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Principal facts for borehole gravity stations in test  
well Uel9z, exploratory drill hole PM-1, and water well 5a,  
Nevada Test Site, Nye County, Nevada

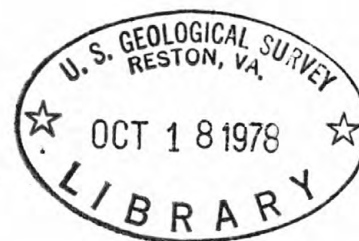
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This report is preliminary and has not been  
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Geological Survey standards and nomenclature

Principal facts for borehole gravity stations in test  
well Uel9z, exploratory drill hole PM-1, and water well 5a,  
Nevada Test Site, Nye County, Nevada

by

Bruce A. Kososki, Stephen L. Robbins, and James W. Schmoker

INTRODUCTION

During field studies conducted in October 1977 and March 1978, borehole gravity surveys were completed by the U.S. Geological Survey at the Nevada Test Site in test well Uel9z, exploratory drill hole PM-1, and water well 5a. The U.S. Geological Survey-LaCoste and Romberg<sup>1/</sup>borehole gravity meter (McCulloh and others, 1967a; McCulloh and others, 1967b) was used in the logging program. The primary objective of this work was to obtain data for the determination of accurate in situ formation densities utilizing an instrument not significantly affected by casing, borehole rugosity, or other near-borehole conditions.

This report provides a brief summary of the geology of the rock formations penetrated by drill holes Ue 19z, PM-1, and water well 5a, and tabulates the subsurface gravity data obtained in these wells. Reduced sections of the gamma-ray logs run in PM-1 and 5a are also included.

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<sup>1/</sup>Use of brand names in this report is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey.

### Test Well Uel9z

Well Uel9z is located on Pahute Mesa at Nevada State coordinates (central zone) N. 928,190 and E. 598,855 (fig. 1). This well was drilled to a total depth of 2,800 ft (853 m) with casing temporarily set to about 2,700 ft (823 m) for the logging operations. The static water level in Uel9z was estimated from nearby drill holes to be at 2,192 ft (668 m); thus most of the formations logged with the borehole gravity meter were not water saturated.

A lithologic and stratigraphic log of the formations present in Uel9z is shown in table 1. Due to equipment failure, a gamma-ray log was not obtained in this hole.

### Exploratory Drill Hole PM-1

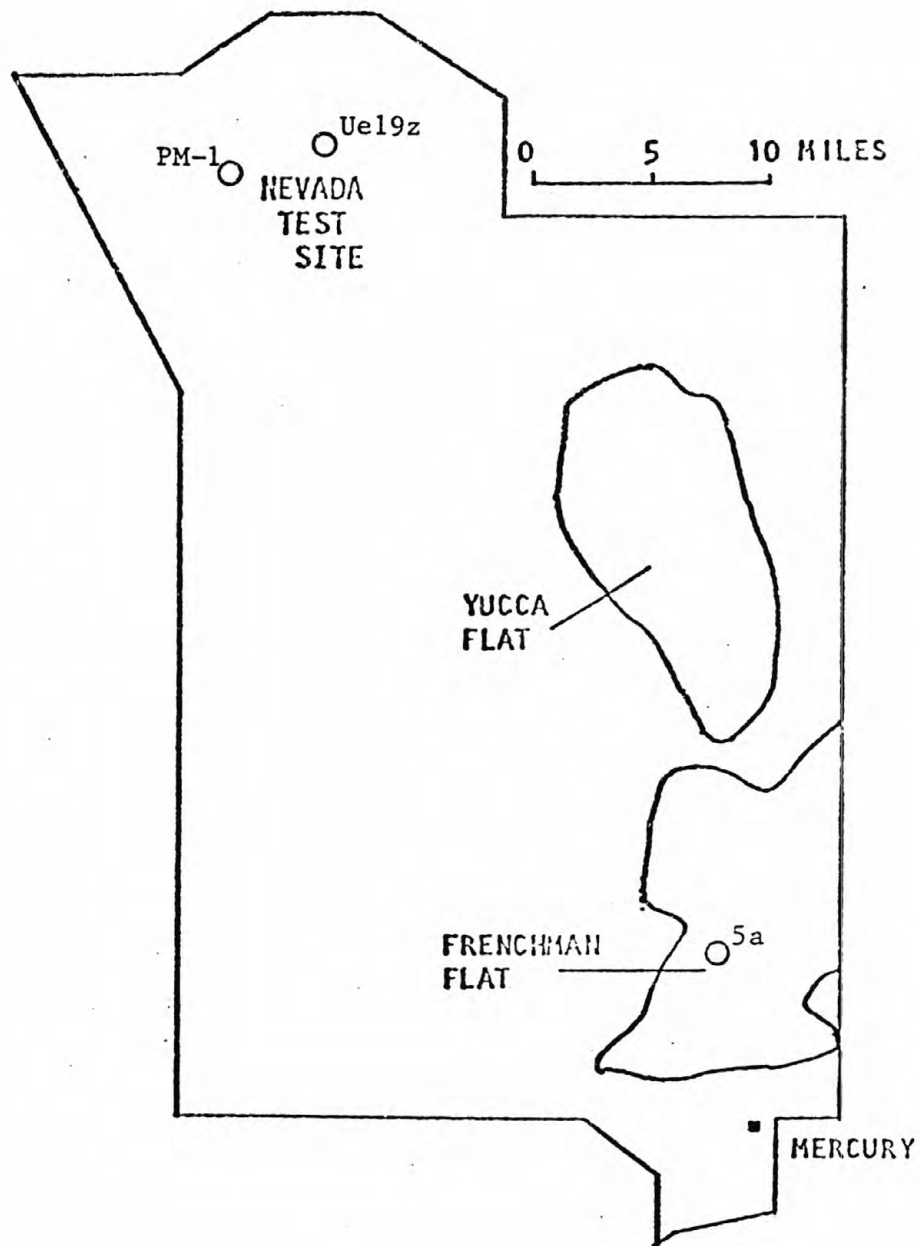
Exploratory drill hole PM-1 is also located on Pahute Mesa, approximately 4 mi (6.4 km) southeast of Uel9z (fig. 1). The state coordinates of this drill site are N. 921,104 and E. 575,868. The static water level in PM-1 lies at 2,112 ft. (644 m) below the surface.

