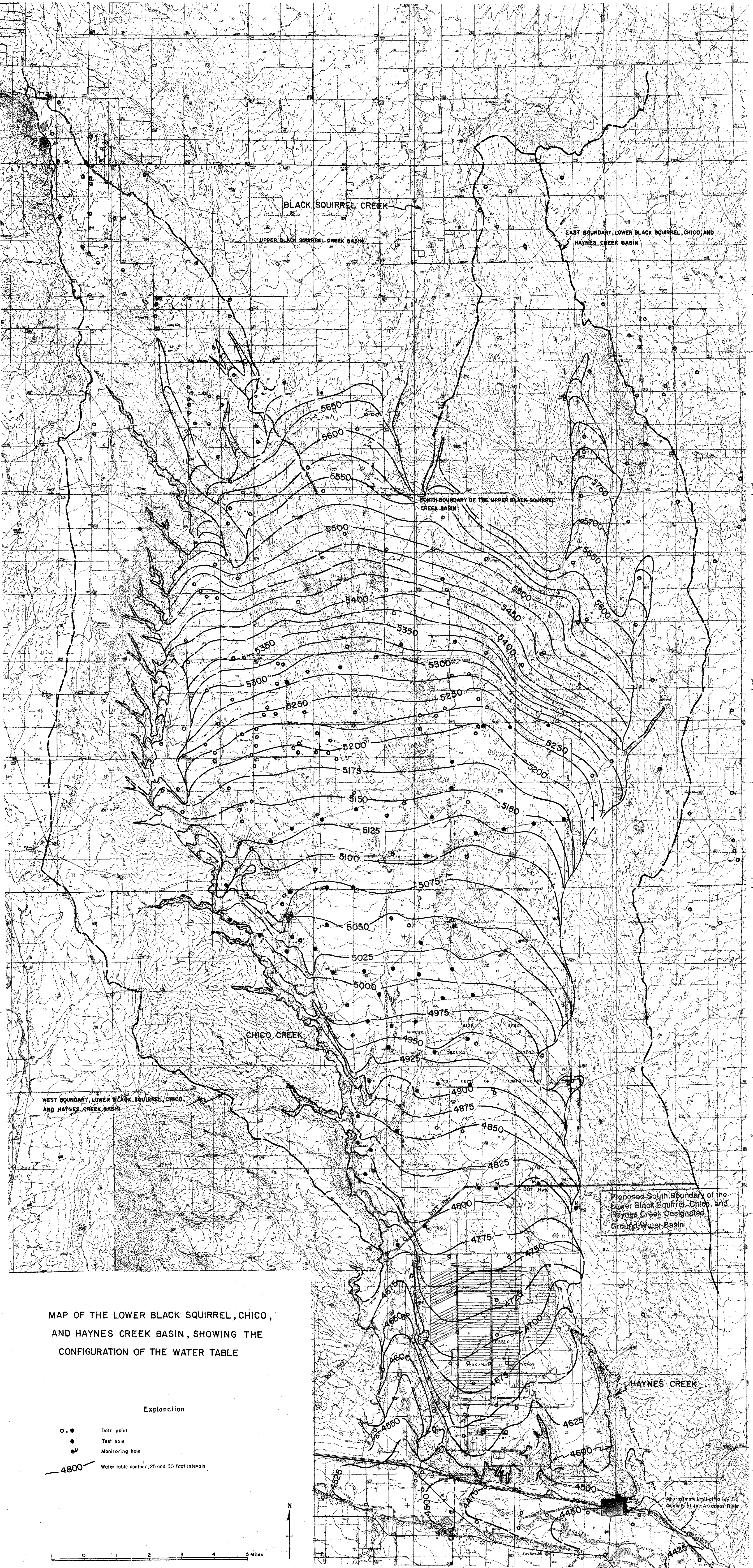
T.17S.
T.18S.

T.18S.
T.19S.

T.18S.
T.19S.

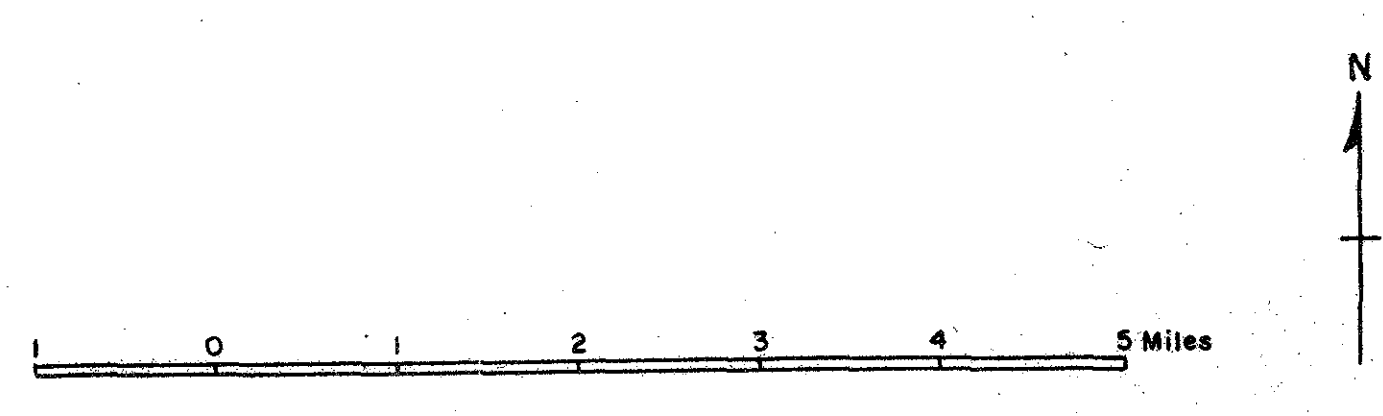
T.19S.
T.20S.

