Principal facts and preliminary interpretation for gravity profiles and continuous magnetometer profiles in Surprise Valley, California

By Andrew Griscom and Arthur Conradi, Jr.

U.S. Geological Survey

Open-file Report No. 76-260

1976

Introduction

These geophysical data were collected in order to investigate faults and thickness of alluvium near hot spring areas in the Surprise Valley area of northeastern California. Surprise Valley lies on the western edge of the Basin and Range province and appears to be a typical basin in a north-trending block-faulted structure. It is flanked on the west by the Warner Range, a westerly dipping block of Tertiary sediments and volcanic rocks and on the east (along the California-Nevada border) by the Hays Canyon Range, composed of similar rocks. Surprise Valley has no outlet and within the valley are three shallow alkali lakes, Lower, Middle, and Upper Alkali Lakes.

Simple Bouguer gravity anomaly values are reported here for 191 gravity stations in the Surprise Valley area. The stations are located between 41°35' and 41°42' north latitude and between 120°00' and 120°15' west longitude. The data provide six gravity profiles (Figs. 1 to 6) the location of which is shown in Fig. 7. In addition there is a gravity map of Surprise Valley, scale 1:62,500, by J. Gimlett (Fig. 8, sheets 1 and 2). This gravity map is part of an unpublished report and is available from the California Department of Water Resources at a scale of 1:31,250.

The magnetic data consist of 12 magnetic profiles (Figs. 9-13) collected with a continuously recording truck-mounted magnetometer. An index map (Fig. 14) shows the location of the profiles, which were collected in the general vicinity of the gravity profiles.

Gravity data

The gravity data were collected with LaCoste-Romberg Meter 130 along roads at a station spacing of 100-200 m. Elevations were surveyed with an alidade and are accurate to ± 0.7 m absolute and to ± 0.03 m relative to adjacent stations. The datum for each profile is a bench mark or spot elevation on the profile. Local terrain corrections relative to adjacent stations are negligible so that relative accuracy of adjacent stations is about ± 0.03 mgal. The stations are referenced to the Alturas Base Station 14 of Chapman (1966, p. 18).

Gravity data format

The principal facts for all 191 gravity stations are listed in table 1. Each data column is described below.

1. STATION column - An alphanumeric combination of up to 5 characters used for station identification.
2. LATITUDE and LONGITUDE columns - Values are listed in degrees and minutes to the nearest hundredth of a minute. These values were determined from U.S. Geological Survey topographic quadrangle maps at a scale of 1:24,000. Values were checked for errors by obtaining a computer plot of the stations and comparing this to the hand-plotted stations.
3. ELEV. column - The station elevation is in feet to the nearest tenth.
4. OBSV. GRAV. column - Each station's observed gravity value is reported to the nearest hundredth of a milligal.
5. THEO-GRAV column - The theoretical gravity value for each station is determined by the formulae given under number 6.

6. <u>FAA column</u> - The free air gravity anomaly values for each station are listed to the nearest hundredth of a milligal. The formula used in calculating these values is:

$$FAA = OG - TG + (.09411549 - .000137789 \sin^2\theta)E - .0000000067E^2$$

where FAA is the free air anomaly in milligals

O.G. is the observed gravity in milligals

T.G. is the theoretical gravity in milligals

obtained by the International Gravity Formula of 1950

$$TG = 978049[1 + .0052884 \sin^2\theta - .0000059 \sin^2(2\theta)]$$

θ is latitude

E is elevation in feet.

7. <u>BA1 column</u> - The listed simple Bouguer anomaly values were determined to the nearest hundredth of a milligal for a crustal density of 2.67 g/cm^3 according to the formula:

$$BA1 = FAA - .012774 \times 2.67E$$

8. The remaining columns (CC, TC, CBA1, CBA2) relate to the calculation of terrain corrections and therefore are irrelevant to this report, being artifacts of the computer program.

Preliminary gravity interpretation

After reduction to simple Bouguer anomalies, the gravity profiles provide us with information on the distribution of rock masses with various densities beneath the surface. The steep gravity gradient down to the east in the profiles on the west side of the valley is the result of the large thick mass of low-density valley fill in the center of Surprise Valley. Superimposed on this gradient are various smaller features of geologic significance. Inflection points are likely to be the location of concealed faults and such features are identified on the profiles.

Of considerable interest are the small gravity highs (0.5 mgal) associated with faults on profiles 1, 2, and 3 (Fig. 1, 2, and 3, respectively). The phrase, "FAULT(?)", indicates a fault deduced from the gravity profile. The features are only 500 to 1000 feet (150 to 300 m) wide and, because of their small width and narrow marginal gradients, must be caused by density differences within 300 to 500 feet (100 to 150 m) of the surface. The association of these anomalies exclusively with faults containing hot waters suggests that the high are caused by partial cementation of the alluvium at the faults which increases the alluvium density by filling some of the pore space with silica or calcium carbonate. The results indicate that in some areas detailed gravity profiles can be used to follow faults through areas of thick alluvium if there are hot saline waters depositing material in the pore space of the alluvium.

Also noted on the gravity profiles are faults taken from plate 2I of Bulletin 98 of the California Department of Water Resources (1963). Some of these faults have no expression on the gravity profiles and must be either very minor or nonexistent. On profile 2 (Fig. 2) at Lake City the Surprise Valley Fault is crossed without even an inflection of 0.1 mgal. Vertical offset of only 100 feet (30 m) in a shallow concealed fault at this location would cause an effect of at least 0.6 mgal (for density contrast of 0.5 g/cm^3) so that the fault cannot exist here.

Conclusions

1. Small gravity highs are associated with faults containing hot saline water and are probably caused by local density increase due to cementation of alluvium.
2. Such gravity highs may be useful guides to hot saline water circulating in areas of thick alluvium.
3. Small gravity highs over the Lake City fault in the center of the valley suggest that the fault contains hot saline water and that the fault acts as a connection between the hot spring areas on the east and west sides of the valley.
4. Inflection points on gravity profiles confirm the existence of previously deduced faults.
5. Lack of inflection points on certain gravity profiles deny the existence of previously deduced faults, especially the Surprise Valley Fault near Lake City.

Gravity map

The gravity map, Fig. 8, sheets 1 and 2, was surveyed by J. I. Gimlett for the California Department of Water Resources in 1960 and is unpublished. Details of the survey are described in Bulletin 98, California Department of Water Resources (1963). The data are simple Bouguer anomalies but the lack of terrain corrections is not particularly important because much of Surprise Valley is extremely level. Gimlett calculated various two-dimensional gravity profiles across the valley in order to locate concealed faults and to determine the depth of the valley fill. Geologic cross-sections based upon these calculated profiles were published in

Bulletin 98 as figures 20 and 21. A manuscript basement contour map was prepared by Gimlett but is not available at present from the California Division of Water Resources, although the inferred faults are shown in plate 21 of Bulletin 98, California Department of Water Resources (1963).

