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BP

LAW OFFICES
OF
WILSON, COMPTON, EGAN & LINCOLN
203 N. SAN FRANCISCO, P. O. BOX 550
FLAGSTAFF, ARIZONA 86001

ORINN C. COMPTON
CHAS. B. WILSON, JR.
WILLIAM M. EGAN
KENNETH J. LINCOLN

TELEPHONE 774-2755
AREA CODE 602

15th July 1970

Paul A. Head, Geophysicist
Heinrichs Geoexploration Company
P. O. Box 5671
Tucson, Arizona 85703

Re: Black Bill & Doney Park Water Users Association
Job No. 403-69

Dear Mr. Head:

It has come to my attention that the report provided by your company to my client, the Black Bill & Doney Park Water Users Association and upon which we relied in having a driller bore test holes in a search for additional water sources was based upon erroneous computations.

It is my client's belief that the computations as provided failed to account for the presence near the test site of two major gas transmission pipelines. In consulting with our engineer, Mr. William Ramsey, of Phoenix, he has indicated that the failure to properly include within the calculations an allowance for the presence of these large metal pipelines would distort the final resort of your testing.

It is to be further understood that we hereby make claim against you and your errors and omissions policy for the amount which we paid for this report, as well as the amount which we expended for test drilling.

I suggest that you have an adjuster for your errors and omissions policy contact me immediately as to the total figures and handling of this claim. The expenditure for this report from your company was $1,684.72 and the amount of $6,000.00 was expended for drilling the test holes in reliance upon what now appears to be erroneous information provided by your company in the report. If

no response to this claim is forthcoming within fourteen (14) days, it will be necessary that we proceed with litigation to recover the amounts which we expended in reliance upon your report.

Very truly yours,

WILSON, COMPTON, EGAN & LINCOLN

Kenneth J. Lincoln

Kenneth J. Lincoln

KJL:bjg

Copy to: Wm. A. Ramsey

Re: Geoph Sol. 403

WM. A. RAMSEY
CONSULTING ENGINEER
1222 East Missouri Ave.
Phoenix, Arizona 85014

Telephone:
274-6017

24 January 1970

HEINRICHS GEOEX
TUCSON, ARIZONA

REC'D JAN 26 1970

BOX 5671 TUCSON, ARIZONA 85703
Phone: (AREA 602) 623-0578

Mr. Grover Heinrichs
Heinrichs Geoexploration Company
P. O. Box 5671
Tucson, Arizona 85703

Dear Grover:

As per our telephone conversation today I am enclosing copies of the driller's logs on the four test holes which we drilled in Section 18, Township 22 N, Range 8 E, adjacent to your geophysical survey of the early part of 1969.

I am also enclosing a copy of your location map which shows the approximate location of the drill holes marked in red. As you will note, they are not exactly as you had recommended but in very close proximity.

I would appreciate it if you and Paul Head would review this information for a day or so and be in a position to discuss it further and see if we might draw some additional conclusions.

I will be in touch with you Wednesday afternoon relative to this.

Very truly yours,

Bill

William A. Ramsey, P. E.

Enclosures

FCM DRILLING SERVICE

1008 HAZEL WAY FLAGSTAFF, ARIZONA ~~774-1006~~ 774-1225

DRILL LOG

Client: Denny Park (Park Us Assn)

Drill Site: Sec 17, T22N, R8E

Date: Dec. 11-16, 1969

Hole No.	Depth From	Depth To	Formation	Remarks
H-1	0	2	Top Soil	
	2	6	Malapai Boulder	
	6	80	Loose Volcanics	Very dry + Caving
				Cemented hole at
				80'
	80	90	Loose Volcanics	
	90	95	damp clay w/ Volcanics	
	95	240	Volcanics	
	240	310	Broken Malapai	No Sample return
	310	320	Very hard Malapai	

Geologist _____

Driller L Gracey

FCM DRILLING SERVICE

1008 HAZEL WAY FLAGSTAFF, ARIZONA 774-4006

DRILL LOG

Client	Drill Site	Date
Black Bill & Donal Parks Wat U Assc	Sec 17, T22N, R8E	Dec 16-31, 1969

Hole No.	Depth From	Depth To	Formation	Remarks
H-2	0	3	Top Soil	
	3	90	Loose Volcanics	Cemented but at 90
	90	290	Volcanics	
	290	300	Molapai	

Geologist _____ Driller R. Stacey

FCM DRILLING SERVICE

1008 HAZEL WAY FLAGSTAFF, ARIZONA 774-4006

DRILL LOG

Client: Black B. 11 & Donaldson Parks Nat'l Park

Drill Site: Sec. 17, T22N, R8E

Date: June 10, 1976

Hole No.	Depth From	Depth To	Formation	Remarks
H-3	0	2	Top Soil	
	2	6	Malapais Boulder	
	6	190	Loose Volcanics	
	190	305	Very damp dacite or Rhyolite	
			Formation started getting dry and hard at 290'	
			Blew hole w. the Compressor for 2 hours = No Water Production	

Geologist _____

Driller L. Gracey

FCM DRILLING SERVICE

1008 HAZEL WAY FLAGSTAFF, ARIZONA 774-4006

DRILL LOG

Client	Drill Site	Date
[illegible]	Sec 17, T 23 N, R 8 E	Dec 16-21, 1970

Hole No.	Depth From	Depth To	Formation	Remarks
Hw 4	0	80	Loose Volcanics	
			Very damp from 60-80	
			Blew water hole for 30 min	with 600 cfm
			water production 10 gpm	
	80	700	Volcanics	
			Blew hole for water	with 600 cfm
			water Production 10 gpm	
		700	Total Depth	

Geologist _____ Driller [illegible]

R. 7 E.

R. 8 E.

T. 22 N.

14

13

23

24

18

17

19

20

LINE 1

25 NE

CENTER EXPANDER # 1

CENTER EXPANDER # 2

25 W

25 E

LINE 2

25 SW

EXPLANATION

OVERLAY OF BASE MAP SUBMITTED BY WM. A. RAMSEY

N

HEINRICHS
GEOEXPLORATION COMPANY
POST OFFICE BOX 5671, TUCSON, ARIZONA, 85703
Phone: 602/623-0578 Cable: GEOEX, Tucson
geophysical engineers vancouver sydney

405-69

LOCATION PLAN

OF

RESISTIVITY SURVEY

FOR
BLACK BILL & DONEY PARKS WATER
USERS ASSOCIATION (BILL RAMSEY)
FLAGSTAFF, ARIZONA

SCALE 1" = 1000' | DRAWN BY J.L. PETRY | DATE 6-69

Please Return to Ramsey GEOEX

UNITED STATES DEPARTMENT OF THE INTERIOR
Douglas McKay, Secretary

GEOLOGICAL SURVEY
W. E. Wrather, Director

GEOLOGICAL SURVEY CIRCULAR 233

A GEOLOGIC AND GEOPHYSICAL RECONNAISSANCE OF THE DONEY PARK-BLACK BILL PARK AREA, ARIZONA WITH REFERENCE TO GROUND WATER

By J. H. Feth

With a section on geophysics
By C. B. Yost, Jr.

Prepared in cooperation with the
Arizona State Land Department
W. W. Lane, Commissioner

Washington, D. C., 1953

Free on application to the Geological Survey, Washington 25, D. C.

A GEOLOGIC AND GEOPHYSICAL RECONNAISSANCE OF THE DONEY PARK-BLACK BILL PARK AREA, ARIZONA, WITH REFERENCE TO GROUND WATER

With a section on geophysics

CONTENTS

INTRODUCTION

Purpose and cooperation

Doney and Black Bill Parks, near Flagstaff, Ariz., are inhabited by a number of families whose domestic water supply is derived almost entirely from precipitation caught on the roofs of farm buildings and stored in cisterns. During dry months in a year of normal precipitation, and throughout much longer periods in years of subnormal precipitation, the residents of the area haul water from Flagstaff.

In 1950 only one of the wells in the area yielded water. Officers of the Doney Park Farm Bureau and of the San Francisco Peaks Soil Conservation District requested that investigation be made in the area to determine whether it would be possible to develop additional domestic water supplies from wells.

The Ground Water Branch of the U. S. Geological Survey, in cooperation with the Arizona State Land Department, made a reconnaissance investigation in the fall of 1950 and the spring of 1951. Field work was under the direction of S. F. Turner, district engineer of the Ground Water Branch. The geology of the area was mapped by J. H. Feth, who was assisted for part of the time by L. R. Moore; the geophysical investigation was made by C. B. Yost, Jr., and J. P. Mooseau, Jr. Residents of the area contributed assistance during the geophysical work and furnished information regarding old wells in the area.

Location

Doney and Black Bill Parks are unforested areas east of the San Francisco Mountains and Elden Mountain on the San Francisco Plateau subdivision of the Colorado Plateaus. The area mapped comprises about 125 square miles. It is bounded on the south by Walnut Canyon, on the west by Elden Mountain and the San Francisco Mountains, on the north by the topographic divide between Black Bill Park and Deadman Flat, and on the east by an irregular range of cinder hills including Sunset Crater and O'Neill Crater (New Caves Hill).

Flagstaff, the county seat of Coconino County, Ariz., is about 15 miles southwest of the center of the area mapped. U. S. Highway 66 and the main line

of the Atchison, Topeka and Santa Fe Railway cross the southern part of the area. U. S. Highway 89 extents north from Flagstaff through the western part of the area. County, Federal, and private roads provide access to all parts of the area.

Climate

U. S. Weather Bureau records have been kept at Flagstaff for more than 50 years. These records show that the mean annual temperature at Flagstaff is about 45° F. The mean temperature during December and January is about 20° F. and during July and August, about 65° F. The mean annual precipitation is about 22 inches, much of which occurs as snowfall. The altitude of Flagstaff is 6,900 feet above sea level. The farm lands in Doney and Black Bill Parks lie 6,500 to 7,000 feet above sea level. The average growing season at Flagstaff is about 125 days a year; this would be about the average for Doney and Black Bill Parks.

Agriculture and industry

The dry-land raising of pinto beans and small grains is the principal industry in the area considered in this report. Lack of water prevents development of any appreciable livestock industry although small herds of beef cattle are raised in a few localities where surface water is stored in earth tanks, and where range conditions permit.

Logging operations are carried on intermittently in forested areas, principally on the flanks of Elden Mountain and the San Francisco Mountains, and a small sawmill was in operation in Black Bill Park during 1950-51.

Previous investigations

The most comprehensive previous geologic investigation of the Black Bill-Doney Park area is reported by Robinson (1913).[1] None of the papers cited in this report have dealt specifically with the geology in relation to the occurrence of ground water. It is believed that the present report is the first to attempt an analysis of ground-water conditions in the parks.

Maps and field work

About 4 man-months was spent in the field during the investigation, a little more than 75 percent of the time being devoted to geologic mapping and to compiling and analyzing data on springs and wells.

Geologic mapping was done on contact prints of aerial photographs made originally for the U. S. Forest Service. Data so recorded were transferred to an uncontrolled aerial mosaic. Land lines were taken from a U. S. Forest Service topographic map and adjusted to section corners recovered in the field. The resulting geologic map appears as plate 1 in this report.

Geophysical probes were made with electrical-resistivity apparatus. The results are discussed in the section on geophysics (p. 5).

[1] See p. 9 for list of literature cited.

LAND FORMS

Three types of land forms predominate in the Doney-Black Bill Parks area. The San Francisco Mountains, composed of numerous volcanic peaks, dominate the landscape. Elden Mountain, an outlier of the volcanic mass, is an important unit on the southwest boundary of the area. Although of volcanic origin, Elden Mountain has been described (Robinson, 1913, pp. 74-84) as a laccolith rather than a volcanic cone. The interpretation of Elden Mountain as a laccolith was based upon the presence of about 2,000 feet of sedimentary strata on the east flank of the mountain, dipping east at angles as much as 50° from the horizontal, and on about 700 feet of sedimentary rocks on the north flank of the mountain, dipping north about 12°. The summit of Elden Mountain is 9,280 feet above sea level, or about 2,500 feet higher than Doney Park. The summits of six of the San Francisco peaks exceed 11,000 feet in altitude.

Numerous cinder cones rise about 100 feet to 1,000 feet above the general level of the country in and adjacent to Doney and Black Bill Parks. Most of these cinder cones have been colored red by oxidation of the originally black cinders. Locally, parts of the cones consist of black or gray basalt ("malpais"). The northeast and east boundaries of the area consist in large part of cinder cones and cinder ridges.

The cultivated parts of Doney and Black Bill Parks are gently rolling unforested areas among the cinder cones. Doney Park is about 3 miles by 4 miles at its maximum, and Black Bill Park is about $2\frac{1}{2}$ miles by 4 miles. Alluvial fans extend eastward from the foot of the mountains to the parks, forming long smooth thinly forested slopes.

In the southern part of the area the presence at or near the surface of horizontal limestone and sandstone strata has led to development of a topography characterized by approximately parallel ridges separated by shallow swales. Walnut Canyon, a gorge cut in the limestone and sandstone beds, is the southern limit of the area.

GEOLOGY AND ITS RELATION TO GROUND WATER

The following paragraphs give in brief what is known about the various rock formations identified in Doney and Black Bill Parks with respect to their geologic age, rock types, and water-bearing properties. The rock units are discussed in order of age, the oldest being presented first.

Rock units

Sedimentary rocks

Devonian. --Sandy limestone and limy sandstone of Devonian age crop out on the east side of Elden Mountain and are the oldest rocks exposed in the area mapped. The limy sandstones grade upward into quartzitic sandstone. The aggregate thickness of Devonian strata is about 125 feet (Brady, 1934, p. 10). These rocks are not known to be water bearing in Doney and Black Bill Parks.

Carboniferous (Mississippian). --About 200 feet of the Redwall limestone of Mississippian age overlies the Devonian rocks (Gutschick, R. C., personal communication, November 1950). The Mississippian strata consist in large part of beds of coarsely crystalline limestone containing many poorly preserved marine fossils. Shaly sandstones and mudstones are locally interbedded. The Redwall limestone is not known to be water bearing in the area.

Carboniferous (Pennsylvanian) and Permian. --Rocks assigned to the Supai formation are about 750 feet thick (Brady, 1934, p. 10) on the east slopes of Elden Mountain. This formation was considered of Pennsylvanian age by Robinson (1913, p. 23). Other investigators have assigned a large part of the Supai formation to the Permian period. Current practice is to consider most of the Supai formation as Permian but to assign some of the lower strata to the Pennsylvanian.

The Supai formation consists mostly of fine-grained sandstone and siltstone. Red is the predominant color. Thin beds of the limestone also occur in the sequence.

About 12 miles west of Flagstaff a well at the Navajo Ordinance Depot obtains water from beds of the Supai formation 1,300 feet below the surface. A spring flowing a few gallons per minute emerges from beds of the Supai formation in sec. 31, T. 22 N., R. 8 E., west of the south end of Doney Park.

The Coconino sandstone overlies the Supai formation on the slopes of Elden Mountain. Brady (1934, p. 10) states that these sandstone beds are about 600 feet thick. Part of the stratigraphic thickness thought to be occupied by the Coconino sandstone at the foot of Elden Mountain is masked at the surface by an overwash of sand and soil from higher slopes. In typical exposures, as in Oak Creek Canyon 15 miles south of Flagstaff, a prominent characteristic of the formation is its large-scale cross bedding.

At various points 50 to 100 miles east of Flagstaff the Coconino sandstone is known to be a good aquifer. In the deep well at the Depot, the Coconino sandstone lies above the water table and does not yield water to the well. In Doney and Black Bill Parks its water-bearing properties have not been tested. There is an intermittent seep, which was dry when visited, in sec. 30, T. 22 N., R. 8 E., at or near the contact between the Coconino and Supai formations.

McKee (1938, pp. 12-27) proposed the name Toroweap formation for a series of beds overlying the Coconino sandstone and underlying the Kaibab limestone in Grand Canyon and elsewhere on the Colorado Plateaus. In Walnut Canyon, beds assigned to the Toroweap formation (McKee, 1938, p. 26) show large-scale cross bedding normally considered typical of the Coconino sandstone. In this report, the Toroweap formation of McKee, if present, is included with the Coconino sandstone.

The Kaibab limestone in the region of the Colorado Plateaus consists of alternating strata of limestone, sandy limestone, sandstone, and locally shaly sandstone and siltstone. In the Flagstaff area the Kaibab limestone is generally sandier than in the Grand Canyon, where the term was first applied. The deep well at the Depot penetrated 525 feet of strata assigned to the Kaibab limestone. Brady (1934, p. 10) recognized 300 feet of beds on the east side of Elden Mountain as Kaibab.

So far as is known, the Kaibab limestone is not water bearing in the area around Flagstaff. The formation is fractured in most places where exposed, and solution of the limestone and lime-cemented sandstone has created channels and sinkholes that readily conduct water downward. The Bottomless Pits in sec. 17, T. 21 N., R. 8 E., are an example of sinkhole development in thoroughly jointed Kaibab strata.

Triassic. --Red sandstone and siltstone of the Triassic Moenkopi formation are prominent on hills between Flagstaff and Doney Park. Outcrops of Moenkopi strata are present in the southern part of the area but are too small to be shown on plate 1.

According to Price,[2] the Moenkopi formation on the rim of Sycamore Canyon, about 15 miles southwest of Flagstaff, averages about 250 feet in thickness and attains a maximum thickness of 370 feet. In Doney and Black Bill Parks, exposures of the Moenkopi formation consist only of a basal conglomerate a foot or a few feet thick, or of the conglomerate and less than 10 feet of overlying sandstone and siltstone. No wells or springs in Doney and Black Bill Parks are known to derive water from the Moenkopi formation.

Quaternary. --Quaternary deposits, mostly of sedimentary origin, occur in both parks--in Doney Park in thicknesses up to about 300 feet. The logs of test bores on the Raymond A. Smith farm in sec. 33, T. 22 N., R. 8 E. (see well logs, pp. 10-11), show 285 to 293 feet of sand, gravel, clay, and tuff from the land surface to the top of the Kaibab limestone. It is not known whether the tuff penetrated in drilling the Smith prospect was dust deposited directly from the air, or whether it settled into water and was deposited as a series of water-laid beds.

The presence of temporary lakes in Quaternary time is indicated in at least two places in the region. Valley fill materials exposed in a gully near the Bottomless Pits in sec. 17, T. 21 N., R. 8 E., contain ripple-marked sands and silts and cross-bedded strata overlying the Kaibab limestone. The appearance of the sand and silt suggests deposition in a shallow body of water.

The presence in Recent time of a temporary lake in the Walnut Creek valley north of U. S. Highway 66 near Winona, 13 miles east of Flagstaff and east of the area mapped, has been reported (Colton, 1929, pp. 93-94). In that locality, Colton found shells of species of mollusks known to inhabit freshwater ponds and lakes.