Exploratory drill hole PM-1 is cased from the surface to a total depth of 7,858 ft (2395 m) where it bottomed in a quartz latite lava flow.

A complete lithologic and stratigraphic log of this drill hole is shown in table 2. Figure 2 is a greatly reduced section of the gamma-ray log obtained in PM-1 prior to conducting the borehole gravity survey.

### Water Well 5a

Water Well 5a is located on Frenchman Flat at Nevada State coordinates N. 738,361 and E. 707,514 (fig. 1). Well 5a was drilled to a total depth of 910 ft (277 m) and cased from the surface to a depth of 877 ft (267 m). The static water level in this well is 705 ft (215 m).



**Figure 1.** Index map of the Nevada Test Site, showing locations of borehole gravity surveys.

Table 1.--Lithologic and stratigraphic log of test well Uel9z  
(modified from P.P. Orkild, personal commun., 1978)

Depth		Rock type		Stratigraphic unit	
ft	m				
0 - 210	0 - 64	Partially to densely welded ash-flow tuff	Ammonia Tanks Member	Timber Mountain Tuff	Rocks of Silent Canyon volcanic center
210 - 230	64 - 70	Vitric bedded tuff			
230 - 1070	70 - 326	Moderately to densely welded ash-flow tuff	Rainier Mesa Member		
1070 - 1362	326 - 415	Vitric bedded tuff		Bedded tuff	
1362 - 1631	415 - 487	Nonwelded to partially welded ash-flow tuff	Tuff of Blacktop Buttes	Paintbrush Tuff	
1631 - 1900	487 - 579	Vitric to zeolitized bedded tuff and tuffaceous sandstone		Bedded tuff	
1900 - 2044	579 - 623	Rhyolitic lava flow		Lavas of Scrugham Peak quadrangle	
2044 - 2680	623 - 817	Zeolitized nonwelded to partially welded lithic-rich ash-flow tuff			
2680 - 2799	817 - 853	Zeolitized reworked bedded tuff		Tuffs and rhyolites of Area 20	

SWL (static water level--estimated from Uel9z to be 2192 feet (668 m) below surface)

Table 2.--Lithologic and stratigraphic log of exploratory drill hole PM-1  
(modified from Jenkins, 1970)