Magnetic profiles

The magnetic profiles were collected along roads by a continuously recording truck-mounted flux-gate magnetometer mounted approximately 13 ft (4 m) above the ground. The data tapes are photographically reduced to a scale of approximately 1:70,500 so that they may be compared easily with the traverse map Fig. 14 (scale 1:62,500). Full scale on the tapes (i.e., from 1 to 11) is 2000 gammas. Location points are the hand-numbered tic marks on the pen tracing along the top of the tapes and are also plotted on the traverse map.

Occasional datum shifts on the magnetic profiles are necessary in order that the recorder stay on scale and are indicated on the records by a four-digit push-button setting (pbs) number. The first digit refers to the number of 2000-gamma increments which have been added to the basic instrument datum level (48,4000 gammas); the second digit refers to the number of 400-gamma increments; the third digit refers to the number of 100-gamma increments; and the fourth digit refers to the number of 20-gamma increments. The sum of the four products (increment value times number of increments) added to the basic instrument datum (48,400 gammas) gives the approximate absolute value of the earth's field when added in turn to the reading on the tape trace.

The magnetic records, in addition to the magnetic effects of nearby rocks, document a variety of man-made magnetic anomalies. Anomalies of the latter type include culverts, bridges, vehicles, certain fences, water pipes, etc. In general such anomalies are distinguished as a very sharp, short-wavelength spike which may be positive or negative depending on the relative locations of source and magnetometer. The instrument operator crossed out or flagged most of these man-made features on the record, at the time of the magnetic survey, but man-made effects can totally obscure the natural magnetic record, especially near or in towns and cities (see Fig. 9 showing effects at Cedarville and Lake City).

The highly magnetic Tertiary volcanic rocks which form the surrounding mountains of Surprise Valley also underlie the non-magnetic alluvium and lake deposits of the valley itself. Where this alluvial material is more than a few hundred feet thick, the effect of the underlying magnetic volcanic rocks is subdued so that only the longer wavelength magnetic anomalies are perceived on the record. Thus an abrupt change from a jagged short-wavelength record to a smooth record implies a sudden change of the position of the volcanic rocks from a near-surface location to one of considerable depth. Such an abrupt change is therefore considered to be good evidence for a steeply dipping fault contact. A more gradual change from rough to smooth record is for similar reasons interpreted as a gently dipping contact, more likely a depositional contact of alluvium on volcanic rocks.

The magnetic profiles have been annotated to indicate the interpreted faults and contacts. A careful study of the geophysically located contacts shows in general a reasonably good agreement with the known geology but also shows some places where the contacts on the geologic map (Bulletin 98, plate 21, California Department of Water Resources) can be better located or, in a few cases, where they are incorrect.

Another type of magnetic feature is observed on the magnetic records taken over areas of thick alluvium in the center of the valley. The alluvium that came from the west side of the valley has a higher amplitude magnetic "noise" associated with it than that of the eastern alluvium. The explanation is not clear but perhaps there are magnetic boulders of volcanic rock near the surface of the western alluvium.

A different and very significant area of magnetic "noise" can be observed on the magnetic record of traverse S-4 (Fig. 10, documentation point 5) in the area where the traverse crosses the Lake City fault. These small magnetic anomalies are associated with an area of small gravity anomalies and are caused by minor amounts of magnetic minerals at depths of less than 200 feet in the alluvium. The associations indicate that perhaps chemical reactions of the hot saline waters have generated these small amounts of magnetic minerals near the fault in the otherwise non-magnetic alluvium. Such anomalies could be used to trace the fault zone across the valley. The data suggest that the Lake City fault in the alluvium is actually a zone about 2000 feet wide.

Conclusions

1. Traverses across Lake City Fault (Traverse S-4, Fig. 10) in the center of valley indicate several minor shallow magnetic features and noise which are associated with minor gravity anomalies. It

is suspected that chemical reactions of the hot saline waters have generated minor local amounts of magnetic minerals in the otherwise non-magnetic alluvium near the faults. The data suggest that the Lake City fault is actually a zone about 2000 feet wide with at least two major strands. Another similar area of noise is observed on traverse S-3, Fig. 10, and is not located on a known fault.

2. Alluvium on the west side of the valley is "noisier" magnetically. See traverses S-4, S-11, and S-12, Figs. 10 and 13. Perhaps this alluvium contains magnetic boulders.

3. Various faults, especially on the east side of the valley, are visible in the magnetic records and in general confirm the geologic map.

    a. The faults on each side of the narrow buried horst of volcanic rocks extending south for 15 miles along the east side of Middle Alkali Lake are clearly defined in traverse S-9, Fig. 12.

    b. Several crossings of the southeast extension of the Lake City fault (east of Surprise Valley) indicate the presence of this fault on the magnetic record of traverse S-9, Fig. 12.

    c. The fault shown on the geologic map as defining the west edge of the small horst of exposed volcanic rocks at the radio facility probably does not exist and in any event does not offset the contact between alluvium and volcanic rocks. The magnetic data (and also the gravity data) show that the more significant contact lies some 1600 feet farther west and dips west at a sufficiently low angle to imply a sedimentary rather than a fault contact between the alluvium and volcanic rocks.

References Cited

California Department of Water Resources, 1963, Northeastern counties groundwater investigation: Bulletin 98, various pages.

Chapman, R. H., 1966, Gravity base station network: California Div. Mines and Geology, Spec. Rept. 90, 49 p.

List of Figures

Table 1. Principal facts for 191 gravity stations in the Surprise Valley area, northeast California.