An area west of Bonito Park at the north boundary of Black Bill Park is underlain by sand and gravel deposited by meltwater from glaciers that existed in Pleistocene time in the Interior Valley of the San Francisco Mountains (Sharp, 1942, pp. 488-489). The thickness of these deposits ranges from about 30 feet to 100 or 150 feet at places where

[2] Price, W. E., Jr., 1948, Rim rocks of Sycamore Canyon, Ariz., p. 37. [Unpublished Master of Science thesis in files of Univ. of Arizona Library.]

geophysical probes were run. The beds, where exposed in gravel pits, dip a few degrees to about 10° east toward Bonito Park. The water-bearing properties of the deposits have not been tested.

The Farrell well in the SW¼ sec. 26, T. 22 N., R. 8 E., yields a small amount of water at a depth of about 30 feet from Quaternary valley-fill materials overlying volcanic rock. The water-bearing properties of the Quaternary deposits otherwise are not definitely known in the area of the two parks.

Igneous rocks

Basaltic flows and basaltic cinders are the predominant rocks in the area and are thought to belong to what Robinson (1913, pp. 87-90) has called the Third Period of eruption. The volcanic activity of the third period took place mostly, or entirely, in Pleistocene and Recent time. Rocks of almost identical composition and appearance were extruded during what Robinson called the First Period of eruption. First Period basalts have not been recognized in the two parks and are thought to be covered by younger lavas and sediments.

The rocks comprising Elden Mountain, Little Elden Mountain, and the foothills of the San Francisco Mountains have been assigned by Robinson (1913, pp. 41-42, 70, 77, 78) to an intermediate stage (the Second Period) of volcanic activity that occurred probably in Pliocene time.

The eruption of Sunset Crater near the northeast corner of the parks (pl. 1) is the most recent event in the volcanic history of the area. This eruption is considered by Colton (1945, p. 7) to have occurred between 1046 and 1071 A. D. Cinders falling from that eruption covered a large part of the Doney and Black Bill Parks and adjacent areas.

The only areas of intrusive igneous rock observed, other than those forming parts of Elden Mountain and the San Francisco Mountains, were the volcanic neck of O'Neill Crater in sec. 29, T. 22 N., R. 9 E., and a small ring dike or plug in the NE¼ sec. 21, T. 21 N., R. 8 E.

Many springs in the Flagstaff area issue from basalt, and seeps at the bases of cinder cones are found west of Flagstaff. In Doney and Black Bill Parks, Little Elden Spring emerges from the dacite of Little Elden Mountain. Basalt flows are thought to form a partial barrier to the downward percolation of water thus creating perched water bodies in places, such as the one that supplies water to the Farrell well in sec. 26, T. 22 N., R. 8 E.

Laboratory tests of a sample of Recent cinder deposits obtained at a depth of about 25 feet below the surface in an auger hole on the Crisp farm, sec. 29, T. 22 N., R. 9 E., show that 44 percent of the volume of the sample consists of pore spaces. The water drained by gravity occupies 23 percent of the volume of the sample, and the water retained by capillary attraction, 21 percent. It is common experience in the two parks to find that, at depths of a few inches to a few feet below the surface, the Recent cinder deposits are wet and seem to be nearly saturated. However, holes drilled to depths of 20 or 30 feet in cinders have, so far as known, failed to yield water.

Structure

In general, sedimentary rocks exposed in the area shown on the geologic map (pl. 1) dip at angles of less than 10°. In many places the Kaibab limestone is horizontal. The glacial outwash gravels dip from 5° to 10° E. The dip of the outwash gravels is considered to be initial, for it is probably the result of deposition on a sloping surface and not indicative of structural deformation after deposition.

The principal area of steep dips in sedimentary rocks is that of the Paleozoic strata on Elden Mountain, where the dip is from 30° to 50° E. This area lies mainly in secs. 30 and 31, T. 22 N., R. 8 E. Robinson (1913, pp. 70-78) interprets the structure of Elden Mountain as that of a laccolith. By this explanation, the dacite that comprises the core of Elden Mountain was forced toward the surface as a mass sufficiently viscous as to drag upward Paleozoic strata more than 2,000 feet thick. The Paleozoic strata exposed on the flanks of Elden Mountain are the remnants of the original mass of rock dragged toward the surface. In the hills at the east base of Elden Mountain the Kaibab limestone dips about 50° SE. Two miles southeast of the hills, in the NS¼ sec. 33, T. 22 N., R. 8 E., a test well on the Smith farm penetrated the Kaibab limestone at a depth of about 300 feet. In an outcrop about 1 mile farther southeast the limestone dips about 4° N. Horizontal strata of the Kaibab limestone crop out in the canyon of Rio de Flag 5 miles east of Elden Mountain. It is obvious that the steep dip observed in the hills does not continue southeastward. Therefore, it is assumed that a fault or a sharp fold exists between the base of Elden Mountain and the Smith farm. No other major structural deformation of the rocks in Doney and Black Bill Parks has been demonstrated in the present investigation.

Minor drag of the Kaibab limestone occurred adjacent to the dike or plug in the NE¼ sec. 21, T. 21 N., R. 8 E. It is probable that comparable drag occurred during intrusion of other small bodies of igneous rock at the cores of cinder cones in the area.

Sets of joints in Kaibab strata have been observed at many places in the area. The jointing is especially well displayed at the Bottomless Pits in sec. 17, T. 21 N., R. 8 E. The more prominent set of joints at Bottomless Pits strikes northeast and dips about 70° SE. Sinkholes have developed there along three of these joints. The other set of joints strikes northwest and is approximately vertical.

At Little Elden Spring, sec. 19, T. 22 N., R. 8 E., joints strike N. 40° E., dipping 75° SE.; and N. 70° W., dipping 70° SW. The joints are believed to provide channels through which water moves to the spring.

OCCURRENCE OF WATER

Surface water

Doney and Black Bill Parks are in the drainage basin of Rio de Flag. Most of the moisture that falls as rain or snow is evaporated or absorbed by

the ... Runoff from the parks occurs only during times of abnormal precipitation. Small stream channels cross the parks from mountain canyons toward Rio de Flag. These channels disappear either in grass-covered meadows or at the edges of cultivated fields.

A few earth tanks have been constructed to catch and store local surface runoff. The largest of these tanks is in Schultz Pass; it is the principal source of water for the Doney Park Water Co. From the pass, the pipeline extends to a small concrete-lined reservoir in Doney Park. From the reservoir, water is distributed to the homes of members of the water company. In some years there is no water in the system, and in many years the supply is insufficient to provide adequate pressure in the water lines. Other earth tanks are used for stock watering.

Ground water

Springs

The occurrence of springs in Doney and Black Bill Parks was previously described under "Rock units." Yields of all springs observed were small, ranging from a trickle to a few gallons per minute. Two springs emerge from Paleozoic sedimentary rocks on the east slope of Elden Mountain. Other springs issue from volcanic rocks at the contact with relatively impermeable underlying materials. A few small seeps in Bonito Park emerge from soil, probably near the contact of glacial outwash gravels with underlying lava.

Wells

Colton (1932, pl. 10) published a map showing seven wells in Doney and Black Bill Parks. He commented (1918, pp. 42-44) that, although three wells in the area were known to contain water part of each year, only one provided water for more than a few months of each year. The most successful well reported by Colton is the only well presently in use in the two parks. This well was dug on the Farrell farm in the SW¼ sec. 26, T. 22 N., R. 8 E., and is 50 feet deep. It provides sufficient water for domestic use even in years of average precipitation, and the yield is increased when runoff occurs in Rio de Flag.

At one time there were two wells on the Richardson ranch in Bonito Park (see well logs, pp. 10-11) in the NE¼ sec. 20, T. 23 N., R. 8 E. According to oral information one well was dug originally to a depth of 30 feet. At that depth, the well yielded water at least part of the year. Later the well was deepened to 60 feet and all water was lost. The second well was drilled to a total depth of 42 feet. It is reported that when the well was drilled the water level was 32 feet beneath the surface. The well was never utilized because it became partly filled with trash, and a pump was not installed.

Colton's map (1932, pl. 10) shows two wells, each 80 feet deep, one in sec. 27, T. 22 N., R. 8 E., the other in sec. 3, T. 21 N., R. 8 E. He reports these wells to have held water during part of the year. No other details are available about these wells. It is probable, however, that the well in sec. 27, T. 22 N., R. 8 E., is the one commonly referred to as the Butler well by present residents of Doney Park. It is reported that the Butler well supplied the needs of several families for a number of years, but an attempt to increase the yield by dynamiting destroyed its usefulness. No effort was made to reopen the well.

The well now known as the Piper well may be the same as that shown by Colton in sec. 3, T. 21 N., R. 8 E. Some years ago, while the property was leased to tenants, the well was partly filled with scrap iron and other debris. To date, no attempt has been made to redeem the well.

Colton's map shows dry holes ranging in depth from 40 to 70 feet in secs. 23, 26, and 35, T. 22 N., R. 8 E. Only one of these, the hole in sec. 23, could be found during the present investigation. When visited, the hole seemed to have been partly filled, and it contained no water.

A hole dug through 12 feet of cinders to an underlying clay layer is in the NE¼ sec. 28, T. 22 N., R. 8 E. The well is curbed with concrete and roofed with wood. The owner reported that at times water in considerable quantity seeped into the hole through the cinders. At some time in the past, during a period in which the well was dry, it was partly filled with cinders slumping from the walls and was therefore abandoned.

On the Crisp Ranch, sec. 28, T. 22 N., R. 9 E., there is evidence of the existence of a truly ancient well. A round depression about 4 feet deep and 40 feet in diameter having a distinct surrounding ridge and containing a heavy concentration of fragments of Indian pottery was first recognized by S. F. Turner as a partly obliterated Indian "walk-in" well. (See fig. 1.) This was later confirmed by archeologists from the Museum of Northern Arizona. Mr. Crisp dug a shaft 32 feet deep at the center of the depression, uncovering Indian artifacts in the upper 10 feet of cinder and clay fill. From 10 feet to 28 feet the shaft (see well logs) penetrated cinders tightly held in a matrix of ice. Below the 18 feet of ice the cinders were loose and wet but not saturated to the point of yielding water. The bottom of the shaft was on basalt boulders.

An attempt was made to deepen the hole with cable-tool drilling equipment. A few additional feet were drilled with cable tools and the driller reported a small amount of water. It was not possible with the available equipment to go farther at that site, and a new hole was started from the surface not far from the collar of the dug shaft. At time of this writing the outcome of drilling the new hole was not known.

GEOPHYSICAL INVESTIGATIONS

By C. B. Yost, Jr.

To determine the thickness and lithology of the various subsurface materials in Doney and Black Bill Parks, 13 electrical-resistivity probes were made in 4 areas. The locations of the probes (pl. 1) were determined after completion of the geologic mapping. Probe sites were selected in areas where the surface geology suggested the possibility that subsurface structures or cinder-clay relations might retard downward percolation of water, or at places where information was desired regarding thickness of weakly consolidated materials overlying bedrock.

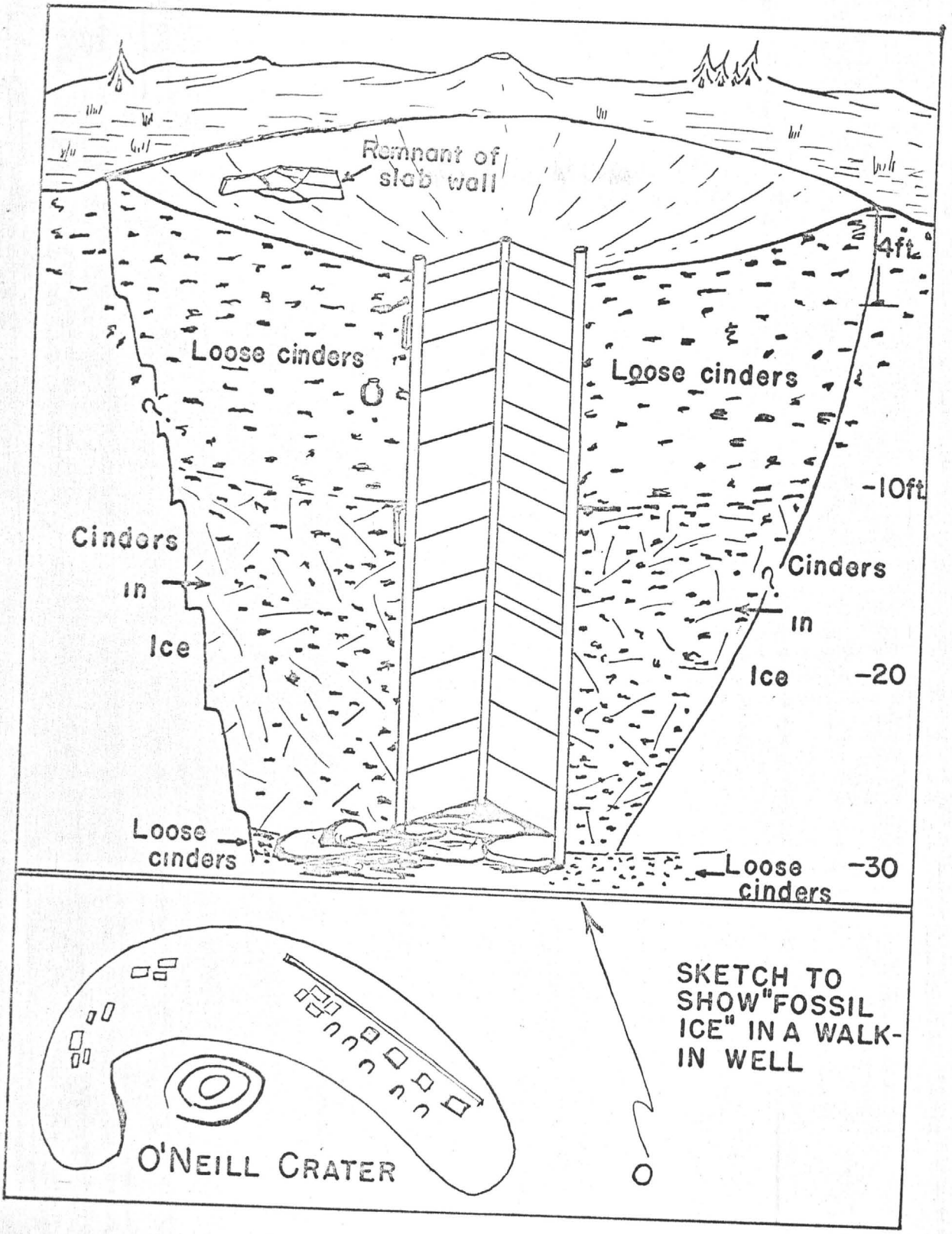

Figure 1.--Sketch showing "fossil ice" in Indian "walk-in" well on Crisp Ranch.

The field work was done from June 13 to 19, 1951. Assistance in placing the electrodes was given by several residents of the area. A modified Gish-Rooney electrical-resistivity apparatus was used. Interpretation of the graphs that resulted from the 13 probes was made by comparing the graphs with theoretical three-layer curves (Wetzel and McMurray, 1937) in the light of knowledge of the geology of the area. In general, for equivalent moisture content, fine-grained materials, such as clay or silt, have a low resistivity; coarser materials, such as gravel, have a higher resistivity; and igneous rocks commonly have a high to very high resistivity. The following discussion describes the investigations and presents an interpretation of results for each of the four areas where work was done.

Doney Park area

Alluvium underlies most of the central part of this irregular topographic basin. The small bordering hills are composed mostly of volcanic cinders and basalt.

Probes were made at five points along a 3½-mile traverse through the central part of the park area. Probe 1 (pl. 1) was on the Smith farm in sec. 33, T. 22 N., R. 8 E., near the site of a drilled hole 410 feet deep. From probe 1 the traverse extended northeast through probe 2 to probe 13, then trended north through probe 4 to probe 3, in sec. 23, T. 22 N., R. 8 E. To avoid side effects, all probes were located as far as practicable from cinder-basalt outcrops.

The maximum stake separation for the five probes ranged from 600 to 3,000 feet, depending upon the depth to which information was desired and upon the space available for extending the two outer electrodes in a straight line without electrical or physical interference.

Interpretation of the graphs of measured resistivity indicates that the area in the vicinity of the traverse is underlain by several layers of material of differing resistivities. The uppermost layer, consisting of alluvium, is of low to medium resistivity and ranges from 20 feet to 200 feet in thickness. The next layer is of high to very high resistivity and is 100 to more than 400 feet thick. The third layer is of low to medium resistivity (pl. 1). Correlation of probe 1 with the log of the 410-foot test hole nearby (pl. 1) shows that at the site of probe 1 the three resistivity layers correspond respectively with alluvium, tuff, and Kaibab limestone.

All the probes indicate that the alluvium is underlain by a second layer consisting of various combinations of tuff, basalt, and cinders.

Probes 1, 2, and 3 are fairly definite in indicating the presence and depth of the third layer of low to medium resistivity.

The probes at sites 13 and 4 showed, at a depth of less than 50 feet, a second layer of material so highly resistive that the current density within it was too low to allow measurement of surface potential differences, and it was therefore impossible to define the lower limit of this layer. It is certain to be at some depth greater than 100 feet. The low to medium resistivity of the third layer is of the magnitude that would be expected for Paleozoic sedimentary rocks or more recent alluvial material. At probe 1 this resistivity layer is known to correspond to the Kaibab limestone.

The resistivity cross section, plate 1, shows material of high to very high resistivity forming an apparent trough with its deepest determined part near probe 2. The profile of the upper surface of the layer of high resistivity between probe 13 and probe 3 rises to a peak near the site of probe 4. It is probable that this peak reflects a shallow subsurface connection between outcrops of igneous rocks east and west of probe 4. (See pl. 1.)

The trough indicated by the resistivity cross section (pl. 1) may be part of a subsurface basin. The basin may, or may not, be sealed at the bottom by material of low permeability. If such a basin exists and is sealed at the bottom, a test hole may reasonably be expected to yield water, at least in small quantities, at a depth of not more than 350 feet. The record of the Farrell well, 1,000 feet southeast of probe 2, indicates that the basin may be at least partially sealed. The well has water at a depth of about 25 feet below the surface, and the water level rises when runoff is carried in Rio de Flag.

Crisp farm

The Crisp farm, sec. 29, T. 21 N., R. 9 E., is in a topographic basin having an area of about 1 square mile. The basin is underlain by cinders and the surrounding hills are composed of cinders and basalt. Two auger holes, bored through the surface cinders, penetrated clay at depths of 22 and 32 feet. Neither hole was deep enough to disclose the thickness of the clay or the identity of the underlying material.

Probes 5 to 9, inclusive (pl. 1), were made on the Crisp farm. Graphs of the probes show a surface layer of medium resistivity, 5 to 20 feet thick. The layer is interpreted as being composed of cinders and alluvium. A second layer of very high resistivity, 10 to 70 feet thick, is interpreted as volcanic cinders. Beneath this is a third layer, of medium resistivity, which could be an older less resistive type of volcanic material or sedimentary rock.