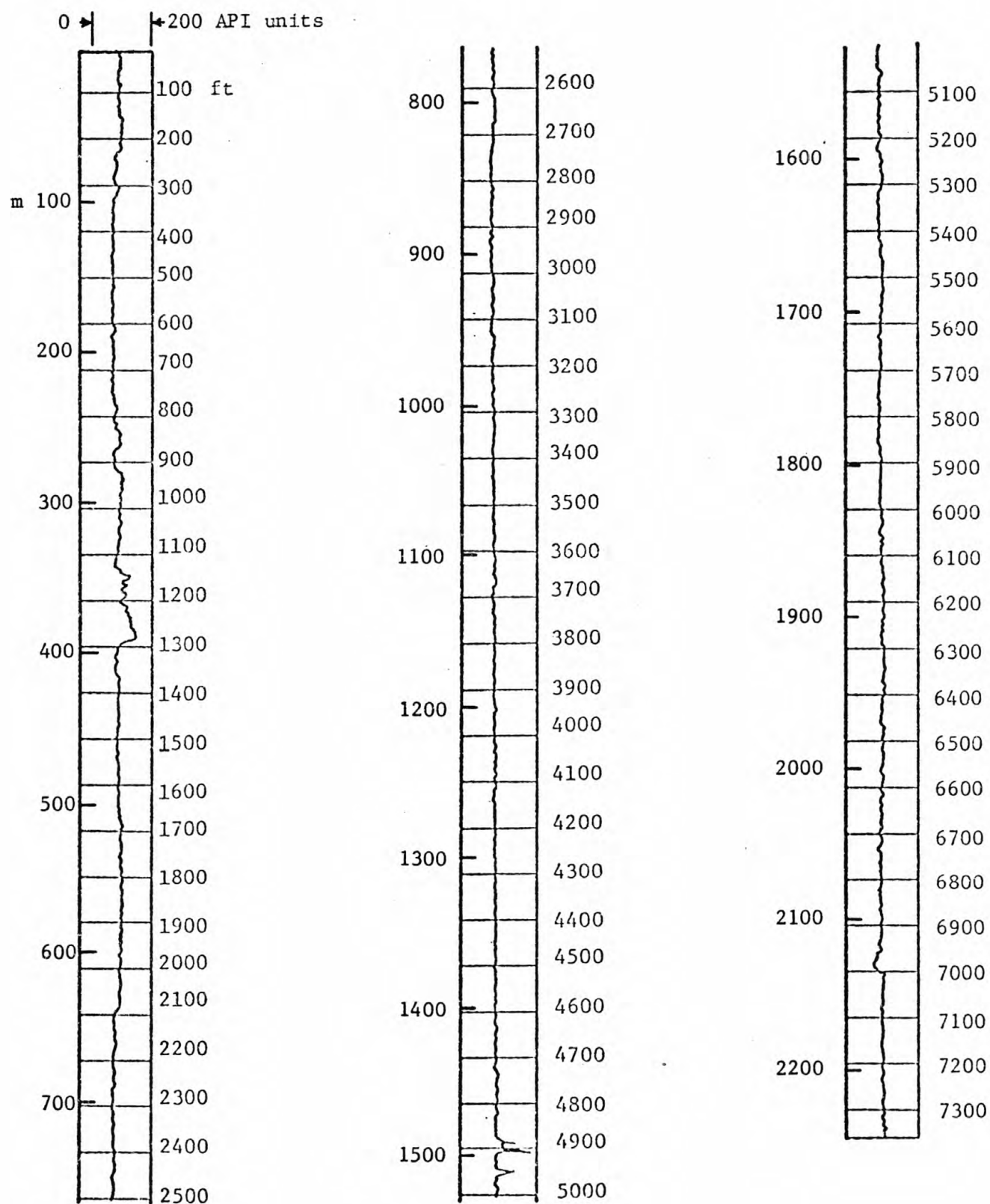
ft	Depth	m	Rock type	Stratigraphic unit	
0 - 580	0 - 177		Densely welded ash-flow tuff	Rainier Mesa Mbr.	Timber Mountain Tuff Bedded tuff
580 - 660	177 - 201		Vitric bedded tuff	Upper rhyolite lavas	Tuffs and rhyolites of Area 20
660 - 720	201 - 219		Rhyolitic lava flow		
720 - 790	219 - 241		Rhyolitic lava flow (vitrophyre)		
790 - 950	241 - 290		Rhyolitic lava flow		
950 - 1000	290 - 305		Vitric bedded tuff	Upper rhyolite lavas	
1000 - 1075	305 - 328		Rhyolitic lava flow		
1075 - 1130	328 - 344		Rhyolitic lava flow (vitric froth)		
1130 - 1150	344 - 351		Rhyolitic lava flow (vitrophyre)		
1150 - 1615	351 - 492		Rhyolitic lava flow	Upper rhyolite lavas	
1615 - 1690	492 - 515		Zeolitized bedded tuff		
1690 - 2000	515 - 610		Rhyolitic lava flow	Upper rhyolite lavas	
2000 - 2185	610 - 666		Zeolitized bedded tuff	Upper rhyolite lavas	
2185 - 2430	666 - 741		Zeolitized partially welded ash-flow tuff		
2430 - 2610	741 - 796		Zeolitized bedded tuff and tuffaceous sandstone		
2610 - 2675	796 - 815		Rhyolitic lava flow		
2675 - 2890	815 - 881		Zeolitized bedded tuff and tuffaceous sandstone	Lower rhyolite lavas	
2890 - 2935	881 - 895		Rhyolitic lava flow		
2935 - 3164	895 - 964		Zeolitized tuff	Tub Spring Mbr.	
3164 - 5235	964 - 1596		Lithic-rich ash-flow tuff		
5235 - 6690	1596 - 2039		Densely welded ash-flow tuff		
6690 - 6770	2039 - 2063		Zeolitized bedded tuff		
6770 - 6940	2063 - 2115		Partially welded ash-flow tuff	Belted Range Tuff	
6940 - 7005	2115 - 2135		Zeolitized bedded tuff		
7005 - 7515	2135 - 2291		Welded ash-fall(?) tuff (phenocryst poor)		
7515 - 5858	2291 - 2395		Quartz latitic lava flow		
					Quartz latite lava