T.20S.
T.21S.



MAP OF THE LOWER BLACK SQUIRREL, CHICO, AND HAYNES CREEK BASIN, SHOWING THE CONFIGURATION OF THE WATER TABLE

- Explanation
- ● Data point
 - Test hole
 - Monitoring hole
 - 4800 — Water table contour, 25 and 50 foot intervals



R.63W R.62W

R.61W R.60W

Prepared by J. Romero, '91

R.64W. R.63W.

R.63W. R.62W.

R.62W. R.61W.

T.13S.
T.14S.

T.13S.
T.14S.

T.14S.
T.15S.

T.14S.
T.15S.

T.15S.
T.16S.

T.15S.
T.16S.

T.16S.
T.17S.

T.16S.
T.17S.

T.17S.
T.18S.

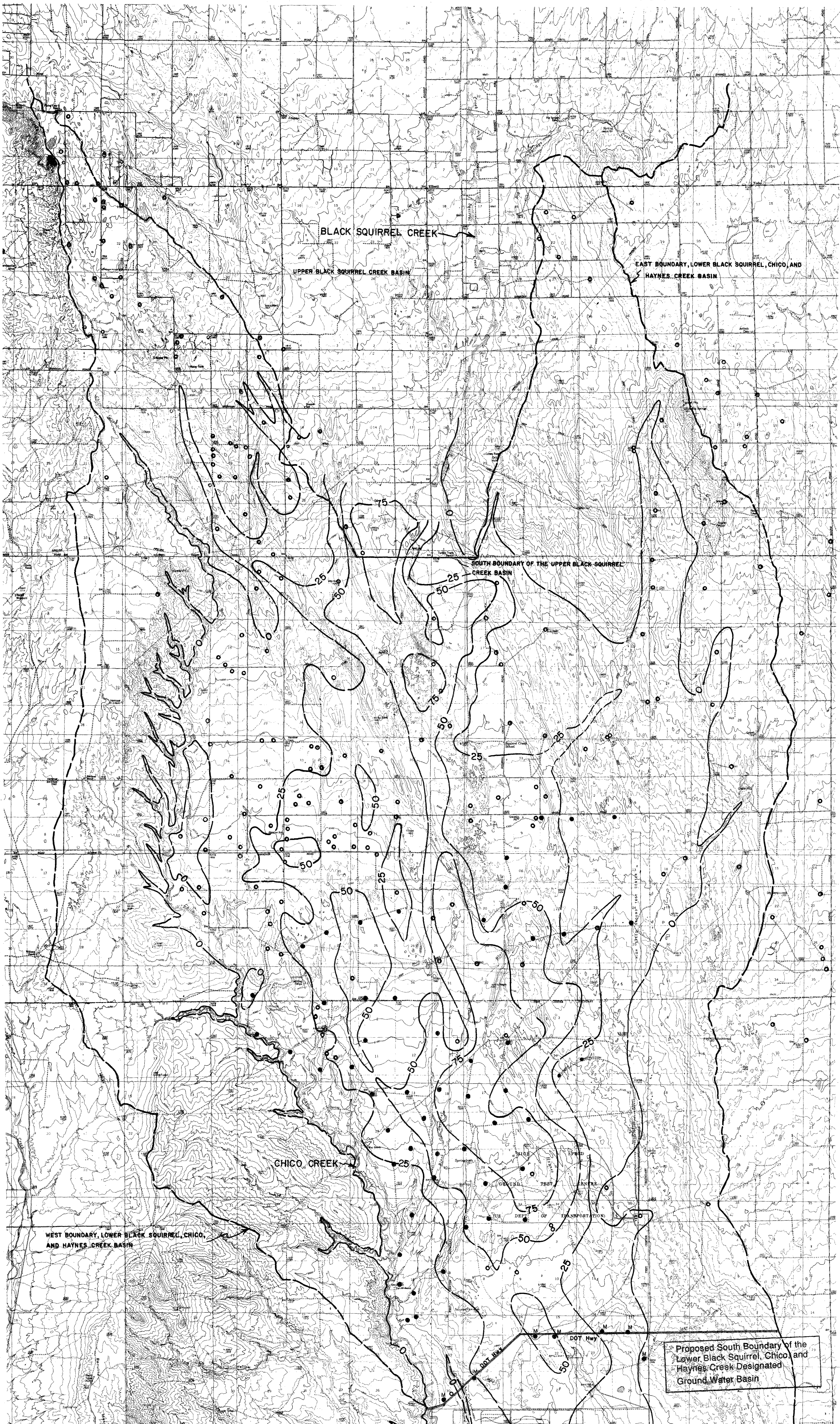
T.17S.
T.18S.

T.18S.
T.19S.

T.18S.
T.19S.

T.19S.
T.20

T.20S.
T.21



MAP OF THE LOWER BLACK SQUIRREL, CHICO, AND HAYNES CREEK BASIN, SHOWING THE THICKNESS OF THE SATURATED ALLUVIUM

- Explanation
- , ● Data point
 - Test hole
 - Monitoring hole
 - 25— Saturated thickness contour