The five probes do not indicate conclusively the presence or absence of an extensive clay layer that might retard downward movement of ground water. The fact that no clay layer was indicated may be due to one or more of the following conditions: The layer is so thin that it has little effect on the flow of electricity; the layer is of limited areal extent; the more resistant overlying layer masks the effect of the clay layer.

According to probes 6 and 8, which were run near the two auger holes, the clay that was penetrated is near the contact between the second and third resistivity layers. Direct delineation of a clay layer does not seem possible with electrical-resistivity methods in this locality. However, if it were determined by drilling that clay occurs everywhere at the top of the third layer, it might be possible to obtain indirect information about the clay by using resistivity methods to trace the position of the third layer.

In the vicinity of probes 8 and 9 the top of the third layer is 10 to 20 feet below the surface; southward, in the vicinity of probes 5, 6, and 7, the depth is 50 to 85 feet.

Although additional resistivity probing in coordination with exploratory drilling might yield information of value, it is probable that augering or drilling would be quicker and would yield more positive results than would resistivity methods. Deeper exploratory drilling would establish the character of the third layer. If the material in this layer is less permeable than that in the overlying layers, or if it is permeable but everywhere separated from the second layer by clay, perched ground water may be present.

Glacial-outwash area

Probes 10 and 11 (pl. 1) were made in the area of glacial outwash gravel in the western part of T. 23 N., R. 8 E.

Both probes show an upper layer of medium to high resistivity which represents the surface gravel. Below this is a second layer of moderately low resistivity interpreted as gravel having a higher proportion of sand and silt. The third layer is highly resistant and probably is volcanic rock. At probe 10, near a gravel pit, the surface of the highly resistant third layer is at a depth of approximately 100 to 150 feet. At probe 11, farther from the mountain front, the top of the highly resistant layer is about 30 to 36 feet below the surface. The probes indicate that the gravel is thicker near the mountain front.

Schultz Pass area

A single probe, no. 12 (pl. 1), was made in the NE¼ sec. 24, T. 22 N., R. 7 E., to determine the thickness of alluvium overlying bedrock. The probe shows a layer of medium resistivity from the bottom of the soil to a depth of 150 to 200 feet. This layer probably corresponds to a mixture of gravel and fine-grained material because the resistivity of the layer is intermediate between that generally found for either material occurring alone.

Below the layer of medium resistivity a layer of medium-high resistivity was found. This layer extends at least to 600 feet, the total depth of the probe. Although the resistivity seems too low for solid igneous material, it could be igneous rock in which fractures or other openings contain moisture.

CONCLUSIONS AND RECOMMENDATIONS

The geologic and geophysical investigation in the Doney Park-Black Bill Park area, supplemented by information obtained in the investigation of other areas near Flagstaff, suggests the following conclusions regarding the occurrence of ground water in the two parks:

1. The supply of ground water that can be developed at depths of a few feet to a few hundred feet is small.
2. There are various localities where ground water has been available to residents of the area, including several springs and six wells, five of which have been abandoned.
3. Ground water at relatively shallow depths occurs only in those formations overlying the Kaibab limestone, at places where impermeable layers retard the downward movement of water. A possible exception exists in an area at the base of Elden Mountain. There it is possible that a fault or fold may retard downward movement of water and thus make water available at depths of a few hundred feet in strata underlying the Kaibab limestone. Elsewhere, water moves readily downward through the limestone and the underlying Coconino sandstone.
4. The places where ground water is stored in beds overlying the Kaibab limestone seem to be few.
5. Ground water is probably available in Recent cinder deposits at several places in Doney and Black Bill Parks, during at least part of each year of average precipitation. Development will depend on finding underlying clay layers or other local impervious bodies that will trap small supplies of water.
6. Recharge to local bodies of perched water depends largely upon direct precipitation. This recharge is supplemented by runoff in Rio de Flag and from the canyons on the east slopes of the San Francisco Mountains.
7. An area of glacial outwash at the mouth of a major canyon at the north end of Black Bill Park presumably conducts water from the San Francisco Mountains toward Bonito Park.

In light of these conclusions, the following possible courses of action are suggested for developing ground water in the area.

Spring development

Little Elden Spring, sec. 19, T. 22 N., R. 8 E., might be developed by means of a shaft extended below the present point of emergence of the spring. Crosscutting from the base of the shaft might develop additional water. No other springs in the area investigated seem to warrant extensive development.

Well development

The dug well in sec. 13, T. 22 N., R. 7 E., adjacent to the pipe line of the Doney Park Water Co. in Schultz Pass, could be cleaned out and equipped to siphon or pump water into the pipe line.

Geophysical exploration in the Schultz Pass area indicates the presence of 150 to 200 feet of talus and alluvial material in the reentrant valley north of Little Elden Mountain. This area appears to warrant experimental drilling to bedrock.

An area in the SE¼ sec. 30, T. 22 N., R. 8 E., lies between Elden Mountain and a line of foothills of the Kaibab limestone. Beds of the Supai formation are exposed on the slopes of Elden Mountain adjacent to this area. Beds in both the Supai formation and the Kaibab limestone in that locality dip steeply southeast.

A major structure may be concealed by fanglomerate east of the foothills. Beds of the Coconino sandstone presumably underlie the area between the foothills and the strata of the Supai formation on Elden Mountain. The writer believes that exploratory drilling to a depth of several hundred feet in the pocket lying between the foothills and the base of Elden Mountain would be warranted. A seep in the SE¼ sec. 30, T. 22 N., R. 8 E., indicated the presence of ground water in the area.

The area of glacial outwash at the north end of Black Bill Park is considered worthy of exploratory drilling to bedrock. At probe 10 a thickness of 100 to 150 feet of gravel and sand was indicated. Of the two places at which probes were made, the more favorable site for test drilling seems to be that in the vicinity of probe 10.

The area in the vicinity of probe 2 seems to be underlain by a basin that may contain ground water. This conclusion is based on an interpretation discussed in the section on geophysics. It is possible that a well drilled to a depth of 250 to 350 feet in the area might develop a supply of water sufficient for one or more families. Previous test holes were only 70 to 80 feet deep and were unsuccessful.

The history of wells along Rio de Flag, notably those presently referred to as the Farrell well, the Butler well, and Piper well, suggests that properly constructed wells in alluvium adjacent to the channel of Rio de Flag would provide water during at least a part of each year. Care is essential in order to prevent (1) sealing off the aquifer during construction or (2) piercing the impermeable underlying layer.

Basalt is exposed in the stream bed of Rio de Flag in sec. 34, T. 22 N., R. 8 E. The presence of dense vegetation suggests that a permanent supply of water may be present. A test well near the trees seems warranted.

Further exploration in the vicinity of the ancient Indian walk-in well on the Crisp farm seems justified.

The presence of groves of walnut trees in the two parks suggested to S. F. Turner (oral communication, 1951) the possibility that ground water is present at depths within reach of the tree roots. It is possible, therefore, that digging in the immediate vicinity of the walnut groves would develop small water supplies. However, the high water-retaining capacity of the cinders may create a unique condition in which the walnut trees extract their supply from capillary water retained in the cinders. Under these conditions, the presence of walnut trees would not necessarily indicate the existence of a water table within reach of the tree roots.

Infiltration galleries in cinder hills

The cinder hills in Doney and Black Bill Parks may offer a source of domestic water. Cinders from the eruption of Sunset Crater were deposited over the entire area considered in this report. Subsequent wind action has created dunes of black cinders derived from the Recent deposits on the windward side of older reddish cinder hills.

In places near Flagstaff, layers of clay soil, or of partly decomposed cinders in a clay matrix, have been observed at or near the surface in the older reddish cinders. If dunes of black cinders overlie depressions on the surface of the older cinders, and if the older deposits are sufficiently clayey, small amounts of water may occur near the bases of the black cinder dunes that occupy such depressions. Exploration of favorable cinder-dune localities by digging tunnels may develop small perched water supplies.

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Logs of wells in Doney Park-Black Bill Park area, Coconino County, Ariz.

	Thickness (feet)	Depth (feet)
Farrell well (dug). M. F. Farrell, owner. Sec. 26, T. 22 N., R. 8 E.		
Soil, some clay and cinders	22	22
Clay, gravelly	28	50
Bore on Lander Ranch (drilled). A. E. Lander, owner and driller. Sec. 33, T. 22 N., R. 8 E.		
Soil, cindery	5	5
Cinders, black	75	80
Lava, black, very hard ("drilled up like flour of emery"). Hole lost water all the way; hit crevice at 95 feet	15	95
Smith Ranch well 1 (drilled). R. A. Smith, owner and driller. Sec. 33, T. 22 N., R. 8 E.		
Soil, loose rock, and a little clay	29	29
Boulder	5	34
Soil and loose rock	84	118
Sandstone, red	23	141
Soil and loose rock	56	197
Soft tuff or lava; a small strip of coarse gravel at 217 feet	96	293
Kaibab limestone	117	410
Smith Ranch well 2 (drilled). R. A. Smith, owner and driller. Sec. 33, T. 22 N., R. 8 E. (100 feet northwest of well 1)		
Missing	15	15
Soil, dark yellowish-brown	5	20
Clay and fine sand, light-tan	10	30
Sand, light reddish-brown, fine- to medium-grained, mostly quartz	5	35
Sand and pebbles of red cinders	5	40
Sand, light reddish-brown, medium-grained; a few pebbles of purple and gray volcanic rock and white chert	10	50
Sand, darker-brown	10	60
Clay, pink, and chert pebbles	10	70
Sand, brown, coarse; some pebbles	5	75
Sand, brown, fine-grained	5	80
Sand and clay, light-tan	15	95
Sand and silt, brown to light reddish-brown; coarser at top and bottom	50	145
As above but coarser-grained; pebbles common in lower 10 feet	40	185
Sand, silt, and granules, probably largely tuffaceous, light grayish-brown; woody fragments and one small twig in samples between 225 and 260 feet	85	270
Silt, light yellowish-tan, very limy	15	285
Kaibab limestone, tan, silty	8	293
Shaft at Indian "walk-in" well (dug). U. S. Forest Service, owner. U. S. Crisp, lessee. Sec. 28, T. 22 N., R. 9 E.		
Cinders, black	1	1
Clay, few to no cinders	9	10
Cinders, black, tightly frozen in ice matrix	18	28
Cinders, black, loose, very wet	1	29
Soil	1	30
Boulders, black lava	2	32

Logs of wells in Doney Park-Black Bill Park area, Coconino County, Ariz.--Continued

	Thickness (feet)	Depth (feet)
Richardson Homestead well (dug). S. I. Richardson, owner. Sec. 20, T. 23 N., R. 8 E.		
Cinders	3	3
Coarse sand and gravel	57	60

Note: Reported that well was used for a time at depth of 30 feet, then deepened to increase yield. All water was lost during deepening and none was recovered.

INT.-DUP. SEC., WASH., D.C. 74979

F THE INTERIOR
EY

EXPL

Recent soil and valley fill, in
Yields water to wells
materials

Basalt (Qb) and basaltic
of Sunset Crater. No

Outwash sand and gravel
A promising aquifer i

Basalt and cinders, mainly
permeable; not wate
by impermeable ma

Rhyolite, dacite, andesite,
Where fractured, yiel

Kaibab limestone. Not kno

Devonian to Permian sedi
Supai formation yiel
Other formations m
exist

Strike and dip

Approximate contac

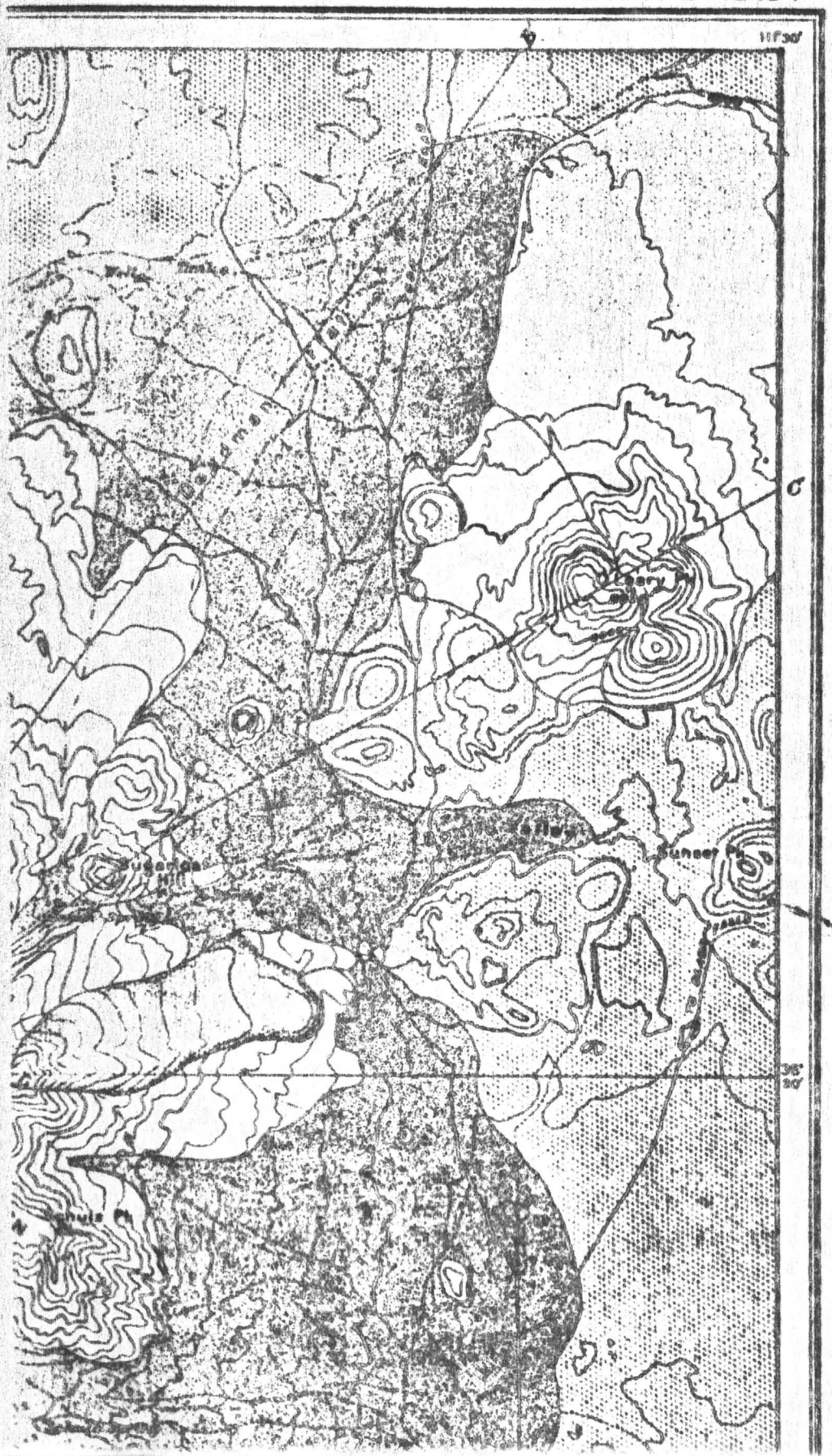
Spring

Well

Railroad

0

U. S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR



LEGEND

SEDIMENTARY ROCKS

Alluvium
(including glacial material on San Francisco Mountain)

QUATERNARY

Moenkopi formation
(red sandstone and shale)

Permian (?)

Kaibab limestone
(includes Coconino sandstone in Walnut Canyon)

Pennsylvanian

Undifferentiated Carboniferous
(outcrops on flanks of Marble Hill and Elden Mountain)

CARBONIFEROUS

IGNEOUS ROCKS

Basalt of third general period of eruption

Andesite

Rhyolite
(including intrusive of Marble Hill)

Hornblende dacite

Pyroxene dacite of San Francisco Mountain
(including dacites of O'Leary Peak, Elden Mountain, and Dry Lake Hills)

Second general period of eruption

QUATERNARY

Andesite

Rhyolite
(including intrusive of Marble Hill)

Hornblende dacite

Pyroxene dacite of San Francisco Mountain (including dacites of O'Leary Peak, Elden Mountain, and Dry Lake Hills)

Latite

Lavas of the first and second general periods of eruption, uppermost on flanks of Marble Hill laccolith

Basalt of the first general period of eruption

Paulin

QUATERNARY

TERTIARY

Recent and Pleistocene

Pliocene

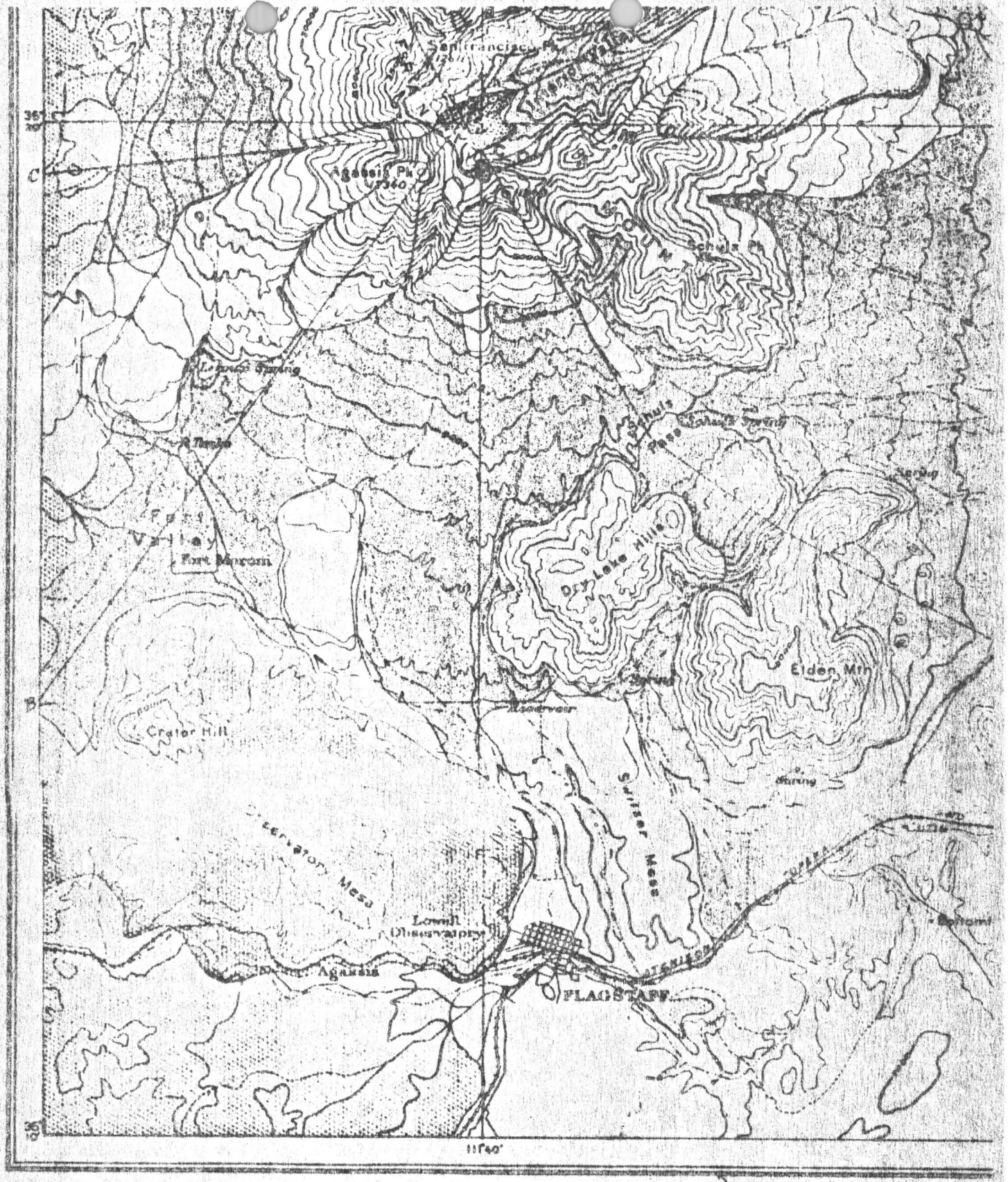
NOTE.—Black stippling over older portions of the igneous rocks of San Francisco Mountain and Marble Hill indicates the core rocks of corresponding kinds.