SURPRISE VALLEY CAL 1975 JAN2310003

CHAPMAN 148 GRV 979887.95 METER 130 READING 3583.89 T+D -0.05 D1 2.67 D2 2.27

STA	LATITUDE	LONGITUDE	ELEV	READING	T+D	OBSV-GRAV	THEO-GRAV	FAA	BA1	CC	TC	CBA1	CBA2
19CGM	41 37.87	120 7.13	4547.2	3570.07	-0.07	979873.42	980326.05	-25.10	-180.19	1.36	0.00	-181.54	-158.10
LAKEC	41 38.72	120 13.02	4618.0	3587.13	-0.07	979891.34	980327.32	-1.79	-159.29	1.37	0.00	-160.65	-136.85
MILL1	41 38.68	120 13.02	4699.0	3582.10	-0.08	979886.04	980327.26	0.60	-159.68	1.38	0.00	-161.05	-136.83
MILL2	41 38.69	120 12.95	4821.0	3575.92	-0.08	979879.55	980327.28	5.56	-158.88	1.39	0.00	-160.27	-135.42
MILL3	41 38.70	120 12.89	4901.0	3571.10	-0.08	979874.49	980327.29	8.00	-159.17	1.40	0.00	-160.56	-135.31
MILL4	41 38.71	120 12.78	4980.0	3566.29	-0.08	979869.43	980327.31	10.36	-159.50	1.41	0.00	-160.91	-135.26
MILL5	41 38.72	120 12.71	5120.0	3558.46	-0.08	979861.21	980327.32	15.27	-159.36	1.43	0.00	-160.79	-134.41
1BOGG	41 39.43	120 2.88	5494.0	3523.10	-0.03	979824.11	980328.38	12.26	-175.13	1.47	0.00	-176.59	-148.30

SURPRISE VALLEY CAL 1975 JAN2410003

CHAPMAN 14H GBV 979887.95 METER 110 READING 3583.49 T+D -0.05 D1 2.67 D2 2.27

STA	LATITUDE		LONGITUDE		ELEV	READING	T+D	OBSV-GRAV	THEO-GRAV	FAA	BA1	CC	TC	CBA1	CBA2
19CGM	41	37.87	120	7.13	4547.2	3570.08	-0.06	979873.44	980326.05	-25.08	-180.17	1.36	0.00	-181.52	-158.08
15F01	41	37.88	120	7.04	4559.5	3569.77	-0.09	979873.08	980326.07	-24.29	-179.80	1.36	0.00	-181.15	-157.65
15E02	41	37.88	120	6.95	4570.9	3569.54	-0.09	979872.84	980326.07	-23.46	-179.36	1.36	0.00	-180.71	-157.15
15E03	41	37.91	120	6.83	4577.6	3569.69	-0.09	979873.00	980326.11	-22.72	-178.84	1.36	0.00	-180.20	-156.61
15E04	41	37.93	120	6.73	4585.0	3569.69	-0.09	979873.00	980326.14	-22.05	-178.43	1.36	0.00	-179.79	-156.16
15E05	41	37.94	120	6.66	4589.1	3570.05	-0.09	979873.37	980326.16	-21.30	-177.82	1.36	0.00	-179.18	-155.53
15E06	41	37.96	120	6.57	4592.4	3570.42	-0.09	979873.76	980326.19	-20.63	-177.27	1.36	0.00	-178.62	-154.95
15E07	41	37.98	120	6.49	4602.4	3570.47	-0.09	979873.82	980326.22	-19.67	-176.64	1.36	0.00	-178.00	-154.28
15E08	41	38.00	120	6.40	4614.6	3570.41	-0.09	979873.75	980326.25	-18.62	-176.01	1.37	0.00	-177.37	-153.58
15E09	41	38.02	120	6.32	4624.4	3570.44	-0.09	979873.78	980326.28	-17.70	-175.42	1.37	0.00	-176.78	-152.95
15E10	41	38.03	120	6.24	4634.4	3570.58	-0.09	979873.93	980326.29	-16.62	-174.69	1.37	0.00	-176.05	-152.17
15E11	41	38.05	120	6.16	4649.2	3570.46	-0.09	979873.81	980326.32	-15.39	-173.96	1.37	0.00	-175.32	-151.36
15E12	41	38.07	120	6.08	4674.1	3569.45	-0.09	979872.74	980326.35	-14.14	-173.56	1.37	0.00	-174.92	-150.84
15E13	41	38.09	120	6.00	4691.8	3568.57	-0.09	979871.82	980326.38	-13.43	-173.45	1.38	0.00	-174.82	-150.64
15E14	41	38.12	120	5.92	4713.8	3567.59	-0.09	979870.79	980326.43	-12.44	-173.21	1.38	0.00	-174.58	-150.29
15E15	41	38.13	120	5.84	4731.9	3566.24	-0.09	979869.37	980326.44	-12.17	-173.56	1.38	0.00	-174.93	-150.55
15E16	41	38.16	120	5.76	4770.1	3564.89	-0.09	979867.95	980326.49	-10.04	-172.73	1.39	0.00	-174.11	-149.53
15E17	41	38.21	120	5.71	4775.0	3565.61	-0.09	979868.71	980326.56	-8.90	-171.76	1.39	0.00	-173.14	-148.53