Rocks of Silent Canyon Volcanic center

Rocks of Silent Canyon Volcanic center

SWL (static water level)--2,112 feet (644 m) below surface

Figure 2. Gamma-ray Log, Test Well No. PM-1





A lithologic and stratigraphic log of water well 5a is shown in table 3. As noted on this table, the well was spudded in alluvial valley fill and penetrated conglomerate beds interpreted to be part of the rocks of Pavits Spring (Poole, 1965). Figure 3 is a reduced section of the gamma ray log run in well 5a.

#### BOREHOLE GRAVITY DATA

A detailed discussion of the relationship between subsurface gravity measurements and mass distributions within the earth is given by McCulloh (1966). Other literature on borehole-gravity-logging fundamentals and data interpretation include Smith (1950); Goodell and Fay (1964); Howell, Heintz, and Barry (1966); Beyer (1971); and Brown and others (1975).

In the absence of complicating factors, the in situ density in grams per cubic centimeter between two observation points in a borehole is given by the equation:

$$\rho = \frac{1}{4\pi k} (F - \Delta g / \Delta z), \quad (1)$$

where  $k$  is the gravitational constant;  $F$ , the free-air vertical gradient of gravity; and  $g / z$ , the vertical gradient of gravity between discrete pairs of gravity measurements in the well. Assuming a "normal" free-air gravity gradient of 0.09406 mgal/ft, equation (1) becomes:

$$\rho = 3.686 - 39.185 (\Delta g / \Delta z) \quad (2)$$

Caution should be exercised when utilizing this equation to compute densities from the borehole gravity data presented in this report. Tower measurements indicate that the free-air gradient at the Nevada Test Site is