The names used for the igneous rocks are those given in Chapter III. They are simplified forms of the detailed petrographic names given in Chapter V.

CISCO MOUNTAIN AND VICINITY, ARIZONA

Geology by H. H. Robinson
Surveyed in 1903

Miles



GENERAL GEOLOGIC MAP OF SAN FRANCISCO MOUNTAIN ANI

H. S. Marshall, Chief Geographer
T. G. Gerdine, Geographer in charge
Topography by Pearson Chapman, T. F. Slaughter, and J. W. Muller
Control by H. L. Baldwin, Jr., J. T. Stewart, and T. A. Green
Surveyed in 1907 and 1908

Scale 1/62500

1 0 1 2 3 4 5 Miles

Contour interval 200 feet
Datum is mean sea level

1913

HEINRICHS GEOEX
GEOPHYSICAL ENGINEERS
TUCSON, ARIZONA

REC'D JUN 2 1969

BOX 5671 TUCSON, ARIZONA 85703
Phone: (AREA 602) 623-0578

HEINRICHS GEOEXPLORATION COMPANY

806 WEST GRANT ROAD, TUCSON, ARIZONA, 85703. P.O. BOX 5671. PHONE: (AREA CODE 602) 623-0578

27 May 1969

Mr. William Ramsey
1222 E. Missouri
Phoenix, Arizona 85014

Re: Proposed Resistivity Survey
Portions of R. 7 E. & R. 8 E.
Sec. 13, 24, 18 & 19

Dear Bill;

Per your request when in the office last Friday, 23 May 1969, we herewith submit a proposal for our mutual understanding and agreement.

1. Beginning on or about 2 June 1969 GEOEX will furnish the personnel and equipment necessary to conduct a resistivity survey of an approximate area as designated by you and indicated above, located in Coconino Co., Arizona.

2. Others of our technical staff will be involved as needed and/or are supplied in the field or office as requested and mutually agreed upon.

3. Charges are $250.00 per field day, and a three man crew will be used. Time will be prorated on a ten (10) hour day, five (5) days per week.

   Production estimate: (according to type of survey, this can and will vary a great deal)
   (a) Very rough to rough terrain, one half to one mile per day.
   (b) Rough to average terrain, one to one and one half miles per day.

4. VEHICLES: $15.00 per day plus 15¢ per mile and one vehicle will be used. Living and other direct job related supplies, communications and incidentals are charged at our invoice cost plus ten percent (10%).

5. Excessive weather delay and standby charges are one half the daily rate quoted above. Breakdown of our equipment in excess of one hour per day will be made up or not charged.

6. Data compilation, interpretation and report is $150.00 per staff day following completion of project in the field. (Average is one office day per one field day on short jobs, longer programs substantially reduce this figure to about one office day per four field days.

7. The budget allotment as discussed with you will be approximately $1,500.00 and with the information currently available it is estimated these funds are sufficient to determine the most favorable drill site for a production water well in the square mile area as outlined by you. If during the course of the work it is determined that additional funds are needed you will be so informed.

All property permits, brushing and trespassing-liability and related costs incurred on behalf of client assumed by client. Charges for extra equipment and personnel employed, if mutually desired, are extra.

GEOEX will save client harmless from all Workmen's Compensation, public liability and property damage liability incurred by GEOEX employees.

Preliminary reports or copies of rough field plotting sheets will be available as work progresses.

Payments are due on presentation, billings may be submitted periodically with final statement after completion of final report.

Indication of your understanding and approval of the above by executing as provided below on the attached copy of this letter and returning it to us will be most appreciated.

Sincerely yours,
HEINRICHS GEOEXPLORATION COMPANY

E. Grover Heinrichs, V. President

DATE: 1 June 1969

ACCEPTED BY: Wm A. Ramsey

TITLE: Consulting Engineer

EGH/plp
Enclosure (cc)

**NOTE: SEE ATTACHED LETTER FOR ADDITIONAL CONDITIONS AS DISCUSSED BETWEEN WM. A. RAMSEY AND E. GROVER HEINRICHS 31 MAY 1969.

WM. A. RAMSEY
CONSULTING ENGINEER
1222 East Missouri Ave.
Phoenix, Arizona 85014
Telephone:
274-6017

1 June 1969

Mr. E. Grover Heinrichs, V. P.
Heinrichs Geoexploration Co.
806 West Grant Road
Tucson, Arizona 85703

Dear Grover:

Following is a brief resume of our telephone conversation relative to additional conditions for your firms' doing the resistivity survey north of Flagstaff:

1. The client is the Black Bill & Doney Parks Water Users' Association, with my acting only as their engineer and agent.

2. The funds for the payment of these services are coming from a loan and grant from the Farmers Home Administration, a committment for which has been made.

3. The funds should be available within 30 to 60 days, or less.

4. All invoicing should be to the Water Users' Association, and made through me.

5. No payments can be forthcoming until the loan and grant is closed and the funds made available.

6. At such time as funds are available, payment will be made direct to your firm.

I trust that these additional conditions are satisfactory. I will be at the Americana Motel, Flagstaff, most of next week, and will call you by or before Thursday, 5 June.

Best Regards

Wm. A. Ramsey

Wm. A. Ramsey, P.E.

WM. A. RAMSEY, P. E.
CONSULTING ENGINEER
749½ WEST CAMELBACK RD.
PHOENIX, ARIZONA 85013

MAP OF
BLACK BILL & DONEY PARKS
WATER USERS ASSOCIATION
FLAGSTAFF, ARIZONA

JOB # 68-002

403-69

R. 7 E.

R. 8 E.

T. 22 N.

TO FLAGSTAFF PIPELINE

2" (Existing)

SCHULTZ TANK

SCHULTZ PASS

PROPOSED WATER INTAKE. SITE 1

PROPOSED WATER INTAKE. SITE 2

PROPOSED WATER INTAKE. SITE 3

2-1/2"

3"

PROPOSED PIPELINE

WELL No. 1 (tentative location)

4"

FENCE

TANK

EXISTING RESERVOIR

PROPOSED SITE OF WATER STORAGE TANK

Line 1

Line 2

Expansion #1

Expansion #2

Center Line

direction of LINES 1, N-10E

" " LINE 2 - E-W

14 13 18 17 23 24 19 20 26 25 30 29

8400 8600 8400 8200 8000 7800 7600 7400 7200 7000

LEGEND

40 FOOT CONTOUR INTERVALS

PROPOSED AREAS FOR FUTURE WELLS

WM. A. RAMSEY
CONSULTING ENGINEER
PHOENIX, ARIZONA

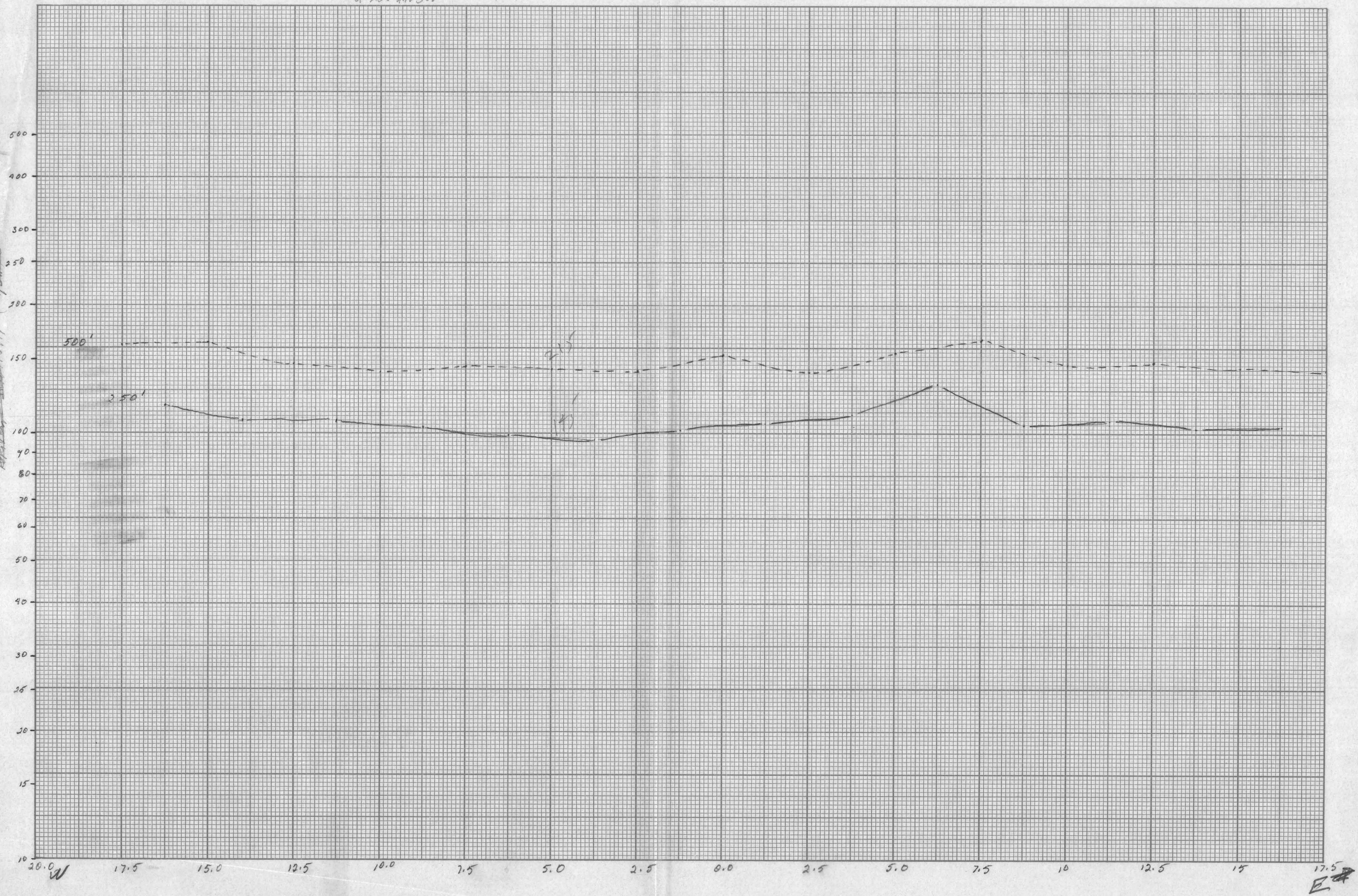
BLACK BILL & DONEY PARKS WATER USERS ASSOCIATION

PROPOSED SUPPLY LAYOUT

6-27-68 68-002-4

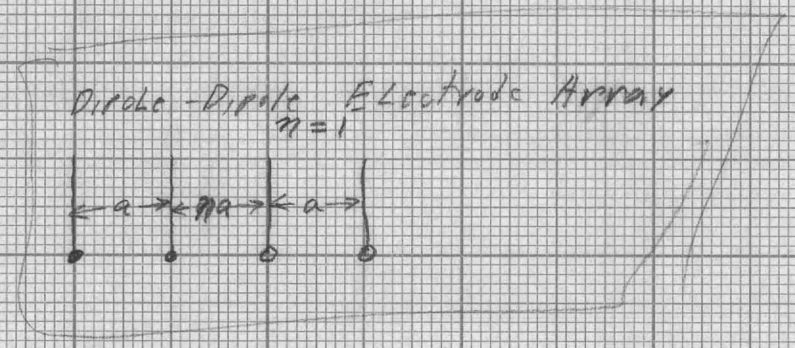
403-69

403-69 (Ramsey) Dipole - Dipole Resistivity Survey Line 2 - [redacted]
a = 250' and 500' n = 1



403-69 (Ramsey) Dipole-Dipole Resistivity Profile Line 1 – [redacted]

a = 250' and 560' n = 1



a = 500'

a = 250'

400
300
250
200
150
100
90
80
70
60
50
40
30
25
20
15

Test hole #2
Test hole #1
Test hole #3
Test hole #4

Scales:
Horizontal 1" = 250 ft
Vertical Logarithmic

20.0 17.5 15.0 12.5 10.0 7.5 5.0 2.5 0.0 2.5 5.0 7.5 10 12.5 15 17.5

SW NE

~~403-69 (Ramsey)~~ ~~Depth Probe #2~~ Expander #2 Wenner Array

DENVER AREA RESISTIVITY DEPTH PROBE

Black Hill for and Denver Parks Water Users Association (William Ramsey)

Sur. #69

$$.8 = \frac{R_2 - 40}{R_2 + 40}$$

$$.8R_2 + 48 = R_2 - 40$$

$$-.2R_2 = -108$$

$$R_2 = 540$$

Apparent Resistivity ($\rho_a/2\pi$) in ohm feet

a spacing in feet

403-69

~~403-69 (Ramey)~~ ~~Problem~~ Expander #1 ~~Denver Station~~

$q = \frac{R_2 - 70}{R_2 + 70}$

$q R_2 + 63 = R_2 - 70$

$133 R_2 = 133$

$R_2 = 133$

LOGARITHMIC
KEUFFEL & ESSER CO.
359-112L
MADE IN U.S.A.
2 X 3 CYCLES

Apparent Resistivity $(\rho_a/2\pi)$ in ohm feet

a spacing in feet

403-69

R. 7 E.

R. 8 E.

T. 22 N.

TO FLAGSTAFF PIPELINE

2" (Existing)

PROPOSED WATER INTAKE. SITE 1

PROPOSED WATER INTAKE. SITE 2

PROPOSED WATER INTAKE. SITE 3

3"

4"

2-1/2"

SCHULTZ TANK

SCHULTZ PASS

PROPOSED PIPELINE

WELL No. 1 (tentative location)

6"

4"

TANK No. 1

EXISTING RESERVOIR (To Be Abandoned)

PROPOSED SITE OF WATER STORAGE TANK

14

13

18

17

23

24

19

20

26

25

30

29

8400 8600 8400 8200 8000 7800 7600 7400 7200 7000

8200 8400 8400 8200 7800

7800 8000 8200 8400 8400 8200 8400 8600 8800 8800 8600 8400 8200 8000 7800 7600 7400 7200 7000

LEGEND

40 FOOT CONTOUR INTERVALS

PROPOSED AREAS FOR FUTURE WELLS

REVISIONS:
1 7-5-69

1/21/70

WM. A. RAMSEY
CONSULTING ENGINEER
PHOENIX, ARIZONA

BLACK BILL & DONEY PARKS
WATER USERS ASSOCIATION

PROPOSED SUPPLY LAYOUT

6-27-68 68-002-4

R. 7 E.

R. 8 E.

1/29/70

T. 22 N.

14

13

23

24

18

17

19

20

LINE 1

25 NE

CENTER EXPANDER # 1

T.H. #4
ELEV. 7189.8

T.H. #3
ELEV. 7189.3

T.H. #1
ELEV. 7170.37

T.H. #2
ELEV. 7178.5

ELEV.
7152.2
CENTER EXPANDER # 2

25 W

25 E

LINE 2

25 SW

EXPLANATION

OVERLAY OF BASE MAP SUBMITTED BY WM. A. RAMSEY

N

HEINRICHS
GEOEXPLORATION COMPANY
POST OFFICE BOX 5671, TUCSON, ARIZONA, 85703
Phone: 602/623-0578 Cable: GEOEX, Tucson
geophysical engineers vancouver sydney