SURPRISE VALLEY CAL 1975 JAN2510003

CHAPMAN 148 GRV 979887.95 METER 130 READING 3581.92 T+D -0.08 D1 2.67 D2 2.27

STA	LATITUDE	LONGITUDE	ELEV	READING	T+D	OBSV-GRAV	THEO-GRAV	FAA	BA1	CC	TC	CBA1	CBA2
15E18	41 38.29	120 5.63	4776.1	3566.46	-0.04	979869.65	980326.68	-7.97	-170.87	1.39	0.00	-172.25	-147.64
15E19	41 38.35	120 5.55	4789.4	3566.63	-0.04	979869.83	980326.77	-6.63	-169.98	1.39	0.00	-171.37	-146.69
15E20	41 38.38	120 5.42	4807.5	3565.52	-0.04	979868.66	980326.82	-6.14	-170.11	1.39	0.00	-171.50	-146.73
15E21	41 38.39	120 5.36	4820.9	3564.38	-0.04	979867.47	980326.83	-6.10	-170.52	1.39	0.00	-171.91	-147.07
15E22	41 38.42	120 5.23	4831.0	3563.56	-0.04	979866.60	980326.88	-6.05	-170.82	1.39	0.00	-172.21	-147.32
15E23	41 38.44	120 5.15	4859.7	3561.42	-0.04	979864.36	980326.90	-5.63	-171.38	1.40	0.00	-172.78	-147.74
15E24	41 38.48	120 5.02	4882.3	3559.86	-0.04	979862.72	980326.96	-5.21	-171.73	1.40	0.00	-173.12	-147.97
15E25	41 38.52	120 4.92	4888.6	3559.34	-0.04	979862.17	930327.02	-5.22	-171.96	1.40	0.00	-173.35	-148.17
15E26	41 38.55	120 4.85	4901.3	3558.43	-0.04	979861.21	980327.07	-5.03	-172.20	1.40	0.00	-173.60	-148.34
15E27	41 38.58	120 4.76	4915.5	3557.64	-0.05	979860.37	980327.11	-4.58	-172.23	1.41	0.00	-173.63	-148.31
15E28	41 38.60	120 4.69	4939.9	3556.19	-0.05	979858.85	980327.14	-3.84	-172.32	1.41	0.00	-173.73	-148.28
15E29	41 38.63	120 4.59	4946.9	3556.08	-0.07	979858.72	980327.19	-3.36	-172.08	1.41	0.00	-173.49	-148.00
15E30	41 38.67	120 4.48	4971.2	3554.68	-0.07	979857.25	980327.25	-2.61	-172.16	1.41	0.00	-173.57	-147.96
15E31	41 38.71	120 4.40	4979.3	3554.32	-0.07	979856.87	980327.31	-2.29	-172.11	1.41	0.00	-173.52	-147.87
15E32	41 38.73	120 4.32	4993.8	3553.50	-0.08	979856.00	980327.34	-1.82	-172.15	1.41	0.00	-173.56	-147.83
15E33	41 38.77	120 4.23	5009.6	3552.37	-0.08	979854.81	980327.40	-1.59	-172.45	1.42	0.00	-173.86	-148.05
15E34	41 38.79	120 4.16	5022.8	3551.00	-0.08	979853.37	980327.43	-1.82	-173.13	1.42	0.00	-174.54	-148.66
15E35	41 38.65	120 4.08	5068.2	3548.23	-0.09	979850.45	980327.52	-0.56	-173.42	1.42	0.00	-174.84	-148.73
15E36	41 38.92	120 4.05	5105.6	3546.33	-0.09	979848.45	980327.62	0.87	-173.28	1.43	0.00	-174.70	-148.40
15E37	41 38.98	120 4.01	5150.2	3543.85	-0.09	979845.85	980327.71	2.36	-173.30	1.43	0.00	-174.73	-148.20
15E38	41 39.03	120 3.95	5191.2	3541.55	-0.09	979843.43	980327.79	3.73	-173.34	1.44	0.00	-174.77	-148.03
15E39	41 39.10	120 3.90	5212.6	3540.62	-0.10	979842.44	980327.89	4.64	-173.15	1.44	0.00	-174.58	-147.73
SV001	41 39.16	120 3.85	5211.8	3540.73	-0.10	979842.56	980327.98	4.60	-173.17	1.44	0.00	-174.61	-147.76
SV003	41 38.50	120 4.33	4986.0	3554.01	-0.10	979856.51	980326.99	-1.70	-171.75	1.41	0.00	-173.16	-147.48
15W01	41 37.88	120 7.16	4545.0	3570.25	-0.09	979873.58	980326.07	-25.15	-180.16	1.36	0.00	-181.52	-158.09
15W02	41 37.88	120 7.25	4540.9	3570.15	-0.09	979873.48	980326.07	-25.64	-180.52	1.35	0.00	-181.86	-158.46
15W03	41 37.88	120 7.33	4536.8	3570.14	-0.09	979873.47	980326.07	-26.04	-180.77	1.35	0.00	-182.12	-158.74
15W04	41 37.88	120 7.43	4527.8	3570.50	-0.08	979873.86	980326.07	-26.49	-180.92	1.35	0.00	-182.27	-158.93
15W05	41 37.89	120 7.52	4523.2	3570.57	-0.08	979873.93	980326.08	-26.87	-181.14	1.35	0.00	-182.49	-159.17
15W06	41 37.89	120 7.62	4521.3	3570.66	-0.08	979874.02	980326.08	-26.95	-181.16	1.35	0.00	-182.50	-159.20
15W07	41 37.89	120 7.73	4518.9	3570.85	-0.08	979874.22	980326.08	-26.98	-181.10	1.35	0.00	-182.45	-159.16
15W08	41 37.89	120 7.83	4516.5	3571.10	-0.08	979874.49	980326.08	-26.94	-180.98	1.35	0.00	-182.33	-159.05
15W09	41 37.89	120 7.93	4513.7	3571.42	-0.07	979874.83	980326.08	-26.86	-180.81	1.35	0.00	-182.15	-158.89
15W10	41 37.89	120 8.01	4510.0	3571.77	-0.07	979875.20	980326.08	-26.84	-180.66	1.35	0.00	-182.00	-158.76
15W11	41 37.89	120 8.08	4512.3	3571.58	-0.07	979875.00	980326.08	-26.82	-180.72	1.35	0.00	-182.07	-158.81
15W12	41 37.89	120 8.15	4515.1	3571.14	-0.07	979874.54	980326.08	-27.02	-181.02	1.35	0.00	-182.36	-159.09
15W13	41 37.89	120 8.24	4515.6	3571.04	-0.07	979874.43	980326.08	-27.08	-181.09	1.35	0.00	-182.44	-159.16
15W14	41 37.89	120 8.34	4518.3	3570.89	-0.06	979874.29	980326.08	-26.97	-181.08	1.35	0.00	-182.42	-159.13
15W15	41 37.89	120 8.42	4518.7	3570.88	-0.06	979874.27	980326.08	-26.95	-181.06	1.35	0.00	-182.41	-159.12
15W16	41 37.89	120 8.50	4519.9	3570.88	-0.06	979874.27	980326.08	-26.83	-180.99	1.35	0.00	-182.34	-159.04

SURPRISE VALLEY CAL 1975 JAN2610003

CHAPMAN 14H GRV 979887.95 METER 130 READING 3583.85 T+D -0.10 D1 2.67 D2 2.27

STA	LATITUDE	LONGITUDE	ELEV	READING	T+D	OBSV-GRAV	THEO-GRAV	FAA	BA1	CC	TC	CBA1	CBA2
15W53	41 37.92	120 11.64	4549.0	3580.16	-0.06	979884.12	980326.13	-14.30	-169.45	1.36	0.00	-170.80	-147.35
15W52	41 37.91	120 11.57	4548.0	3579.67	-0.06	979883.60	980326.11	-14.89	-170.01	1.36	0.00	-171.36	-147.92
15W51	41 37.90	120 11.50	4548.4	3579.10	-0.06	979883.00	980326.10	-15.44	-170.57	1.36	0.00	-171.92	-148.48
15W50	41 37.90	120 11.42	4550.2	3578.56	-0.06	979882.44	980326.10	-15.84	-171.03	1.36	0.00	-172.38	-148.93
15W49	41 37.90	120 11.35	4550.9	3578.03	-0.06	979881.88	980326.10	-16.33	-171.54	1.36	0.00	-172.90	-149.44
15W48	41 37.90	120 11.22	4550.2	3577.16	-0.07	979880.96	980326.10	-17.32	-172.51	1.36	0.00	-173.86	-150.41
15W47	41 37.90	120 11.12	4549.3	3576.62	-0.07	979880.39	980326.10	-17.97	-173.13	1.36	0.00	-174.48	-151.03
15W46	41 37.90	120 11.02	4547.9	3576.03	-0.07	979879.77	980326.10	-18.72	-173.83	1.36	0.00	-175.19	-151.75
15W45	41 37.90	120 10.95	4547.0	3575.67	-0.07	979879.39	980326.10	-19.18	-174.27	1.36	0.00	-175.62	-152.18
MIL10	41 38.45	120 13.05	4658.0	3585.33	-0.11	979889.50	980326.92	0.55	-158.33	1.37	0.00	-159.70	-135.69
MILL9	41 38.48	120 13.00	4640.0	3586.14	-0.11	979890.35	980326.96	-0.35	-158.60	1.37	0.00	-159.97	-136.06
MILL8	41 38.50	120 12.93	4628.0	3587.14	-0.11	979891.40	980326.99	-0.46	-158.30	1.37	0.00	-159.66	-135.81
MILL7	41 38.51	120 12.86	4607.0	3587.88	-0.11	979892.18	980327.01	-1.67	-158.80	1.36	0.00	-160.16	-136.41
MILL6	41 38.51	120 12.78	4590.0	3588.23	-0.11	979892.55	980327.01	-2.90	-159.45	1.36	0.00	-160.80	-137.15
SV004	41 38.34	120 12.90	4623.0	3586.64	-0.11	979890.88	980326.76	-1.21	-158.89	1.37	0.00	-160.25	-136.42