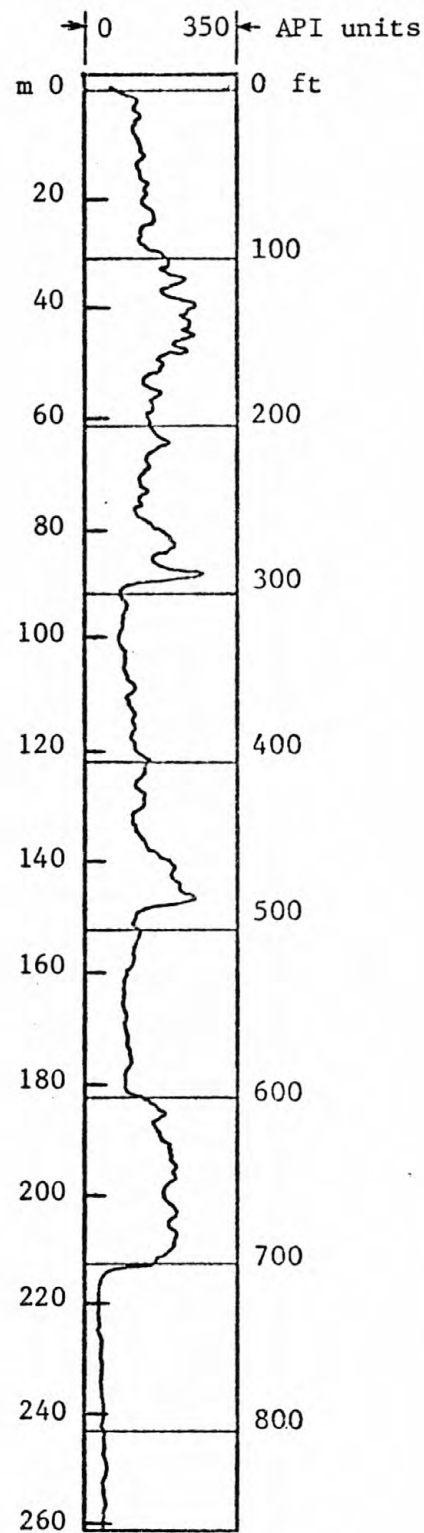
Table 3.--Lithologic and stratigraphic log of water well 5a  
(modified from Hood, 1961)

Footage	Rock Type	Stratigraphic unit
0 - 180	Valley fill, coarse gravel, sand, silt, and clay. Rock fragments are predominantly limestone with some quartzite	
180 - 250	Valley fill, limestone, and quartzite gravel and sand	
250 - 550	Valley fill, subangular quartzite and limestone fragments in gravel and sand layers embedded in a silt and clay matrix. Some gravel layers are well cemented	
550 - 585	Transition zone. Valley alluvium to fanglomerate composed of rounded pebbles in a tuffaceous matrix. Pebbles are largely of quartz and quartzite origin	
585 - 870	Conglomerate. Interbedded layers of cobbles, pebbles, and granules, largely of quartz and quartzite origin, well rounded and embedded in tuffaceous matrix	Rocks of Pavits Spring?*
870 - 890	Hard, siliceous conglomerate. Cobbles and pebbles, largely of quartz and quartzite origin, embedded in a siliceous matrix	
890 - 910	Unknown	

SWL (static water level)--705 feet below surface

\*mapped by F. G. Poole, 1965

Figure 3. Gamma Ray Log, Water Well No. 5a



often lower than the so-called "normal" value of .09406 mgals/ft. In addition, the surface of the dense Paleozoic rocks which underlie the alluvial fill and Tertiary volcanic rocks may be steeply dipping, whereas equation 2 is derived under the assumption of horizontal contacts.

Tables 4, 5, and 6 record the data associated with each subsurface gravity station in the three wells. The column headings are explained in the following list:

Station number:	A numbering of borehole gravity stations in the order recorded.
Depth:	Depth of stations in feet and meters. Datum is ground level.
Time:	Greenwich mean time of each gravity reading.
Uncorrected gravity:	Observed gravity in milligals, referenced to an arbitrary base, uncorrected for tide, terrain, and drift effects.
Tide correction:	Theoretical correction for earth tides in milligals.
Terrain correction:	Terrain correction in milligals calculated for a density of $2.67 \text{ g/cm}^3$ out to a distance of 71,996 ft (21,944 m), corresponding to zone M of Hammer's terrain correction chart (Hammer, 1939).
Drift correction:	A correction for instrument drift derived from station reoccupations.
Corrected gravity:	Observed gravity in milligals, referenced to an arbitrary base, corrected for tide, terrain, and drift effects.

Table 4.--Test well 6e19z, Nevada Test Site, Nye County, Nevada. Logged

October 18-19, 1977. Well coordinates N-928,190 E-598,855.