LOCATION PLAN
OF
RESISTIVITY SURVEY

FOR
BLACK BILL & DONEY PARKS WATER
USERS ASSOCIATION (BILL RAMSEY)
FLAGSTAFF, ARIZONA

SCALE 1" = 1000'	DRAWN BY J.L. PETRY	DATE 6-69

ELECTRICAL RESISTIVITY SURVEY

For

Black Bill and Doney Parks
Water Users Association

Near

Flagstaff, Arizona
Job #403-69

ELECTRICAL RESISTIVITY SURVEY

FOR

BLACK BILL AND DONEY PARKS WATER USERS ASSOCIATION

Near

Flagstaff, Arizona

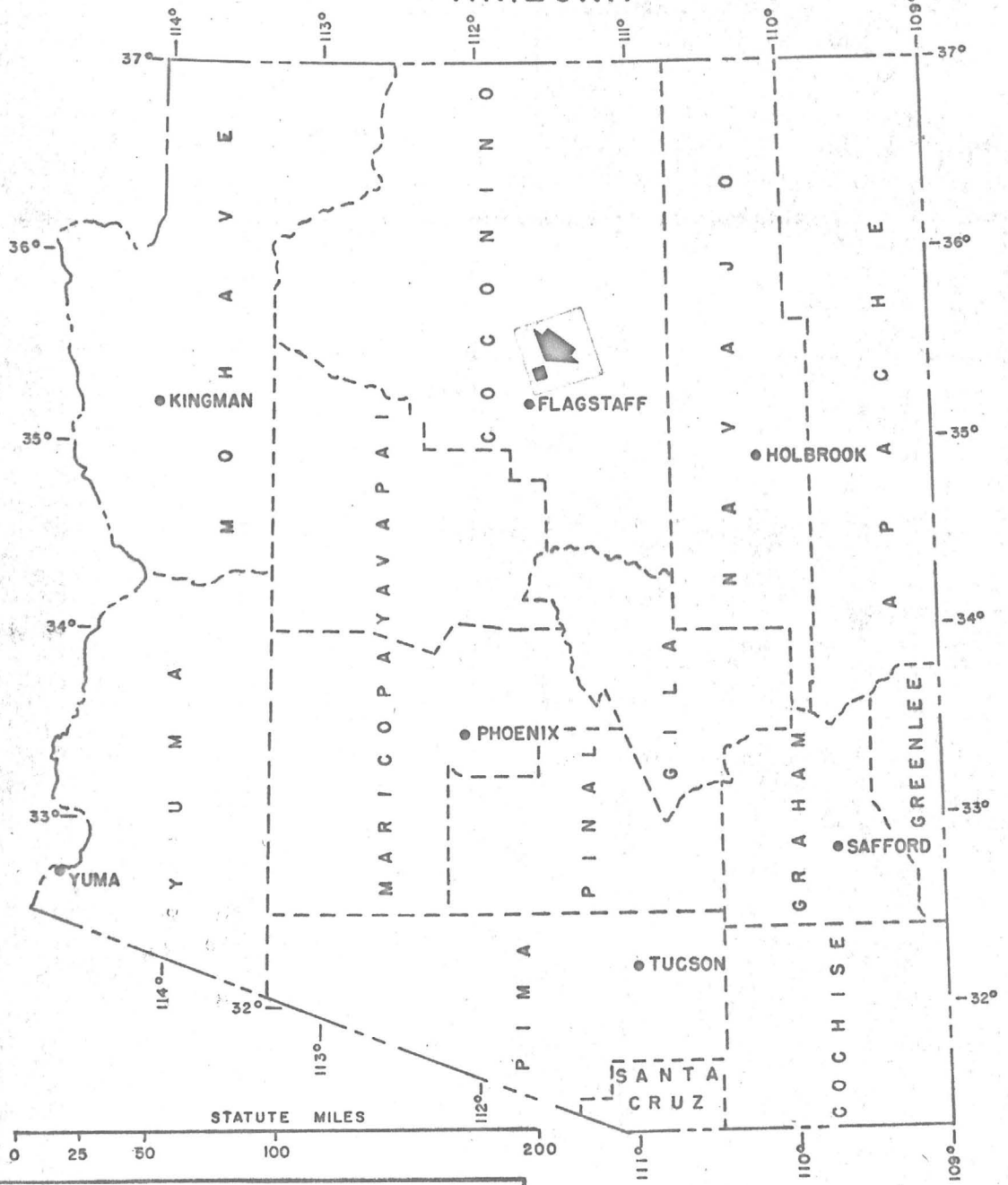
By

Heinrichs Geoexploration Company
P. O. Box 5671 Tucson, Arizona 85703
Phone: 623-0578 Area Code: 602

JUL 2 1969

Job #403-69

GENERAL LOCATION OF
BLACK BILL & DONEY PARK WATER USERS ASSOCIATION (BILL RAMSEY)
FLAGSTAFF, ARIZONA



HEINRICHS
GEOEXPLORATION COMPANY

BOX 5671 TUCSON, ARIZONA 85703
PH: 602/623-0578 CABLE: GEOEX, TUCSON

GEOPHYSICAL ENGINEERS SYDNEY VANCOUVER

INTRODUCTION

At the request of Mr. William A. Ramsey and on behalf of the Black Bill and Doney Parks Water Users Association, a resistivity survey was conducted by Heinrichs Geoexploration Company in June 1969. The survey was located in the immediate vicinity of the southwest corner of Section 17, T. 22 N., R. 8 E., near Flagstaff, Arizona.

The purpose of the survey was to locate favorable well sites using applied geophysical resistivity methods. The scope of the project was somewhat limited by budget and cannot be considered to have adequately satisfied the stated purpose.

Two Wenner expanding depth probes using logarithmically increasing electrode spacings were used to locate the alluvium bedrock contact. In addition, two collinear dipole-dipole electrode n=1 profiles, each consisting of data obtained from electrode spacings of 250 and 500 feet were used in conjunction with the depth probes to locate significant alluvium depth or resistivity changes. Reference to any of the standard geophysical text books such as "Geophysical Exploration" by C.A. Heiland will describe in detail the theory of the procedures used.

Geoex personnel involved in this job were Mr. J. Bauersachs, crew chief; M. Critchley and B. Terrell Technicians. Mr. Paul A. Head, Geophysicist was in charge of the project and is responsible for this report.

INTERPRETATION AND RECOMMENDATIONS

Expander #1 reveals rather strong lateral changes that prevent good depth interpretation from most of the data. Apparently good data was observed out to an "a" spacing of 50 feet resulting in a fairly easily interpreted surface layer of 70 ohm feet, 25 feet thick. The remainder of the probe is badly distorted but we believe another layer begins at 100 to 200 feet deep, probably representing solid rock having a resistivity perhaps as high as 1,500 ohm feet. Unfortunately it is this deeper layer that is of the most importance to this survey and is the most poorly defined.

Expander #2 also shows considerable lateral distortion but is quite a bit more interpretable than #1. The alluvial layer as calculated from Expander #2 is about 150 feet thick and has a resistivity of about 1,000 ohm feet. The agreement between expanders is remarkably good in spite of lateral effects.

Line #1 is oriented N 10° E as shown on the plan map. A north-south oriented fence crossing the line at about a 10° angle near 0.0 NE probably has a marked effect on the resistivity data but does not seriously impair relative depth calculations since it is nearly parallel to the line and quite long compared to the dipole spacings used. The resistivity low centered at about 1.25 SW is a valid feature that caused the poor depth probe data on Expander #1 and may represent either a change in bedrock resistivity or a channel in the bedrock filled with alluvium. The north end of the line

from the 12.5 NE indicates that bedrock is coming near surface which is a surprising conclusion or that the alluvium has become more resistive. From about 10 SE on, the south end of the line indicates bedrock about 50 feet deep.

Line #2 is oriented east-west and crosses Line #1 as shown on the enclosed plan map. This line indicates fairly uniform depths on the order of 50 feet to bedrock over its entire length. The possible exception being at 6.25 E where a minor decrease of cover may occur.

The general conclusions are that this survey has not been successful in terms of defining a "best" location to drill for water but a possible buried channel in the bedrock has been found. It is our recommendation that three or four well points or small bore test holes be drilled along Line #1 as shown on the profile sheet to identify the true geological nature of the resistivity low between 5 SW and 2.5 NE. If these test holes prove the existance of either higher porosity alluvium or the existance of a channel in bedrock, then a possible source of ground water was located. Based on encouraging drill results of this type we would then recommend tracing the underground course of the ground water by a more extensive resistivity survey or by a continued program of small bore test drilling to define the best place for water production.

Respectfully Submitted,

HEINRICHS GEOEXPLORATION COMPANY

Paul A. Head
Geophysicist

JUL 2 1969

APPROVED BY

HEINRICHS GEOEXPLORATION COMPANY

Walter E. Heinrichs, Jr.
President

Registered Professional Engineer (Mining)
CERTIFICATE EXPIRES
WALTER E. HEINRICHS, JR.
DEC. 31, 19
ARIZONA, U.S.A.

EXPANDER #1

WENNER ARRAY RESISTIVITY DEPTH PROBE

for

BLACK BILL & DONEY PARKS WATER USERS ASSOCIATION (BILL RAMSEY)

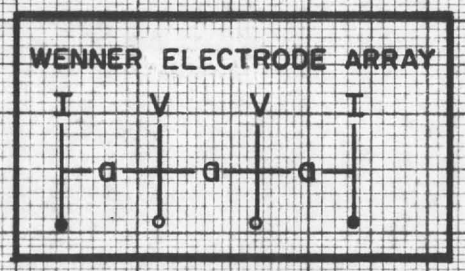
JUNE 1969

REINHARDS
GEOEXPLORATION COMPANY 403-69
POST OFFICE BOX 6671, TUCSON, ARIZONA, 85703
Phone: 602/623-9378 Cable: GEOEX, Tucson
geophysical engineers
vancouver sydney

$\rho_a/2\pi$ (IN OHM FEET)

a (IN FEET)

WENNER ELECTRODE ARRAY



LOGARITHMIC 2 X 3 CYCLES KEUFFEL & ESSER CO. 47 7323 MADE IN U.S.A.

EXPANDER #2

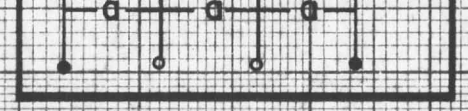
WENNER ARRAY RESISTIVITY DEPTH PROBE
for
BLACK BILL & DONEY PARKS WATER
USERS ASSOCIATION (BILL RAMSEY)
JUNE 1969

HEINRICHS
GEOEXPLORATION COMPANY 405-69
POST OFFICE BOX 5671, TUCSON, ARIZONA 85703
Phone: 602/623-0578 Cable: GEOEX, Tucson
geophysical engineers
vancouver
sydney

$\rho_a/2\pi$ (IN OHM FEET)

a (IN FEET)

WENNER ELECTRODE ARRAY



LINE I

DIPOLE-DIPOLE RESISTIVITY PROFILE
for
BLACK BILL & DONEY PARKS WATER USERS ASSOCIATION (BILL RAMSEY)

JUNE 1969

HEINRICHS GEOEXPLORATION COMPANY 403-69
POST OFFICE BOX 5671, TUCSON, ARIZONA, 85703
Phone: 602/623-0578 Cable: GEOEX, Tucson
geophysical engineers
vancouver
sydney

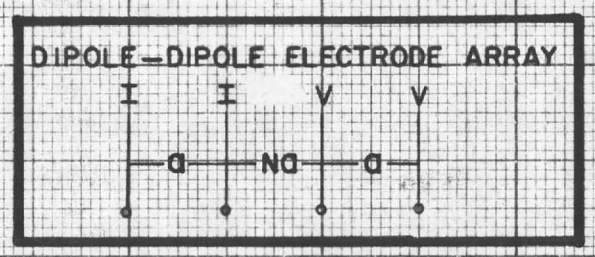
$\rho_a/2\pi$ (IN OHM FEET)

400
300
250
200
150
100
90
80
70
60
50
40
30
25
20
15

a = 500' N=1

a = 250' N=1

DIPOLE-DIPOLE ELECTRODE ARRAY



TEST HOLES

#2 #1 #3 #4

1/29/70

4" steel water

42" steel Gas Line

20.0 17.5 15.0 12.5 10.0 7.5 5.0 2.5 0.0 2.5 5.0 7.5 10 12.5 15 17.5

SW

LINE STATIONING IN 100 FEET

NE

SCALE:
HORIZONTAL 1"=250 FEET
VERTICAL LOGARITHMIC IN OHM FEET

LINE 2

DIPOLE-DIPOLE RESISTIVITY PROFILE

for

BLACK BILL & DONEY PARKS WATER

USERS ASSOCIATION (BILL RAMSEY)

JUNE 1969

HEINRICHS
GEOEXPLORATION COMPANY 403-69
POST OFFICE BOX 5671, TUCSON, ARIZONA, 85703
Phone: 602/623-0578 Cable: GEOEX, Tucson
geophysical engineers
vancouver
sydney

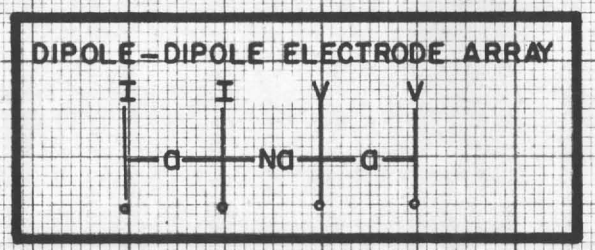
$\rho_a/2\pi$ (IN OHM FEET)

500 400 300 250 200 150 100 90 80 70 60 50 40 30 25 20 15 10

a=500' N=1

a=250' N=1

DIPOLE-DIPOLE ELECTRODE ARRAY



SCALE:

HORIZONTAL 1" = 250

VERTICAL LOGARITHMIC IN OHMFEET

20.0 17.5 15.0 12.5 10.0 7.5 5.0 2.5 0.0 2.5 5.0 7.5 10 12.5 15 17.5

LINE STATIONING IN 100 FEET

R. 7 E.

R. 8 E.

T. 22 N.

14

13

18

17

23

24

19

20

LINE 1

25 NE

CENTER EXPANDER # 1

CENTER EXPANDER # 2

25 W

25 E

LINE 2

25 SW

EXPLANATION

OVERLAY OF BASE MAP SUBMITTED BY WM. A. RAMSEY

N

HEINRICHS GEOEXPLORATION COMPANY

POST OFFICE BOX 5671, TUCSON, ARIZONA, 85703

Phone: 602/623-0578 Cable: GEOEX, Tucson

geophysical engineers vancouver sydney 403-69

LOCATION PLAN

OF

RESISTIVITY SURVEY

FOR

BLACK BILL & DONEY PARKS WATER USERS ASSOCIATION (BILL RAMSEY)

FLAGSTAFF, ARIZONA

SCALE 1" = 1000' | DRAWN BY J.L. PETRY | DATE 6-69

VERITY & SMITH
ATTORNEYS AT LAW
SUITE 902 TRANSAMERICA BUILDING
177 NORTH CHURCH AVENUE
TUCSON, ARIZONA 85701

VICTOR H. VERITY
LEO N. SMITH
JAMES E. MUELLER
JOHN C. LACY
KENNETH L. ALLEN

AREA CODE 602
TELEPHONE 622-7445

September 28, 1970

HEINRICHS
GEOEX
Cable: GEOEX

RECD SEP 29 1970 RECD

BOX 5964 TUCSON, ARIZONA 85703
Phone: (AREA 602) 623-0578

Mr. Grover Heinrichs
Heinrichs Geoexploration Co.
P. O. Box 5964
Tucson, Arizona 85703

Dear Grover:

Attached is a rough draft of a proposed letter to Mr. Lincoln, the attorney for ~~Black~~ Bill and Doney Parks Water Users Association. Will you please read it very carefully and return the enclosed extra copy to me with your comments, suggestions, changes, etc.

If the field crew, seeing the wire fence, could run the survey in such a way as to eliminate the effect of the fence, could the same technique be used to eliminate the effect of the pipe? I assume there is an explanation but you will have to educate me.

I am returning the map. Please make another just like it and return both to me. One will go to Mr. Lincoln.

Also enclosed are some extra copies of correspondence which I do not need.

Very truly yours,

Victor H. Verity

VHV/mej
Enclosures

VERITY & SMITH
ATTORNEYS AT LAW
SUITE 902 TRANSAMERICA BUILDING
177 NORTH CHURCH AVENUE
TUCSON, ARIZONA 85701

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Very truly yours,

Victor H. Verity

VHV/mej
Enclosures

October 2, 1970

Mr. Victor H. Verity
Verity & Smith
Attorneys at Law
Suite 902 Transamerica Building
177 North Church Avenue
Tucson, Arizona 85701

Dear Vic:

In answer to your question regarding the elimination of fence effects, the problem of unwanted effects of fences, pipes, cables or other grounded conductors is in theory and technically quite easy. All that is needed is to dig them up and move them away from the area being surveyed. Practically this is nearly always impossible. In the case of fences, it is possible to insert insulators into each strand of the fence for several hundred feet every 100 feet to eliminate most of the interference. However, this is expensive and more commonly, in the field, we try to cross the fence at right angles with electrodes equally spaced straddling the fence line. To a degree this will minimize but not eliminate interference when it is possible to cross at right angles.

We could have minimized the pipe effect by this approach and in fact this is actually about the way it worked out, accidentally. There is no practical way to really correct or eliminate the effects of a 42" gas main - short of digging it up.

Cont'd.....

C ont'd.....

We have read over your letter to Mr. Lincoln and suggest only the minor addition of Grover's name and changing those words on the edited copy of the letter to Mr. Lincoln which is enclosed. Also enclosed are two copies of the map you desired.

The above is in reference to your letter dated 28, September 1970 to Mr. Grover Heinrichs.

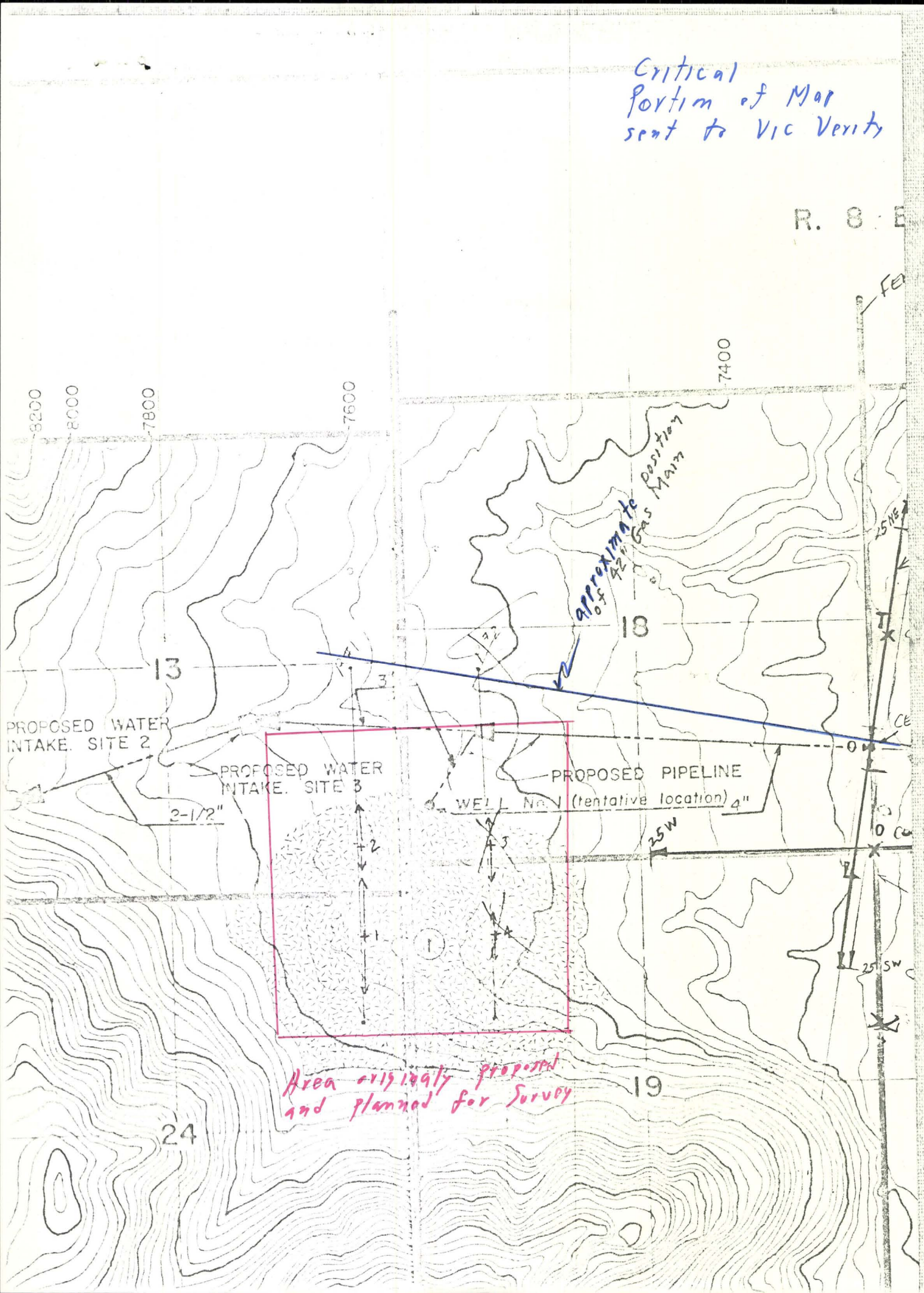
Sincerely,
HEINRICHS GEOEXPLORATION COMPANY

Paul A. Head
Geophysicist

Enclosures: copy of letter to Mr. Lincoln

2 copies of map requested

PAH/re:


Critical Portion of Map sent to Vic Verity
R. 8 E
9200
8000
7800
7600
7400
13
18
19
24
approximate position of 42" Gas Main
PROPOSED WATER INTAKE. SITE 2
PROPOSED WATER INTAKE. SITE 3
PROPOSED PIPELINE
WELL No. 1 (tentative location)
2-1/2"
4"
25 NE
25 SW
Area originally proposed and planned for Survey

HEINRICHS GEOEXPLORATION COMPANY

806 WEST GRANT ROAD, TUCSON, ARIZONA, 85703. P.O. BOX 5671. PHONE: (AREA CODE 602) 623-0578

5964

September 1, 1970

Mr. Victor H. Verity
Verity & Smith, Attorneys at Law
Suite 902, Transamerica Bldg.
177 North Church Avenue
Tucson, Arizona 85701

Dear Vic:

Furthering your conversation with Grover today, enclosed is a memo on a conference held in Phoenix regarding the Black Bill & Doney Parks Water Users Association.