SURPRISE VALLEY CAL 1975 JAN2710003

CHAPMAN 14H GBV 979897.95 METER 130 READING 3583.88 T+D -0.11 D1 2.67 D2 2.27

STA	LATITUDE	LONGITUDE	ELEV	READING	T+D	OBSV-GRAV	THEO-GRAV	FAA	BA1	CC	TC	CBA1	CBA2
LKC06	41 38.77	120 10.83	4483.1	3575.00	-0.08	979878.66	980327.40	-27.23	-180.13	1.35	0.00	-181.47	-158.36
LKC07	41 38.77	120 10.94	4487.5	3575.40	-0.08	979879.08	980327.40	-26.39	-179.45	1.35	0.00	-180.79	-157.66
LKC08	41 38.77	120 11.03	4486.8	3576.21	-0.07	979879.94	980327.40	-25.60	-178.63	1.35	0.00	-179.97	-156.84
LKC09	41 38.77	120 11.15	4486.7	3577.12	-0.07	979880.89	980327.40	-24.65	-177.68	1.35	0.00	-179.02	-155.89
LKC10	41 38.77	120 11.25	4487.5	3577.82	-0.07	979881.63	980327.40	-23.84	-176.89	1.35	0.00	-178.23	-155.10
LKC11	41 38.77	120 11.42	4493.8	3578.96	-0.07	979882.83	980327.40	-22.05	-175.32	1.35	0.00	-176.66	-153.50
LKC12	41 38.77	120 11.53	4495.8	3579.80	-0.06	979883.72	980327.40	-20.97	-174.31	1.35	0.00	-175.65	-152.48
LKC13	41 38.77	120 11.70	4499.3	3581.27	-0.06	979885.26	980327.40	-19.10	-172.55	1.35	0.00	-173.89	-150.70
LKC14	41 38.76	120 11.82	4501.3	3582.41	-0.06	979886.46	980327.38	-17.69	-171.22	1.35	0.00	-172.56	-149.36
LKC15	41 38.75	120 11.97	4505.0	3583.94	-0.06	979888.07	980327.37	-15.72	-169.37	1.35	0.00	-170.72	-147.50
LKC16	41 38.75	120 12.07	4506.5	3584.86	-0.05	979889.04	980327.37	-14.61	-168.31	1.35	0.00	-169.65	-146.43
LKC17	41 38.74	120 12.29	4515.6	3586.31	-0.05	979890.57	980327.35	-12.21	-166.23	1.35	0.00	-167.57	-144.30
LKC18	41 38.74	120 12.40	4525.2	3586.72	-0.05	979891.00	980327.35	-10.88	-165.22	1.35	0.00	-166.57	-143.24
LKC19	41 38.73	120 12.50	4533.6	3587.12	-0.04	979891.43	980327.34	-9.65	-164.27	1.35	0.00	-165.62	-142.25
LKC20	41 38.73	120 12.61	4544.2	3587.62	-0.04	979891.95	980327.34	-8.12	-163.11	1.36	0.00	-164.46	-141.04
LKC05	41 38.72	120 12.71	4558.0	3588.36	-0.03	979892.74	980327.32	-6.02	-161.48	1.36	0.00	-162.83	-139.34
LKC04	41 38.71	120 12.78	4566.6	3588.47	-0.03	979892.86	980327.31	-5.09	-160.84	1.36	0.00	-162.19	-138.65
LKC03	41 38.70	120 12.89	4584.3	3588.26	-0.03	979892.64	980327.29	-3.63	-159.98	1.36	0.00	-161.34	-137.71
LKC02	41 38.69	120 12.94	4595.9	3588.16	-0.03	979892.53	980327.28	-2.63	-159.38	1.36	0.00	-160.74	-137.05
LKC01	41 38.68	120 13.02	4614.8	3587.41	-0.03	979891.74	980327.26	-1.62	-159.02	1.37	0.00	-160.38	-136.60
F4459	41 40.52	120 12.00	4459.0	3586.31	-0.01	979890.61	980330.01	-20.15	-172.23	1.34	0.00	-173.57	-150.59
13E01	41 40.52	120 11.93	4455.5	3585.43	-0.01	979889.68	980330.01	-21.41	-173.37	1.34	0.00	-174.70	-151.74
13E02	41 40.52	120 11.91	4453.0	3584.55	-0.01	979888.76	980330.01	-22.57	-174.44	1.34	0.00	-175.78	-152.83
13W01	41 40.52	120 12.11	4461.6	3587.73	-0.01	979892.10	980330.01	-18.42	-170.59	1.34	0.00	-171.92	-148.93
13W02	41 40.52	120 12.22	4465.9	3589.15	-0.01	979893.59	980330.01	-16.52	-168.84	1.34	0.00	-170.17	-147.16
13W03	41 40.52	120 12.33	4474.4	3590.15	-0.01	979894.64	980330.01	-14.67	-167.28	1.34	0.00	-168.62	-145.55
13W04	41 40.52	120 12.42	4480.9	3591.21	-0.01	979895.76	980330.01	-12.95	-165.77	1.35	0.00	-167.11	-144.02
13W05	41 40.52	120 12.58	4496.6	3592.26	-0.02	979896.85	980330.01	-10.38	-163.74	1.35	0.00	-165.08	-141.91
13W06	41 40.52	120 12.75	4517.7	3592.67	-0.02	979897.28	980330.01	-7.96	-162.05	1.35	0.00	-163.39	-140.11
13W07	41 40.52	120 12.88	4539.9	3593.07	-0.02	979897.70	980330.01	-5.46	-160.30	1.35	0.00	-161.65	-138.25
13W08	41 40.52	120 12.97	4555.3	3593.45	-0.02	979898.10	980330.01	-3.61	-158.98	1.36	0.00	-160.33	-136.85
13W09	41 40.52	120 13.03	4569.7	3593.33	-0.03	979897.96	980330.01	-2.39	-158.25	1.36	0.00	-159.60	-136.05
15W16	41 37.89	120 8.50	4519.9	3570.95	-0.08	979874.40	980326.08	-26.71	-180.87	1.35	0.00	-182.21	-158.92
15W17	41 37.89	120 8.62	4523.2	3570.94	-0.08	979874.39	980326.08	-26.41	-180.68	1.35	0.00	-182.03	-158.71
15W18	41 37.89	120 8.70	4524.2	3571.04	-0.08	979874.50	980326.08	-26.21	-180.51	1.35	0.00	-181.86	-158.54
15W19	41 37.89	120 8.79	4527.5	3570.88	-0.08	979874.33	980326.08	-26.07	-180.48	1.35	0.00	-181.83	-158.50
15W20	41 37.89	120 8.88	4532.9	3570.46	-0.08	979873.89	980326.08	-26.00	-180.60	1.35	0.00	-181.95	-158.59
15W21	41 37.89	120 8.94	4533.4	3570.45	-0.09	979873.87	980326.08	-25.97	-180.59	1.35	0.00	-181.94	-158.57
15W22	41 37.89	120 9.07	4533.5	3570.50	-0.09	979873.92	980326.08	-25.91	-180.53	1.35	0.00	-181.88	-158.52
15W23	41 37.89	120 9.15	4538.1	3570.18	-0.09	979873.58	980326.08	-25.82	-180.59	1.35	0.00	-181.94	-158.55
15W24	41 37.89	120 9.23	4540.1	3570.02	-0.09	979873.41	980326.08	-25.80	-180.64	1.35	0.00	-181.99	-158.59
15W25	41 37.89	120 9.32	4544.4	3569.77	-0.09	979873.15	980326.08	-25.65	-180.65	1.36	0.00	-182.00	-158.58
15W26	41 37.89	120 9.40	4546.3	3569.72	-0.09	979873.10	980326.08	-25.53	-180.59	1.36	0.00	-181.94	-158.51
15W27	41 37.89	120 9.50	4548.7	3569.58	-0.10	979872.94	980326.08	-25.46	-180.60	1.36	0.00	-181.95	-158.51
15W28	41 37.89	120 9.58	4560.5	3569.59	-0.10	979872.95	980326.08	-25.28	-180.48	1.36	0.00	-181.83	-158.38
15W29	41 37.89	120 9.66	4551.7	3569.78	-0.10	979873.15	980326.08	-24.97	-180.21	1.36	0.00	-181.56	-158.10
15W30	41 37.89	120 9.75	4547.9	3570.21	-0.10	979873.60	980326.08	-24.87	-179.99	1.36	0.00	-181.34	-157.90
15W31	41 37.89	120 9.83	4544.1	3570.61	-0.10	979874.02	980326.08	-24.81	-179.79	1.36	0.00	-181.14	-157.72
15W32	41 37.89	120 9.92	4537.7	3571.34	-0.10	979874.79	980326.08	-24.64	-179.41	1.35	0.00	-180.76	-157.37
15W33	41 37.90	120 9.98	4531.5	3572.09	-0.10	979875.58	980326.10	-24.45	-179.01	1.35	0.00	-180.36	-157.00
15W34	41 37.90	120 10.08	4530.6	3572.54	-0.10	979876.05	980326.10	-24.07	-178.59	1.35	0.00	-179.94	-156.59
15W35	41 37.90	120 10.18	4531.7	3572.85	-0.10	979876.38	980326.10	-23.64	-178.20	1.35	0.00	-179.55	-156.19
15W36	41 37.90	120 10.27	4534.3	3573.05	-0.11	979876.58	980326.10	-23.19	-177.84	1.35	0.00	-179.19	-155.82
15W37	41 37.90	120 10.35	4535.4	3573.33	-0.11	979876.87	980326.10	-22.79	-177.48	1.35	0.00	-178.83	-155.45
15W38	41 37.90	120 10.41	4536.7	3573.53	-0.11	979877.08	980326.10	-22.46	-177.19	1.35	0.00	-178.54	-155.16