It is our understanding that a meeting is to be held in your office at 10 a.m. on September 16 to further discuss the matter. We will try to have all parties available at that time.

Sincerely,

Walter E. Heinrichs, Jr.

WEH:jh

cc: Extra Encl
P. A. Head
J. Bauersachs
E. G. Heinrichs

HEINRICHS GEOEXPLORATION COMPANY

806 WEST GRANT ROAD, TUCSON, ARIZONA, 85703. P.O. BOX 5671. PHONE: (AREA CODE 602) 623-0578

September 1, 1970

Conference Lunch with William A. Ramsey
at Westward Ho Hotel, Phoenix 12:15 p.m. August 27, 1970

Paul Head, Jim Bauersache, E. Grover Heinrichs

Ramsey stated that the Water District owed him $31,000.00. They were short on funds and in his opinion were trying to get additional funds any way they can for additional work to find water.

Ramsey said categorically that neither the Water Users Association nor the attorneys have professional geophysical advice.

Ramsey picked the spot to run survey in the field, recalled shifting the area to be covered at the last minute when the crew arrived on site. He reitorated that we were informed of pipe in the field.

Ramsey stated that the pipe line right of way was marked by signs every 100 feet. However, our crew did not have occasion to traverse along this right of way. Their ingress and egress was by a different and more direct and convenient route via the Eldon Springs road and a Forest Service road. Ramsey remembered this after being reminded by Jim Bauersachs. Ramsey stated that he thought a mathematical calculation should have been made to correct for pipeline.

We stated that existence of pipe line could not be corrected for mathematically, that one would have to ignore the area of the pipe.

HEINRICHS GEOEXPLORATION COMPANY

806 WEST GRANT ROAD, TUCSON, ARIZONA, 85703. P.O. BOX 5671. PHONE: (AREA CODE 602) 623-0578

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VICTOR H. VERITY
LEO N. SMITH
JAMES E. MUELLER
JOHN C. LACY
KENNETH L. ALLEN

AREA CODE 602
TELEPHONE 622-7445

August 6, 1970

Mr. Kenneth J. Lincoln
Wilson, Compton, Egan & Lincoln
Attorneys at Law
P.O. Box 550
Flagstaff, Arizona 86001

Dear Mr. Lincoln:

Mr. Heinrichs has returned to Tucson and we have discussed the matter of the work that was performed for Black Bill and Doney Parks Water Users Association. We need additional facts but are having a little difficulty getting them because employees are on vacation. One of the key men is due back within a few days and after his return I will again confer with Mr. Heinrichs and his men and get the information I need to take the matter up with you.

Very truly yours,

Victor H. Verity

VHV:lh

cc: Mr. Walter E. Heinrichs, Jr.

HEINRICHS
GEOEXPLORATION CO.
Box 5964 Tucson, Arizona 85703
Phone: (602) 623-0578
Cable: GEOEX

MESSAGE DATE July 27 / 70

TO

Mr. Victor H. Verity
Suite 902
Transamerica Building
Tucson, Arizona

Re: Letter to: Wilson, Compton, Egan & Lincoln

Dear Vic:

The attached letter, subject to your review, is proposed to be mailed to the above attorneys in Flagstaff.

We await your comment and approval.

Walt leaves tomorrow (July 28) at 11.am. Contact Paul A. Head in the event Walt has left before you have a chance to call back.

Sincerely,

SIGNED (Mrs. W. E. Heinrichs, Jr.)

REPLY DATE 8 / 6 / 70

Dear Walt:

Confirming our last phone call, I did not mail your letter of July 27, 1970 to Wilson, Compton, Egan and Lincoln because I did not want to give them any facts before you and I have gone over the matter very thoroughly in advance. I return the and a carbon original of that letter to you enclosed and am keeping a carbon copy for office use.

Very truly yours,

SIGNED Victor H. Verity

Rediform® 4S 473

SEND PARTS 1 AND 3 WITH CARBON INTACT - PART 3 WILL BE RETURNED WITH REPLY.

HEINRICHS GEOEXPLORATION COMPANY

806 WEST GRANT ROAD, TUCSON, ARIZONA, 85703. P.O. BOX 5671. PHONE: (AREA CODE 602) 623-0578

July 27, 1970

Messrs. Wilson, Compton, Egan
and Lincoln
203 N. San Francisco
P.O. Box 550
Flagstaff, Arizona 86001

Re: Black Bill & Doney Park Water
Users Association
Job No. 403-69

Gentlemen:

1. We were asked and agreed to run a very tight economy budget survey and stated at the time we could promise little for the magnitude expenditure proposed. Moreover, we stated we were discouraged regarding the practical applicability to really help.

2. Nevertheless we tried to accommodate Mr. Ramsey and his client because of awareness of seriousness of the water problem involved and therefore agreed to try to assist as requested.

3. The pipes would have had little or no effect if work had been done as originally discussed, proposed and contracted. However, even after moving the location at Mr. Ramsey's last minute field request, the pipe effects then encountered would not materially change the geophysical conclusions or recommendations regarding the tiny area chosen and covered. Regardless of pipe effect, a channel was technically <u>possible,</u> because it is not feasible to quantitatively correct for pipe lines effects, or to look at any given set of data and say it is <u>ALL</u> pipe effect or <u>NO</u> pipe effect. However, if we had prior knowledge of the pipe line and were instructed to do a resistivity survey across it, the data and computations would of course still be the same. Our interpretation would have recognized

Cont'd.....

Cont'd.....

that the pipe effected the data and that the only possible location for a buried channel not eliminated would be under the pipe. Therefore the only course possible to confirm or eliminate a channel at the pipe is to drill.

It was understood that client desperation warranted grasping at almost any straw and the fact that the client or their consultant may not have been fully aware of pipe line implications should not be blamed on us because we did not pick the area or manage the considerations. In fact, at the outset we inferred and even later stated when additional work was being proposed by Mr. Ramsey, that perhaps a non geophysical approach would be best. This was covered in our Mr. Head's letter to Mr. Ramsey on 28 April 1970 and in prior discussions. Moreover, WE did not recommend the expenditure of any amounts of funds to drill this or any area as opposed to other available alternatives. We did recommend if you want to rule out a possible channel here, it will likely take about four holes to do it and Mr. Ramsey certainly was at least partially aware of this.

We did not guarantee water, or even any channel, or anything else, except to endeavor to assist you as requested and at your direction. Unfortunately, usually geophysics is only at best an incremental aid to the geologist or geohydrologist and is rarely categorical and Mr. Ramsey knows this. Certainly we tried to hold back all false hopes and if any were conveyed they were not from us, and could and should have been avoided. We have no idea why Mr. Ramsey chose to move the work one mile north-easterly, but that was not our concern or responsibility.

Very truly yours,
HEINRICHS GEOEXPLORATION COMPANY

Walter E. Heinrichs, Jr.
President

WEH/re:

HEINRICHS GEOEXPLORATION COMPANY

806 WEST GRANT ROAD, TUCSON, ARIZONA, 85703. P.O. BOX 5671. PHONE: (AREA CODE 602) 623-0578

July 27, 1970

Messrs. Wilson, Compton, Egan
and Lincoln
203 N. San Francisco
P.O. Box 550
Flagstaff, Arizona 86001

Re: Black Bill & Doney Park Water
Users Association
Job No. 403-69

Gentlemen:

1. We were asked and agreed to run a very tight economy budget survey and stated at the time we could promise little for the magnitude expenditure proposed. Moreover, we stated we were discouraged regarding the practical applicability to really help.

2. Nevertheless we tried to accommodate Mr. Ramsey and his client because of awareness of seriousness of the water problem involved and therefore agreed to try to assist as requested.

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806 WEST GRANT ROAD, TUCSON, ARIZONA, 85703. P.O. BOX 5671. PHONE: (AREA CODE 602) 623-0578

August 27, 1970

Conference Lunch with William A. Ramsey
@ Westward Ho Hotel 12:15 P.M. 8-27-70

Paul Head, Jim Bauersachs, E. Grover Heinrichs

Ramsey stated that the Water District owed him $31,000.00. They were short funds and in his opinion were trying to get additional funds any way they can for additional work to find water.

Ramsey said categorically that neither the Water Uses Association nor the attorneys have professional geophysical advice.

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HEINRICHS GEOEXPLORATION COMPANY

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5964

September 1, 1970

Mr. Victor H. Verity
Verity & Smith, Attorneys at Law
Suite 902, Transamerica Bldg.
177 North Church Avenue
Tucson, Arizona 85701

Dear Vic:

Furthering your conversation with Grover today, enclosed is a memo on a conference held in Phoenix regarding the Black Bill & Doney Parks Water Users Association.

It is our understanding that a meeting is to be held in your office at 10 a.m. on September 16 to further discuss the matter. We will try to have all parties available at that time.

Sincerely,

Walter E. Heinrichs, Jr.

WEH:jh

cc: Extra Encl.
P. A. Head
J. Bauersachs
E. G. Heinrichs

5964

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ATTORNEYS AT LAW
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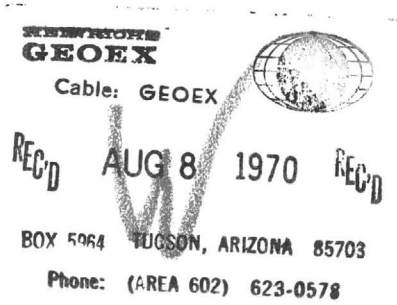
TUCSON, ARIZONA 85701

VICTOR H. VERITY
LEO N. SMITH
JAMES E. MUELLER
JOHN C. LACY
KENNETH L. ALLEN

AREA CODE 602
TELEPHONE 622-7445

August 7, 1970



Mr. Walter E. Heinrichs, Jr.
Heinrichs Geoexploration Co.
P. O. Box 5964
Tucson, Arizona 85703

Dear Mr. Heinrichs:

As you requested in our telephone conversation this afternoon, I am returning to you enclosed your Black Bill & Doney Parks Water Users Association file.

Very truly yours,

Lynn Hubbard

Lynn Hubbard

LH

Received

850

5964

September 1, 1970

Mr. Victor H. Verity
Verity & Smith, Attorneys at Law
Suite 902, Transamerica Bldg.
177 North Church Avenue
Tucson, Arizona 85701

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Walter E. Heinrichs, Jr.

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cc: Extra Encl.
P. A. Head
J. Bauersachs
E. G. Heinrichs

403

(B B&D Park. F

September 1, 1970

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at Westward Ho Hotel, Phoenix 12:15 p.m. August 27, 1970

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#403

VERITY & SMITH
ATTORNEYS AT LAW
SUITE 902 TRANSAMERICA BUILDING
177 NORTH CHURCH AVENUE
TUCSON, ARIZONA 85701

VICTOR H. VERITY
LEO N. SMITH
JAMES E. MUELLER
JOHN C. LACY

AREA CODE 602
TELEPHONE 622-7445

December 30, 1970

HEINRICHS GEOEX
Cable: GEOEX
BOX 5964 TUCSON, ARIZONA 85703
Phone: (AREA 602) 623-0578

Mr. Walter E. Heinrichs, Jr.
Heinrichs Geoexploration Company
P. O. Box 5964
Tucson, Arizona 85703

Dear Walt:

With reference to Black Bill & Doney Parks, I agree with you that it is best "to let sleeping dogs lie". In the letter to Mr. Lincoln we laid the cards on the table and I have a feeling that this is more than his client did. I am in hopes that he has discussed the matter with his client and uncovered enough information to make it clear that there were two sides to the story and, such being the case, a law suit would not be the best way to settle the matter. Let us wait and see what happens.

Very truly yours,

Victor H. Verity

VHV:bd

December 23, 1970

Mr. Victor H. Verity
Verity & Smith, Attorneys at Law
Suite 902, Transamerica Bldg.
177 North Church Avenue
Tucson, Arizona 85701

Dear Vic:

This will acknowledge your statement dated 18 December 1970 in the amount of $305.07. We probably are not quite the slowest pay in town, but I have had feed-back from some young attorneys discussing the fact that we were also not the most prompt.

Since the letter from you to the attorneys in Flagstaff dated 28 September 1970, there has been absolutely nothing regarding Black Bill & Doney Parks. If anything at all comes up we will let you know immediately.

Intuitively, I am willing to let sleeping dogs lie. If you have other recommendations, please let me know.

We enjoyed Loretta's Christmas card very much. Sounds like you will have a happy and busy season. Jean and Fred join me in wishing you all the very best of the season.

Sincerely,

Walter E. Heinrichs, Jr.

WEH:jh

VERITY & SMITH
ATTORNEYS AT LAW
SUITE 902 TRANSAMERICA BUILDING
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JOHN C. LACY

AREA CODE 602
TELEPHONE 622-7445

C.S.L. R.H.

October 6, 1970

HEINRICHS GEOEX
Cable: GEOEX

REC'D OCT 7 1970 REC'D

BOX 5964 TUCSON, ARIZONA 85703
Phone: (AREA 602) 623-0578

Mr. Kenneth J. Lincoln
Wilson, Compton, Egan & Lincoln
Attorneys at Law
P. O. Box 550
Flagstaff, Arizona 86001

Dear Mr. Lincoln:

I have conferred with representatives of my client, Heinrichs Geoexploration Company, and there are aspects of the matter which make it unlikely that Geoex could be held responsible for any alleged negligence in the performance of the geophysical work for Black Bill and Doney Parks Water Users Association. In order that we may have a better understanding, I shall give you some information in this letter which you may then wish to check out with your clients and we can pursue the matter further at a later date.

#403

It is my understanding that Mr. William A. Ramsey was retained by your client and authorized to employ a geophysicist to perform services at a location determined by Mr. Ramsey. Mr. Ramsey then talked with Mr. Grover Heinrichs and Mr. Paul Head of Geoex and arranged for a resistivity survey and from that a study to see if any other geophysical methods would be useful. The plan was for an inexpensive geophysical survey and of necessity once the arrangements had been made and the area selected, Geoex could not assign Mr. Head to personally supervise field work and that, I believe, was a fact known to Mr. Ramsey. As in most geophysical work, the basic results obtained by the field crew were to be interpreted in the Geoex office by a geophysicist and a report made.

Enclosed is a map that was furnished Geoex by Mr. Ramsey and on which Geoex has shown in red the area that was originally designated by Mr. Ramsey for the geophysical survey and agreed upon between Mr. Head and Mr. Ramsey. The map showed only a proposed water line to be built at some future date by the Association. The map does not show an existing pipeline on the designated area.

After the arrangements were made between Mr. Head and Mr. Ramsey, a field crew was sent from Geoex, in charge

of Mr. J. Bauersachs, to perform the work in accordance with the instructions of Mr. Head. When Mr. Bauersachs reported to perform the work, Mr. Ramsey had made a decision to have the geophysical survey made in a different location. The work performed by the field crew was done at the new area designated by Mr. Ramsey. The lines run by the field crew are shown in black on the map and are completely outside the area originally designated. The approximate position of the gas pipeline is shown in blue, having been added to the map at my request.

Mr. Bauersachs has no recollection of Mr. Ramsey having mentioned the existence of a gas pipeline. Mr. Ramsey has told Mr. Head that he did so inform Mr. Bauersachs. Mr. Bauersachs was aware of a wire fence across the site selected by Mr. Ramsey and took the necessary steps to minimize the effect of the fence. He says that if he had known of the existence of a pipeline he would have undoubtedly mentioned it. Mr. Bauersachs was aware of what appeared to be a road. There was a fire somewhere in the distance and the Forest Service was moving a lot of traffic back and forth. It turned out later that it was not simply a road but also the right-of-way under which the pipeline was laid. However, this was ascertained only after Mr. Ramsey brought the matter to the attention of Geoex about six months after the report had been made. The fact that the cleared area was not merely a road but a pipeline as well was not known to Mr. Bauersachs at the time he did the field work. The Geoex crew did not drive along this right-of-way. Their ingress and egress was by a different and more direct and convenient route via the Eldon Springs road and a Forest Service road.

Unfortunately, the field crew went out to do work in a given area but were directed by Mr. Ramsey to perform it in another area where, as it turned out, there was a gas pipeline which did have some effect on the survey. However, Mr. Walter Heinrichs has advised me that there is no practical way to eliminate the effect of that pipeline. Had its presence been known to Mr. Head, it would have been mentioned in the geophysical report. He did not know about it and it was not mentioned. In any event, the computations were correct.

Based upon the survey, drill sites were suggested by Geoex and holes were put down. Water was found in two out of the four holes and Mr. Ramsey has advised Geoex that these holes can be developed into producing wells.

I want to do all I can to ascertain the facts. After you have read this letter I am sure you will discuss the subject with your clients and I will look forward to hearing from you.