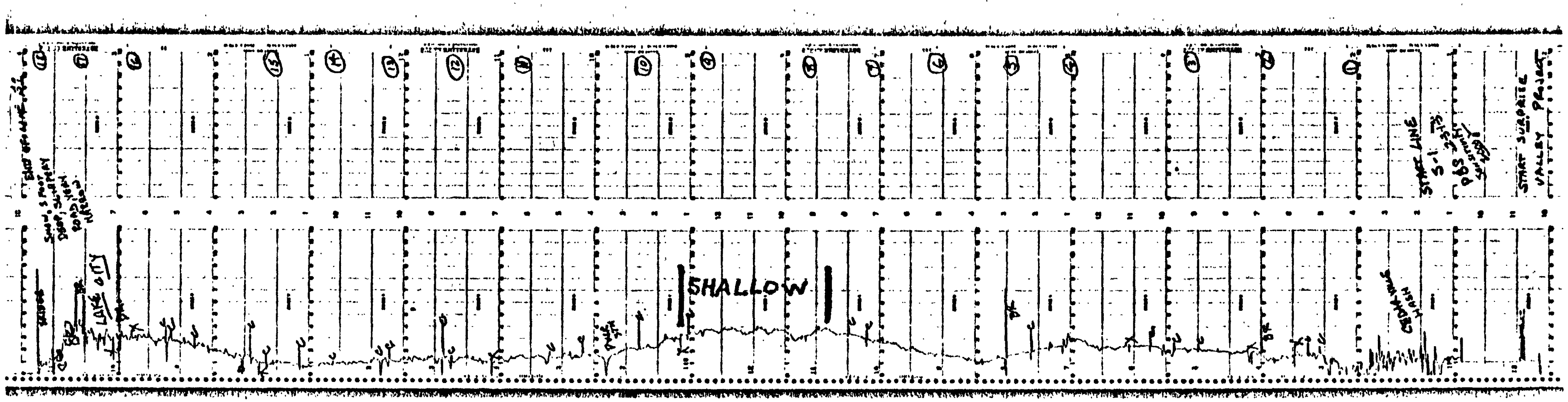
15W39	41	37.90	120	10.50	4537.9	3573.80	-0.11	979877.36	980326.10	-22.07	-176.84	1.35	0.00	-178.19	-154.80
15W40	41	37.90	120	10.58	4540.0	3574.13	-0.11	979877.71	980326.10	-21.52	-176.37	1.35	0.00	-177.72	-154.32
15W41	41	37.90	120	10.68	4543.5	3574.39	-0.11	979877.98	980326.10	-20.92	-175.88	1.35	0.00	-177.23	-153.82
15W42	41	37.90	120	10.75	4546.4	3574.66	-0.11	979878.27	980326.10	-20.36	-175.43	1.36	0.00	-176.78	-153.34
15W43	41	37.90	120	10.83	4547.8	3574.99	-0.11	979878.62	980326.10	-19.89	-175.00	1.36	0.00	-176.35	-152.91

6/7

SURPRISE VALLEY CAL 1975 JAN2810003

CHAPMAN 148 GBV 979887.95 METER 130 READING 3583.92 T+D -0.11 D1 2.67 D2 2.27

STA	LATITUDE	LONGITUDE	ELEV	READING	T+D	OBSV-GRAV	THEO-GRAV	FAA	BA1	CC	TC	CBA1	CBA2
SV005	41 33.73	121 16.20	6305.0	3483.74	-0.11	979782.71	980319.87	55.59	-159.46	1.51	0.00	-160.97	-128.53
SV006	41 36.97	120 12.45	4755.0	3579.37	-0.06	979883.22	980324.71	5.60	-156.59	1.38	0.00	-157.97	-133.47
SV007	41 36.60	120 12.31	4807.0	3576.67	-0.05	979880.40	980324.16	8.21	-155.75	1.39	0.00	-157.13	-132.37
SV008	41 36.36	120 12.22	4829.0	3575.13	-0.04	979878.79	980323.80	9.03	-155.68	1.39	0.00	-157.07	-132.19
SV009	41 36.10	120 12.03	4827.0	3575.08	-0.03	979879.59	980323.41	10.03	-154.61	1.39	0.00	-156.00	-131.13
SV010	41 36.15	120 11.40	4744.0	3576.12	-0.02	979879.85	980323.49	2.41	-159.40	1.38	0.00	-160.78	-136.33
SV011	41 36.15	120 10.83	4696.0	3574.58	-0.02	979878.23	980323.49	-3.72	-163.89	1.38	0.00	-165.26	-141.06
SV012	41 36.15	120 10.27	4573.0	3577.89	-0.01	979881.72	980323.49	-11.80	-167.77	1.36	0.00	-169.12	-145.55
SV013	41 36.16	120 9.69	4518.0	3575.68	-0.01	979879.40	980323.50	-19.30	-173.40	1.35	0.00	-174.74	-151.46
SV014	41 36.16	120 9.40	4508.0	3572.91	-0.01	979876.49	980323.50	-23.15	-176.91	1.35	0.00	-178.25	-155.02
SV015	41 36.17	120 8.82	4483.0	3569.72	0.00	979873.15	980323.52	-28.86	-181.76	1.35	0.00	-183.10	-159.99
SV016	41 36.15	120 8.54	4486.0	3567.63	0.00	979870.95	980323.49	-30.75	-183.75	1.35	0.00	-185.09	-161.97
SV017	41 36.14	120 7.99	4493.0	3564.64	0.00	979867.81	980323.47	-33.21	-186.45	1.35	0.00	-187.80	-164.64
SV018	41 36.13	120 7.36	4506.0	3563.55	0.00	979866.66	980323.46	-33.12	-186.81	1.35	0.00	-188.15	-164.93
SV019	41 36.12	120 5.92	4519.0	3573.65	0.01	979877.29	980323.44	-21.26	-175.39	1.35	0.00	-176.74	-153.45
SV020	41 35.15	120 1.57	4781.0	3554.60	-0.02	979857.33	980321.99	-15.15	-178.21	1.39	0.00	-179.60	-154.96
SV021	41 38.17	119 59.15	5457.0	3522.47	-0.05	979823.45	980326.50	10.01	-176.11	1.46	0.00	-177.57	-149.47
SV022	41 40.58	119 59.77	5497.0	3527.87	-0.07	979829.11	980330.10	15.83	-171.67	1.47	0.00	-173.13	-144.82
SV023	41 39.20	120 1.64	5308.0	3533.53	-0.09	979835.03	980328.04	6.05	-175.00	1.45	0.00	-176.44	-149.10
15S34	41 35.68	120 4.61	4566.9	3574.61	-0.10	979878.18	980322.78	-15.21	-170.97	1.36	0.00	-172.32	-148.78
15S32	41 35.80	120 4.79	4558.0	3575.84	-0.10	979879.48	980322.96	-14.93	-170.39	1.36	0.00	-171.74	-148.25
11CGM	41 35.88	120 5.00	4547.4	3574.70	-0.10	979878.28	980323.08	-17.24	-172.34	1.36	0.00	-173.69	-150.25
15S29	41 36.01	120 5.08	4547.8	3574.29	-0.10	979877.85	980323.28	-17.83	-172.94	1.36	0.00	-174.29	-150.85
15S28	41 36.05	120 5.19	4543.7	3574.55	-0.10	979878.12	980323.34	-18.00	-172.97	1.35	0.00	-174.32	-150.90
15S27	41 36.07	120 5.29	4544.1	3575.16	-0.10	979878.76	980323.37	-17.35	-172.34	1.36	0.00	-173.69	-150.27
15S26	41 36.18	120 5.39	4546.4	3575.48	-0.10	979879.10	980323.53	-16.97	-172.03	1.36	0.00	-173.38	-149.95
15S25	41 36.18	120 5.43	4548.3	3575.87	-0.10	979879.51	980323.53	-16.38	-171.50	1.36	0.00	-172.85	-149.41
15S24	41 36.23	120 5.52	4547.6	3576.59	-0.10	979880.26	980323.60	-15.76	-170.86	1.36	0.00	-172.21	-148.78
15S23	41 36.27	120 5.60	4549.5	3576.29	-0.10	979879.95	980323.66	-15.96	-171.13	1.36	0.00	-172.48	-149.03
15S22	41 36.32	120 5.70	4548.9	3576.42	-0.10	979880.09	980323.74	-15.95	-171.10	1.36	0.00	-172.45	-149.00
15S21	41 36.37	120 5.79	4549.4	3576.76	-0.10	979880.44	980323.81	-15.62	-170.79	1.36	0.00	-172.14	-148.69
15S20	41 36.42	120 5.86	4554.4	3576.51	-0.10	979880.18	980323.89	-15.49	-170.82	1.36	0.00	-172.18	-148.70
15S19	41 36.47	120 5.95	4571.0	3575.26	-0.10	979878.87	980323.96	-15.32	-171.22	1.36	0.00	-172.57	-149.01
15S18	41 36.54	120 6.02	4572.9	3574.96	-0.10	979878.55	980324.07	-15.56	-171.52	1.36	0.00	-172.88	-149.31
15S17	41 36.62	120 6.10	4566.5	3575.12	-0.10	979878.72	980324.19	-16.11	-171.86	1.36	0.00	-173.21	-149.68
15S16	41 36.69	120 6.16	4567.1	3574.97	-0.10	979878.56	980324.29	-16.32	-172.09	1.36	0.00	-173.44	-149.90
15S15	41 36.76	120 6.23	4558.5	3574.20	-0.10	979877.75	980324.40	-18.04	-173.51	1.36	0.00	-174.87	-151.37
15S14	41 36.82	120 6.30	4559.0	3572.78	-0.10	979876.26	980324.49	-19.57	-175.07	1.36	0.00	-176.42	-152.92
15S13	41 36.87	120 6.37	4560.5	3571.22	-0.09	979874.63	980324.56	-20.38	-176.20	1.36	0.00	-177.55	-154.01
15S12	41 36.98	120 6.42	4586.8	3569.61	-0.09	979872.94	980324.72	-20.52	-176.96	1.36	0.00	-178.32	-154.68
15S11	41 37.07	120 6.48	4587.5	3569.10	-0.09	979872.40	980324.86	-21.12	-177.59	1.36	0.00	-178.94	-155.30
15S10	41 37.15	120 6.50	4590.7	3568.79	-0.09	979872.08	980324.98	-21.27	-177.84	1.36	0.00	-179.20	-155.54
15S09	41 37.23	120 6.52	4588.7	3568.85	-0.09	979872.14	980325.10	-21.51	-178.02	1.36	0.00	-179.37	-155.72
15S08	41 37.31	120 6.53	4602.0	3568.06	-0.09	979871.31	980325.22	-21.21	-178.17	1.36	0.00	-179.53	-155.81
15S07	41 37.40	120 6.57	4594.8	3568.48	-0.09	979871.75	980325.35	-21.58	-178.30	1.36	0.00	-179.65	-155.97
15S06	41 37.46	120 6.64	4576.6	3569.49	-0.09	979872.81	980325.44	-22.32	-178.41	1.36	0.00	-179.77	-156.18
15S04	41 37.62	120 6.73	4569.6	3570.13	-0.08	979873.50	980325.68	-22.54	-178.39	1.36	0.00	-179.74	-156.19
15S03	41 37.72	120 6.83	4559.1	3570.55	-0.08	979873.94	980325.83	-23.23	-178.73	1.36	0.00	-180.08	-156.58
15S02	41 37.78	120 6.93	4556.0	3570.51	-0.08	979873.90	980325.92	-23.65	-179.04	1.36	0.00	-180.40	-156.91
15S01	41 37.84	120 7.03	4555.8	3569.84	-0.08	979873.19	980326.01	-24.47	-179.85	1.36	0.00	-181.20	-157.72
15S05	41 37.53	120 6.70	4569.7	3569.83	-0.06	979873.20	980325.55	-22.69	-178.54	1.36	0.00	-179.90	-156.35