Very truly yours,

Victor H. Verity

VHV/mej
Enclosure

cc: Heinrichs Geoexploration Company

VERITY & SMITH
ATTORNEYS AT LAW
SUITE 902 TRANSAMERICA BUILDING
177 NORTH CHURCH AVENUE
TUCSON, ARIZONA 85701

VICTOR H. VERITY
LEO N. SMITH
JAMES E. MUELLER
JOHN C. LACY
KENNETH L. ALLEN

AREA CODE 602
TELEPHONE 622-7445

September 28, 1970

Mr. Kenneth J. Lincoln
Wilson, Compton, Egan & Lincoln
Attorneys at Law
P. O. Box 550
Flagstaff, Arizona 86001

Dear Mr. Lincoln:

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Enclosure

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July 27, 1970

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Flagstaff, Arizona 86001

Re: Black Bill & Doney Park Water
Users Association
Job No. 403-69

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1. We were asked and agreed to run a very tight economy budget survey and stated at the time we could promise little for the magnitude expenditure proposed. Moreover, we stated we were discouraged regarding the practical applicability to really help.

2. Nevertheless we tried to accommodate Mr. Ramsey and his client because of awareness of seriousness of the water problem involved and therefore agreed to try to assist as requested.

3. The pipes would have had little or no effect if work had been done as originally discussed, proposed and contracted. However, even after moving the location at Mr. Ramsey's last minute field request, the pipe effects then encountered would not materially change the geophysical conclusions or recommendations regarding the tiny area chosen and covered. Regardless of pipe effect, a channel was technically <u>possible,</u> because it is not feasible to quantitatively correct for pipe lines effects, or to look at any given set of data and say it is <u>ALL</u> pipe effect or <u>NO</u> pipe effect. However, if we had prior knowledge of the pipe line and were instructed to do a resistivity survey across it, the data and computations would of course still be the same. Our interpretation would have recognized

Cont'd.....

Cont'd.....

that the pipe effected the data and that the only possible location for a buried channel not eliminated would be under the pipe. Therefore the only course possible to confirm or eliminate a channel at the pipe is to drill.

It was understood that client desperation warranted grasping at almost any straw and the fact that the client or their consultant may not have been fully aware of pipe line implications should not be blamed on us because we did not pick the area or manage the considerations. In fact, at the outset we inferred and even later stated when additional work was being proposed by Mr. Ramsey, that perhaps a non geophysical approach would be best. This was covered in our Mr. Head's letter to Mr. Ramsey on 28 April 1970 and in prior discussions. Moreover, WE did not recommend the expenditure of any amounts of funds to drill this or any area as opposed to other available alternatives. We did recommend if you want to rule out a possible channel here, it will likely take about four holes to do it and Mr. Ramsey certainly was at least partially aware of this.

We did not guarantee water, or even any channel, or anything else, except to endeavor to assist you as requested and at your direction. Unfortunately, usually geophysics is only at best an incremental aid to the geologist or geohydrologist and is rarely categorical and Mr. Ramsey knows this. Certainly we tried to hold back all false hopes and if any were conveyed they were not from us, and could and should have been avoided. We have no idea why Mr. Ramsey chose to move the work one mile north-easterly, but that was not our concern or responsibility.

Very truly yours,
HEINRICHS GEOEXPLORATION COMPANY

Walter E. Heinrichs, Jr.
President

WEH/re:

April 28, 1970

Mr. Bill Ramsey
1222 E. Missouri Ave.
Phoenix, Arizona 85014

Dear Mr. Ramsey:

A good many weeks have passed since Jack Young delivered your photo-mosaic of the Black Bill Area to our office. After assimilating the reports you left with us and looking over the general topography we have reached the conclusion that small bore drill holes will be the quickest and most economical approach to locating usable ground water in this area.

Seismic methods would very likely be of great assistance, but to obtain data to the depths needed it would be necessary to employ multi-channel systems and explosives. This would of course become somewhat more costly than less elaborate seismic techniques.

Magnetics might also offer some help but we doubt that any quantitative evaluation of structure or depths would result.

Electrical methods will all be seriously restricted by the large pipe line through the area, however, useful interpretation well away from the pipe is possible. To obtain a satisfactory interpretation of the subsurface, the area of interest will need to be very completely analyzed and would be quite expensive relative to resistivity surveys we have done for you in the past.

In summary, we would expect that the ideal program for the Black Bill Area would entail about one month in the field, possibly using more than one method. This combined with the office work required would be estimated at about $5000 to $7500. We expect that this amount could be at least as well spent using a 2" rotary drill to test for water bearing strata.

If you do elect to drill rather than pursue the geophysical approach, we strongly recommend that a competent hydrologist be on hand at the drill sites to log the cuttings.

We will contact Jack Young and have him pick up the mosaic this week.

Sincerely yours,
HEINRICHS GEOEXPLORATION COMPANY

Paul A. Head
Geophysicist

PAH/re:

27 January 1970

Mr. Bill Ramsey
1222 E. Missouri Avenue
Phoenix, Arizona 85014

Re: GEOEX Job #403-69

Dear Bill;

I received your letter of 24 January 1970 and have reviewed in part the data in the light of the new drill information. It is still a difficult problem and perhaps some discussion with you would be beneficial to help untangle it.

I want to point out these discussions will of necessity be charged to the project at the rate of $18.00 per hour.

We will be looking for you tomorrow afternoon.

Very truly yours,

HEINRICHS GEOEXPLORATION COMPANY

E. Grover Heinrichs,
Vice President

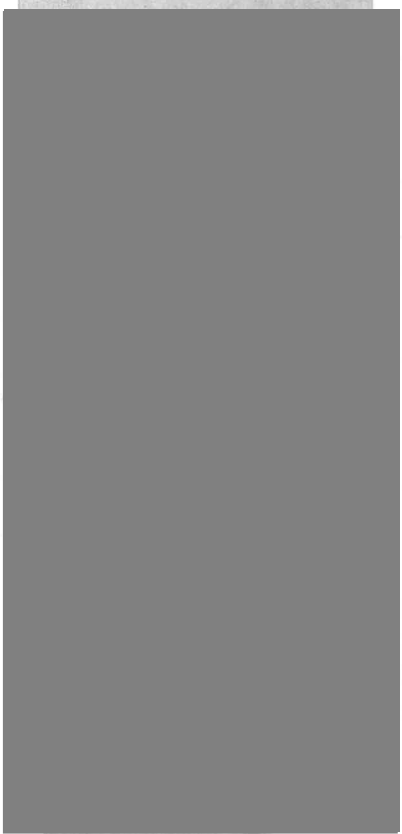
EGH/plp

27 January 1970

Mr. Bill Ramsey
1222 E. Missouri Avenue
Phoenix, Arizona

7/1/71 - Star

Coconino County Sets Up Group To Seek Water



HEINRICHS GEOEXPLORATION CO.

I. P. SENDER NOTES

PROJECT Ramsey (403-69)

LINE 2 HALF W SP. 1 DATE 6-13

SEND	1-3	2-4	1-2	3-5	2-3	4-6	3-4	5-7	4-5	6-8
RECEIVE	25-20	22.5-17.5	20.0-17.5	20-15	17.5-15	17.5-12.5	15.0-12.5	15-10	12.5-10	12.5-7.5
RANGE										
VOLTAGE	700Lo	600Lo	690Lo	600Lo	500Lo	640Lo	590Lo	700Lo	660Lo	850Lo
CURRENT	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.6A
SEND	5-6	7-9	6-7	8-10	7-8	9-11	8-9	10-12	9-10	11-13
RECEIVE	10-7.5	10-5.0	7.5-5.0	7.5-2.5	5.0-2.5	5.0-0.0	2.5-0	2.5-2.5	0-2.5	0-5.0
RANGE										
VOLTAGE	610Lo	520Lo	630Lo	820Lo	470Lo	670Lo	880Lo	600Lo	440Lo	590
CURRENT	0.3	0.3	0.3	0.6	0.3	0.6	0.9	0.3	0.3	0.6

FREQUENCIES .1

SENDER NO. 13671-S

OPERATOR M. Critch

RECEIVER NO.

OPERATOR Jim B

COMMENTS:

CAL

HEINRICHS GEOEXPLORATION CO.

I. P. SENDER NOTES

PROJECT Ramsey (403-69.
LINE 2 HALF E SP. 1 DATE 13-6

SEND	10-11	4-6	11-12	5-7	12-13	6-8	9-10	7-9	10-11	8-10
RECEIVE	2.5-5.0	2.5-7.5	5.0-7.5	5.0-10.0	7.5-10.0	7.5-12.5	10.-12.5	10.0-15.0	12.5-15.0	12.5-17.5
RANGE										
VOLTAGE	440Lo	610Lo	460Lo	670Lo	420Lo	800Lo	870Lo	500	870Lo	750Lo
CURRENT	0.3	0.3	0.3	0.3	0.3	0.6	0.6	0.3	0.6	0.6
SEND	11-12	9-11	12-13	10-12	11-13		CAL	CAL		
RECEIVE	15.0-17.5	15.0-20	17.5-20	17.5-22.5	20-25		5-7	8-9		
RANGE										
VOLTAGE	450Lo	630Lo	820Lo	530Lo	830Lo		660	580		
CURRENT	0.3	0.6	0.6	0.3	0.9		0.3	0.6		

FREQUENCIES 0.1
SENDER NO. 13671 MK7
OPERATOR M Critch
RECEIVER NO.
OPERATOR Jim B.

COMMENTS:

HEINRICHS GEOEXPLORATION CO.
I.P. RECEIVER NOTES

PROJECT Ramsey - 403
LINE 2 HALF ALL SP. 1 DATE June 13 1969

SEND	500'	500'	250'	500'	250	500	250	500	250	500
RECEIVE	2500	2250	2000	2000	1750	1750	1500	1500	1250	1250
RANGE	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
DC 1	32.7	31.9	50.9	31.0	45.2	27.9	44.4	29.9	47.1	60.1
DC 2	34.6	36.0	48.8	30.8	45.6	32.2	46.3	31.8	42.0	60.1
DC 3	32.7	30.9	51.2	32.7	45.2	25.8	44.3	29.1	47.8	59.0
DC 4	34.6	36.7	48.5	29.9	45.6	33.4	46.7	32.4	41.2	61.2
DC 5		30.8	51.8	34.0		25.0	44.1	28.5	48.5	57.8
DC 6		36.8	48.1	28.2		34.1	47.0	32.4	40.5	62.3
DC 7		30.2	52.0	34.7		23.7	43.8	28.5	49.0	57.0
DC 8		37.6	48.0	27.8		35.4	47.4	32.5	40.1	62.6
DC AVG.	33.65	33.9	49.9	31.1	45.4	29.7	45.5	30.6	44.5	60
AC 1										
AC 2										
AC AVG.										
S.P.										
AC NOISE										
POT RES.										

HEINRICHS GEOEXPLORATION CO.

I.P. RECEIVER NOTES

PROJECT Ramsey 403

LINE 2 HALF ALL SP. 1 DATE June 13 1965

SEND	250'	500'		250'	500'	250'	500'	250'	500'	250'	500'	250'	500'
RECEIVE	1000	1000		750	750	500	500	250	250	0	0		
RANGE	.1	.1		.1	.1	.1	.1	.3	.1	.1	.1		
DC 1	43.9	34.0	29.7	40.1	62.8	44.1	62.5	138	32.3	45.8	69.4		
DC 2	40.8	25.9	31.0	42.9	63.2	42.9	59.8	132	34.8	44.1	70.0		
DC 3	43.2	35.9	31.0	39.8	64.3	44.0	61.1	138	32.1	45.9	69.6		
DC 4	41.0	24.4	29.1	43.1	62.1	43.1	60.7	132	35.0	44.0	70.0		
DC 5	42.7	37.8	32.0	39.5	65.6	43.3	60.0		32.0	46.0	69.3		
DC 6	41.7	22.1	28.4	43.7	62.4	43.8	62.1		34.7	43.9	70.2		
DC 7	42.2	39.7	33.8	39.0	64.1	42.9	58.7		32.2	46.0	70.1		
DC 8	42.0	20.8	27.9	44.0	63.1	44.1	63.1		34.5	44.0	70.0		
DC AVG.	42.1	BK. 30.2		41.5	63.4	43.5	61	136	33.4	45.0	70		
AC 1													
AC 2													
AC AVG.													
S.P.													
AC NOISE													
POT RES.													

HEINRICHS GEOEXPLORATION CO.
I.P. RECEIVER NOTES

PROJECT Ramsey - 403
LINE 2 HALF ALL S.P. ____ DATE June 13 1969

SEND	250'	500'	250'	500'	250'	500'	250'	500'	250'	500'
RECEIVE	250	250	500	500	750	750	1000	1000	1250	1250
RANGE	.1	.1	.1	.03	.1	.1	.1	.1	.1	
DC 1	53.5	34.4	40.2	28.0	44.2	66.4	90.8	32.6	85.3	56.7
DC 2	51.8	29.7	40.0	27.1	43.9	56.6	87.0	29.8	85.8	57.6
DC 3	54.6	35.2	40.2	28.7	43.9	66.7	91.4	32.9	85.8	59.5
DC 4	50.8	29.0	40.6	26.7	44.0	57.6	86.3	29.6	85.0	57.2
DC 5	55.1	35.8		28.7	43.5	67.2	91.7	34.0	86.1	59.9
DC 6	49.8	28.2		26.3	44.0	55.2	86.3	28.5	84.9	56.2
DC 7	55.7	36.2		29.2	43.5	68.5	91.6	34.7	86.3	60.2
DC 8	49.3	28.5		25.8	44.0	54.7	86.2	27.9	84.3	56.0
DC AVG.	52.5	32.1	40.1	27.6	43.9	61.5	88.0	31.3	85.4	58.1
AC 1										
AC 2										
AC AVG.										
S.P.										
AC NOISE										
POT RES.										

HEINRICHS GEOEXPLORATION CO.
I.P. RECEIVER NOTES

PROJECT Ramsey 403
LINE 2 HALF ALL SP. 1 DATE June 13 1969

SEND	250'	500'	250'	500'	500'		CAL 1	CAL 2		
RECEIVE	1500	1500	1750	1750	2000		500' W(5)	500' E 9		
RANGE	.1	.1	.1	.1	.1					
DC 1	40.8	59.6	82.8	29.0	81.1		31.9	60.2		
DC 2	43.0	58.6	86.5	27.8	87.0		32.0	60.3		
DC 3	40.4	58.8	82.2	27.9	79.5		31.9	60.2		
DC 4	43.1	58.9	87.0	28.8	89.0		32.0	60.3		
DC 5	40.2	58.8	81.7	26.8	77.8					
DC 6	43.2	58.6	88.0	29.9	90.0					
DC 7	40.0	59.0	80.7	25.8	76.5					
DC 8	43.5	58.5	88.3	30.1	91.9					
DC AVG.	41.8	58.9	84.7	28.3	84.1		31.95	60.25		
AC 1										
AC 2										
AC AVG.										
S.P.										
AC NOISE										
POT. RES.										

HEINRICHS GEOEXPLORATION COMPANY

INDUCED POLARIZATION SURVEY COMPUTATION SHEET

Page 1

Project 403-69 LAWSEY Line 2 - Sp. 1 W½ Field date 6-13-69 Data page 1 Comp. date _____. Comp by CRITCH

(A) Send	1-3	2-4	1-2	3-5	2-3	4-6	3-4	5-7	4-5	6-8		
(B) Receive	25-20	22.5-17.5	20-17.5	20-15	17.5-15	17.5-15	15-12.5	15-10	12.5-10	12.5-7.5		
(C) ~~n separation~~ @ Spacing	500	500	250	500	250	500	250	500	250	500		
(D) I	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.6		
(E) Vdc (avg)	33.65	33.9	49.9	31.1	45.4	29.7	45.5	30.6	14.5	60		
(F) DCcal	.939											
(G) Kn x 10^{-3}	1.5	1.5	.75	1.5	.75	1.5	.75	1.5	.75	1.5		
(H) ρdc=ExFxGx10^3/D	158	159	117	146	107	139	107	144	104	141		
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρ dc/ρac=ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

Project _____ Line _____ Field date _____ Data page 2 Comp. date _____ Comp by _____

(A) Send	5-6	7-9	6-7	8-10	7-8	9-11	8-9	10-12	CAL		9-10	11-13
(B) Receive	10-7.5	10-5.0	7.5-5.0	7.5-2.5	5.0-2.5	5.0-0.0	2.5-0.0	2.5S-2.5N	5-7		0-2.5	0-5.0
(C) ~~n separation~~ @ Spacing	250	500	250	500	250	500	250	500	500		250	500
(D) I	0.3	0.3	0.3	0.6	0.3	0.6	0.9	0.3	0.3		0.3	0.6
(E) dc (avg)	42.1	30.2	41.5	63.4	43.5	61	136	33.4	31.95		45.0	70
(F) DCcal	.939										.996	
(G) Kn x 10^{-3}	.75	1.5	.75	1.5	.75	1.5	.75	1.5			.75	1.5
(H) ρ dc=ExFxGx10^3/D	99	142	97	149	102	143	106	157			112	174
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρdc/ρac =ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

HEINRICHS GEOEXPLORATION COMPANY

INDUCED POLARIZATION SURVEY COMPUTATION SHEET

Page 2

Project 403-69 RAMSEY Line 2-Sp. 1 Field date 6-13-69 Data page 3 Comp. date _____. Comp by CRITCH

(A) Send	10-11	4-6	11-12	5-7	12-13	6-8	9-10	7-9	10-11	8-10		
(B) Receive	2.5-5.0	2.5-2.5	5.0-2.5	5.0-10	7.5-10	7.5-12.5	10-12.5	10-15	12.5-15	12.5-17.5		
(C) ~~n separation~~ a-Spacing	250	500	250	500	250	500	250	500	250	500		
(D) I	0.3	0.3	0.3	0.3	0.3	0.6	0.6	0.3	0.6	0.6		
(E) Vdc (avg)	52.5	32.1	40.1	27.6	43.9	61.5	89.0	31.3	85.4	58.1		
(F) DCcal	.996											
(G) Kn x 10^{-3}	.75	1.5	.75	1.5	.25	1.5	.25	1.5	.25	1.5		
(H) ρdc=ExFxGx10^3/D	131	160	100	137	109	153	111	156	106	146		
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρdc/ρac=ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

Project _____ Line _____ Field date _____ Data page 4 Comp. date _____ Comp by _____

(A) Send	11-12	9-11	12-13	10-12	11-13			CAL				
(B) Receive	15-17.5	15-20	17.5-20	17.5-22.5	20-25			9-10				
(C) ~~n separation~~ a-Spacing	250	500	250	500	500							
(D) I	0.3	0.6	0.6	0.3	0.9			0.6				
(E) ρdc (avg)	41.8	58.9	84.7	28.3	84.1			60.25				
(F) DCcal	.996											
(G) Kn x 10^{-3}	.75	1.5	.75	1.5	1.5							
(H) ρdc=ExFxGx10^3/D	104	147	105	141	140			606				
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρdc/ρac =ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

HEINRICHS GEOEXPLORATION CO.