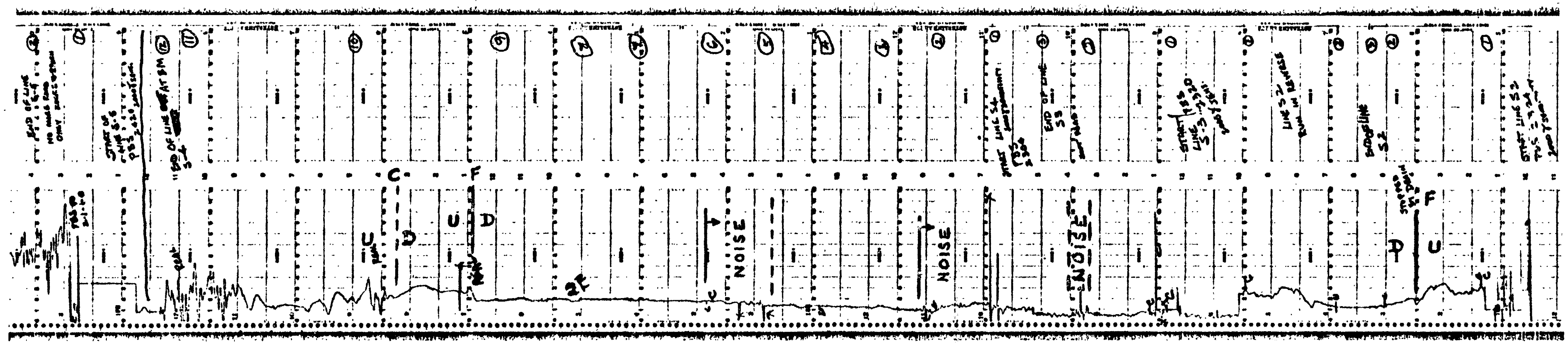


SHALLOW
LAKE CITY
CEDAR VALE WASH
START LINE S-1
START SURPRISE VALLEY PROJECT

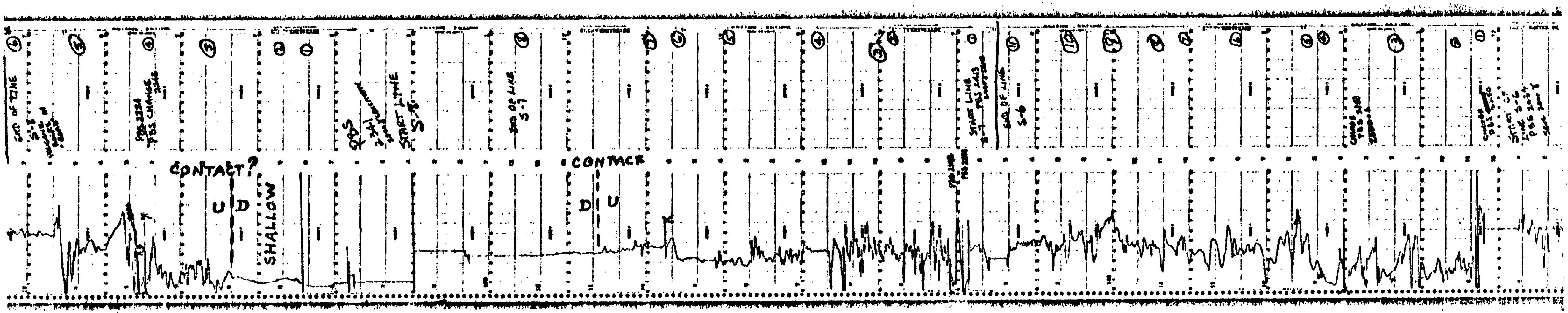
S-1 FIG9

S-2, S-3, S-4, S-5

FIG. 10



S-6, S-7, S-8 FIG. 11



S-10, S-11, S-12 FIG. 13