I. P. SENDER NOTES

PROJECT Ramsey 403-64

LINE 1 ~~HALF~~ 5 1/2 SP. 3 DATE 12-6

PAGE 1

SEND	1-3	2-4	1-2	3-5	2-3	4-6	3-4	5-7	4-5	6-8
RECEIVE	25-20	22.5-17.5	20.-17.5	20-15	17.5-15	17.5-12.5	15.0-12.5	15-10	12.5-10.	12-5-7.5
RANGE	500'	500'	250'	500'	250'	500'	250'	500'	250'	500'
VOLTAGE	765 LO	765 LO	780 LO	820 LO	830 LO	590 LO	630 LO	670 LO	710 LO	750 LO
CURRENT	1Amp	1Amp	0.9A	0.9A	0.9A	1Amp	1Amp	0.6A	1Amp	1Amp
SEND	5-6	7-9	6-7	8-10	7-8	9-11	8-9	10-12	9-20	11-13
RECEIVE	10.75	10-5.0	7.5-5.0	7.5-2.5	5.0 2.5	5.0-0	2.5-0	2.5-2.5	0-2.5	0-500
RANGE	250'	500'	250'	500'	250'	500'	250'	500'	250'	500'
VOLTAGE	730 LO	660 LO	860 LO	790 LO	860 LO	560 LO	760 LO	610 LO	860 LO	800 LO
CURRENT	0.9A	0.6A	0.9A	0.9A	0.9A	0.3A	0.9A	0.6A	0.9A	0.3

FREQUENCIES ~~—~~ 0.1

SENDER NO. 13671-5

OPERATOR M. Critch

RECEIVER NO.

OPERATOR Jim B.

COMMENTS:

CHL 5-7

CAL 9-10

PAGE 2

HEINRICHS GEOEXPLORATION CO.

I. P. SENDER NOTES

PROJECT Ramsey 403-6-9

LINE 1 HALF N/2 SP. 3 DATE 12-6

SEND	10-11	4-6	11-12	5-7	12-13	6-8	9-10	7-9	10-11	8-10
RECEIVE	2.5-5.0	2.5-7.5	5.0-7.5	5.0-10.0	7.5-10	7.5-12.5	10-12.5	10.0-15.	12.5-15.0	12.5-17.5
RANGE	250'	500'	250'	500'	250'	500'	250'	500'	250'	500'
VOLTAGE	560LO	570LO	570LO	660LO	540LO	710LO	860LO	650LO	560LO	830 LO
CURRENT	0.3A	1.0Amp	0.3A	0.6A	0.3	1AMP	0.9A.	0.6A	0.3A	1.0A
SEND	11-12	9-11	12-13	10-12	11-13		CAL	CAL		
RECEIVE	15.0 17.5	15.0-20	17.5-20	17.5-22.5	20-25		5-7	9-10		
RANGE	250'	500'	250'	500'	500'		500'	250'		
VOLTAGE	570LO	550LO	540LO	880LO	790LO		650	560LO		
CURRENT	0.3A	0.3	0.3	0.9	0.3		0.6A	0.6A		

FREQUENCIES 0.1

SENDER NO. 13671-5

OPERATOR M. Cital

RECEIVER NO.

OPERATOR Jim B.

COMMENTS:

HEINRICHS GEOEXPLORATION CO.
I.P. RECEIVER NOTES

PROJECT Ramsey #403
LINE 1 ~~HALF~~ SP. 3 DATE June 12-69

SEND	(500')	(500')	(250')	(500')	(250')	500'	(250')	(500')	(250')	(500')
RECEIVE	2500	2250	2000	2000	1750'	1750'	1500	1500	1250'	1250'
RANGE	300	300	300	100	300	300	300	100	300	100
DC 1	126	107	134	99.5	147	117	153	67.0	158	63.8
DC 2	119	104	131	100.0	150	113	154	68.3	161	63.0
DC 3	120	107	134	99.5	147	117	154	66.5	158	64.4
DC 4	119	104	131	100.0	151	113	153	68.7	161	62.6
DC 5				262	145		155	66.0		64.7
DC 6				251	152		152	69.1		62.4
DC 7					144		156	65.7		65.0
DC 8					153		152	69.5		62.0
DC AVG.										
AC 1										
AC 2										
AC AVG.										
S.P.										
AC NOISE										
POT RES.										

HEINRICHS GEOEXPLORATION CO.

I.P. RECEIVER NOTES

PROJECT Ramsey #403

LINE 1 HALF ~~#~~S SP. 3 DATE 4/12/69

SEND	250'	(500')	(250')	(500')	(250)	(500)	(250'	(500')	(250')	(500')
RECEIVE	1000'	1000'	750	750	500	500	250'	250'	0	0
RANGE	300	100	100	100	100	30	300	100	300	100
DC 1	177	42.9	82.1	45.1	53.9	29.4	141	84.0	152	40.0
DC 2	161	38.5	82.9	45.2	51.5	30.4	147	81.7	155	40.8
DC 3	177	43.6	82.2	44.5	54.5	28.9	141	84.4	152	38.9
DC 4	161	38.1	82.9	45.6	50.2	30.8	147	80.8	155	41.8
DC 5		43.8	82.1	43.9	55.7	29.0		85.1		38.5
DC 6		37.8	83.0	46.0	49.8	30.6		80.1		42.0
DC 7		44.2	82.1	43.8	56.2	29.1		85.8		38.1
DC 8		37.2	83.0	46.1	49.5	30.4		79.8		42.5
DC AVG.										
AC 1										
AC 2										
AC AVG.										
S.P.										
AC NOISE										
POT RES.										

HEINRICHS GEOEXPLORATION CO.

I.P. RECEIVER NOTES

PROJECT Ramsey 403

LINE 1 HALF N SP. 3 DATE 6/12/69

SEND	(250)'	(500)	(250)	(500)	(250)	(500)	(250)	(500)	(250)	(500)
RECEIVE	250	250	500	500	750	750	1000	1000	1250	1250
RANGE	100	100	100	100	100	300	300	100	100	300
DC 1	45.3	49.2	45.8	59.2	42.6	139	141	86.0	47.6	140
DC 2	48.1	50.1	45.7	60.6	48.2	136	144	83.5	45.1	147
DC 3	45.0	49.1	45.9	58.8	41.7	139	139	86.5	48.0	138
DC 4	48.1	50.2	45.5	61.7	48.7	136	146	82.8	44.6	148
DC 5	44.7	48.7	45.9	57.8	41.0		138	87.4	48.7	138
DC 6	48.3	50.5	45.6	62.0	49.0		147	82.1	44.1	149
DC 7	45.8	48.2	46.0	57.8	40.8		137	88.1	49.0	137
DC 8	47.8	50.8	45.4	62.2	49.7		148	81.8	43.8	150
DC AVG.										
AC 1										
AC 2										
AC AVG.										
S.P.										
AC NOISE										
POT RES.										

HEINRICHS GEOEXPLORATION CO.

I.P. RECEIVER NOTES

PROJECT Ramsey 403

LINE 1 HALF N SP. 3 DATE 4/12/69

SEND	(250')	(500')	(250')	(500')	(500')		CAL 1	CAL 2		
RECEIVE	1500	1500	1750	1750	2000		500' S(5)	500' N(9)		
RANGE	100	100	300	300	100		100	100		
DC 1	62.8	57.5	106	177	53.0		62.7	60.5		
DC 2	59.8	56.9	113	177	47.7		62.1	60.7		
DC 3	62.6	57.3	104	177	53.7		62.7	60.5		
DC 4	59.9	57.6	115	177	46.9		62.1	60.7		
DC 5	63.0	57.1	104		54.0					
DC 6	59.2	57.8	115		47.0					
DC 7	63.1	56.9			54.1					
DC 8	59.1	58.1			46.7					
DC AVG.		56.7			54.3					
AC 1										
AC 2										
AC AVG.										
S.P.										
AC NOISE										
POT RES.										

HEINRICHS GEOEXPLORATION COMPANY

INDUCED POLARIZATION SURVEY COMPUTATION SHEET

Page 2

Project 403-69 Line 1-503 N½ Field date 6-12-69 Data page 3 Comp. date _____. Comp by Critch

(A) Send	10-11	4-6	11-12	5-7	12-13	6-8	9-10	7-9	10-11	8-10		
(B) Receive	2.5-5.0	2.5-7.5	5.0-7.5	5.0-10	7.5-10	7.5-12.5	10-12.5	10-15	12.5-15	12.5-17.5		
(C) ~~n separation~~ a spacing	250	500	250	500	250	500	250	500	250	500		
(D) I	0.3	1.0	0.3	0.6	0.3	1.0	0.9	0.6	0.3	1.0		
(E) Vdc (avg)	46.6	49.6	45.7	60	45	137.5	142.5	84.8	46.4	143		
(F) DCcal	.991											
(G) Kn x 10^{-3}	.75	1.5	.75	1.5	.75	1.5	.75	1.5	.75	1.5		
(H) ρdc=ExFxGx10^3/D	115	74	113	149	111	204	118	210	115	212		
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρ dc/ρac=ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

Project _____ Line _____ Field date _____ Data page 4 Comp. date _____ Comp by _____

(A) Send	11-12	9-11	12-13	10-12	11-13			CAL				
(B) Receive	15-17.5	15-20	17.5-20	17.5-22.5	20-25			9-10				
(C) n separation	250'	500'	250'	500'	500'							
(D) I	0.3	0.3	0.3	0.9	0.3			0.6				
(E) Vdc (avg)	61.2	57.3	109.5	177	50.8							
(F) DCcal	.991											
(G) Kn x 10^{-3}	.75	1.5	.75	1.5	1.5			60.6				
(H) ρ dc=ExFxGx10^3/D	152	284	271	292	251							
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρdc/ρac =ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

250' = .75
500' = 1.5

HEINRICHS GEOEXPLORATION COMPANY
INDUCED POLARIZATION SURVEY COMPUTATION SHEET

Page 1

Project 403-69 Ramsey Line 1-Sp.3 Field date 6-12-69 Data page 1 Comp. date _____. Comp by CRITCH

(A) Send	1-3	2-4	1-2	3-5	2-3	4-6	3-4	5-7	4-5	6-8		
(B) Receive	25-20 S	22.5-17.5	20-17.5	20-15 S	17.5-15	17.5-12.5	15-12.5	15-10	12.5-10	12.5-7.5		
(C) ~~n separation~~ a-Spacing	500'	500'	250'	500'	250'	500'	250'	500'	250'	500'		
(D) I	1.0	1.0	0.9	0.9	0.9	1.0	1.0	0.6	1.0	1.0		
(E) Vdc (avg)	119.5	105.5	136.5	99.75	148.6	115	153.6	67.6	159.5	63.4		
(F) DCcal	.96153											
(G) Kn x 10^{-3}	1.5	1.5	.75	1.5	.75	1.5	.75	1.5	.75	1.5		
(H) ρ dc=ExFxGx10^3/D	172	152	109	160	119	166	111	162	115	91		
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρ dc/ρac=ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

STA 17.5 S 15

Project _____ Line _____ Field date _____ Data page 2 Comp. date _____ Comp by _____

(A) Send	5-6	7-9	6-7	8-10	7-8	9-11	8-9	10-12	CBL		9-10	11-13
(B) Receive	10-7.5	10-5.0	7.5-5.0	7.5-2.5	5.0-2.5	5.0-0.0	2.5-0.0	2.55-.25M	5-7		0-2.5	0-5.0
(C) ~~n separation~~ a Spacing	250'	500'	250'	500'	250'	500'	250'	500'	500'		250'	500'
(D) I	0.9	0.6	0.9	0.9	0.9	0.3	0.9	0.6	0.6		0.9	0.3
(E) ρdc (avg)	172	40.8	82.5	45.0	52.7	29.8	144	82.7	62.4		153.5	40.3
(F) DCcal	.96153								.96153		.991	
(G) Kn x 10^{-3}	.75	1.5	.75	1.5	.75	1.5	.75	1.5			.75	1.5
(H) ρ dc=ExFxGx10^3/D	139	98	66	72	42	143	115	199			128	200
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρdc/ρac =ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

Exp #1

PAGE 1

HEINRICHS GEOEXPLORATION CO.

I.P. RECEIVER NOTES

PROJECT RAMSEY - #403

LINE 1 HALF ___ SP. 1 DATE 10 JUNE 1969

SEND	1	2	3	4	5	6	7	8	9	10
RECEIVE	5	10	15	20						
RANGE	3000	3000	3000	3000	1000	1000	.300	.300	.300	.300
DC 1	2190	1850	1320	1170	962	972	203	173	130	132
DC 2	2200	1790	1340	1170	962	980	216	174	127	130
DC 3	2190	1850	1320	1170	962	972	208	173	130	132
DC 4	2200	1799	1340	1170	962	970	213	174	127	131
DC 5							207			131
DC 6							212			130
DC 7							208			132
DC 8							211			130
DC AVG.							208			132
AC 1							210			129
AC 2										132
AC AVG.										
S.P.	-29.9	-30.1								
AC NOISE	440V H	420V H	495V H	345V H	400V H	530V H	400V H	305V H	175V H	530V H
POT RES.	.14	.24	.24	.24	.24	.24	.24	.24	.24	.24

HEINRICHS GEOEXPLORATION CO.

I.P. RECEIVER NOTES

PROJECT Ramsey 403

LINE 1 HALF ___ SP. ___ DATE ___

SEND	11	12	13	14				CAL 1		
RECEIVE	.300									
RANGE		.300	.300	.300						
DC 1	177	167	117	203				3.79		
DC 2	172	158	117	204				3.79		
DC 3	177	167	117	202				3.79		
DC 4	172	158	116	204				3.79		
DC 5			117	202						
DC 6			116	204						
DC 7				202						
DC 8				205						
DC AVG.										
AC 1										
AC 2										
AC AVG.										
S.P.										
AC NOISE	380V H	305V H	180V H	280V H				800V L		
POT RES.	.34	.34	.34	.72				.35		

Wenner Depth probe #1 V/I x 2

HEINRICHS GEOEXPLORATION COMPANY

INDUCED POLARIZATION SURVEY COMPUTATION SHEET

Page 1

Project 403-69 Ramsey Line 1 Spr 1 Field date 6/10/69 Data page 1 Comp. date _____. Comp by Critch

(A) Send	1	2	3	4	5	6	7	8	9	10		CAL
(B) Receive	5'	10'	15'	20'	30'	50'	75'	100'	150'	200'		
(C) n separation												
(D) I	.14	.24	.24	.24	.24	.24	.24	.24	.24	.24		.35
(E) Vdc (avg)	2195	1820	1330	1170	962	971	209.2	173.5	128.5	131		379
(F) DCcal	0.923											.92398
(G) Kn x 10^{-3}												
(H) ρ dc=ExFxGx10^3/D V/I x2	72.0	70	77	90	111	187	60	67	74	101		
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρ dc/ρac=ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

Project _____ Line _____ Field date _____ Data page 2 Comp. date _____ Comp by _____

(A) Send	11	12	13	14								
(B) Receive	300'	500'	750'	1000'								
(C) n separation												
(D) I	.34	.34	.34	.72								
(E) Vdc (avg)	174.5	162.5	117	203								
(F) DCcal	0.923											
(G) Kn x 10^{-3}												
(H) ρ dc=ExFxGx10^3/D	142	221	238	260								
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρdc/ρac =ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

HEINRICHS GEOEXPLORATION CO.

I.P. RECEIVER NOTES

Ex #2

PROJECT Ramsey - #903

LINE 1 HALF ___ SP. 2 DATE ___

SEND	1	2	3	~~3~~ 5	~~5~~ 6	~~6~~ 7	~~7~~ 8	~~8~~ 9	~~9~~ 10	~~10~~ 11
RECEIVE										
RANGE	3000	3000	1000	1000	1000	1000	300	300	300	
DC 1	2150	1280	698	492	371	305	272	182	112	106
DC 2	2170	1260	697	499	358	304	267	179	117	105
DC 3	2150	1280	699	492	372	305	272	182	112	106
DC 4	2170	1260	696	499	357	304	267	179	117	106
DC 5			700		372					105
DC 6			695		357					107
DC 7			700		372					104
DC 8			695		357					107
DC AVG.			700							
AC 1										
AC 2										
AC AVG.										
S.P.										
AC NOISE	180VH	325VH	400VH	390VH	710VL	400L	400L	750L	630L	800L
POT RES.	.2	.3	.2	.2	.2	.225	.25	.325	.225	.24

HEINRICHS GEOEXPLORATION CO.

I.P. RECEIVER NOTES

PROJECT Ramsey #403

LINE 1 HALF SP. 2 DATE

SEND	#12	#13	#14	#4					CAL 1	
RECEIVE										
RANGE	300	100	300	1000					25.8	
DC 1	101	78.1	103	259					25.9	
DC 2	101	77.2	105	258					25.8	
DC 3	101	79.1	103	260					25.9	
DC 4	101	76.3	105	258						
DC 5		79.7		260						
DC 6		75.8								
DC 7		80.3								
DC 8		74.7								
DC AVG.										
AC 1										
AC 2										
AC AVG.										
S.P.										
AC NOISE	570 L	690 L	730 L	540 L					745 L	
POT RES.	.125	.225	.325	.1					.25	

Wenner Depth Probe #2 V/I x a

HEINRICHS GEOEXPLORATION COMPANY
INDUCED POLARIZATION SURVEY COMPUTATION SHEET

Page 1

Project (403-69) Ramsey Line 1 - Spr 2 Field date 6-11-69 Data page 1 Comp. date _____. Comp by Critch

(A) Send	1	2	3	4	5	6	7	8	9	10	11	CAL
(B) Receive	5'	10'	15'	20'	30'	50'	75'	100'	150'	200'		
(C) n separation												
(D) I	.2	.3	.2	.1	.2	.2	.225	.25	.325	.225		.25
(E) Vdc (avg)	2160	1270	697.7	259	495.5	364.5	304.5	269.5	180.5	114.5		25.85
(F) DCcal	.9671											
(G) Kn x 10^{-3}	2160	1270	697.7	259	495.5	364.5	304.5	269.5	180.5	114.5		
(H) ρdc=ExFxGx10^3/D	52	41	51	50	72	88	98	104	81	98		
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac(corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρ dc/ρac=ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												

Project _____ Line _____ Field date _____ Data page 2 Comp. date _____ Comp by _____

(A) Send	11	12	13	14								
(B) Receive	300'	500'	750'	1000'								
(C) n separation												
(D) I	.24	.25	.225	.325								
(E) Vdc (avg)	105.75	101	77.65	104								
(F) DCcal	.9671											
(G) Kn x 10^{-3}												
(H) ρ dc=ExFxGx10^3/D	128	195	250	309								
(I) Vac Σ												
(J) AC noise x 2												
(K) Vac (corr) = $\sqrt{I^2 - J^2}$												
(L) AC-DC cal.												
(M) ρdc/ρac =ExL/K												
(N) PFE=(M-1)(10^2)												
(O) MCF=(M-1)(10^5)/H												