Ground level datum, elevation 6888 ft (2099 m)

Station	Depth		Time	Uncorrected gravity	Tide correction	Terrain correction	Drift correction	Corrected gravity
	ft	m						
1	995.7	303.49	1810	38.397	-0.041	- 1.212		37.144
2	1065.7	324.83	1825	41.293	- .046	- 1.296		39.951
3	1110.7	338.54	1840	43.604	- .050	- 1.350		42.204
4	1209.6	368.69	1855	48.889	- .054	- 1.466		47.369
5	1275.7	388.83	1910	52.120	- .057	- 1.543		50.520
6	1355.7	413.22	1925	56.402	- .060	- 1.634		54.708
7	1445.7	440.65	1935	60.832	- .061	- 1.736		59.035
8	1535.7	468.08	1950	65.126	- .063	- 1.835	N	63.228
9	1625.7	495.51	2005	69.552	- .064	- 1.934	E	67.554
10	1715.7	522.95	2015	73.735	- .064	- 2.030	G	71.641
11	1805.7	550.38	2030	77.549	- .064	- 2.125	L	75.360
12	1895.7	577.81	2045	81.815	- .064	- 2.219	I	79.532
							G	
13	1955.7	596.10	2100	84.225	- .063	- 2.281	I	81.881
14	2005.7	611.34	2115	86.165	- .062	- 2.332	B	83.771
15	2038.7	621.40	2130	87.470	- .060	- 2.365	L	85.045
16	2055.7	626.58	2140	88.146	- .059	- 2.382	E	85.705
17	2105.7	641.82	2150	89.958	- .057	- 2.432		87.469
18	2155.7	657.06	2200	91.727	- .056	- 2.481		89.190
							D	
19	2205.7	672.30	2215	93.464	- .054	- 2.530	R	90.880
20	2255.7	687.54	2230	95.189	- .051	- 2.579	I	92.559
21	2325.7	708.87	2240	97.647	- .049	- 2.646	F	94.952
22	2395.7	730.21	2255	100.225	- .047	- 2.713	T	97.465
23	2495.7	760.69	2302	103.915	- .046	- 2.807		101.062
24	2595.8	791.20	2312	107.619	- .044	- 2.899		104.676
25	2005.7	611.34	2350	86.144	- .038	- 2.332		83.774
26	1535.7	468.08	0010	65.079	- .035	- 1.835		63.209
27	995.7	303.49	0030	38.396	- .033	- 1.212		37.151
28	930.7	283.68	0040	36.084	- .032	- 1.132		34.920
29	820.7	250.15	0050	31.682	- .032	- .996		30.654
30	720.7	219.67	0100	27.769	- .031	- .869		26.869
31	620.7	189.19	0115	24.090	- .030	- .739		23.321
32	520.6	158.68	0125	20.449	- .030	- .604		19.815
33	421.7	128.53	0135	16.804	- .030	- .465		16.309
34	321.7	98.05	0155	12.498	- .030	- .313		12.155

Table 5.--Exploratory drill hole PM-1, Nevada Test Site, Nye County, Nevada.

Logged April 1-2, 1978. Well coordinates N-921,104 E-575,868.

Ground level datum, elevation 6558 ft (1999 m)

Station	Depth		Time	Uncorrected gravity	Tide correction	Terrain correction	Drift correction	Corrected gravity
	ft	m						
1	2117.0	645.26	1629	93.254	-0.015	- 2.955	0.383	90.667
2	4000.0	1219.20	1722	165.478	- .020	- 3.725	.321	162.054
3	4167.1	1270.13	1733	171.534	- .021	- 3.783	.309	168.039
4	4334.0	1321.00	1753	177.717	- .024	- 3.840	.286	174.139
5	4500.0	1371.60	1807	183.805	- .026	- 3.897	.269	180.151
6	4668.0	1422.81	1820	189.880	- .028	- 3.953	.254	186.153
7	4866.0	1483.16	1833	196.690	- .030	- 4.019	.239	192.880
8	4950.0	1508.76	1842	199.501	- .031	- 4.046	.229	195.653
9	5167.0	1574.90	1852	206.776	- .033	- 4.117	.217	202.843
10	5235.0	1595.63	1900	208.987	- .034	- 4.139	.208	205.022
11	5400.0	1645.92	1914	214.449	- .036	- 4.192	.192	210.413
12	5540.0	1688.59	1930	218.896	- .038	- 4.236	.173	214.795
13	5725.0	1744.98	1952	224.554	- .040	- 4.294	.148	220.368
14	5900.0	1798.32	2006	229.870	- .041	- 4.349	.132	225.612
15	6070.0	1850.14	2018	234.987	- .041	- 4.402	.118	230.662
16	6240.0	1901.95	2028	239.968	- .041	- 4.454	.106	235.579
17	6400.0	1950.72	2040	244.697	- .041	- 4.503	.093	240.246
18	6570.0	2002.54	2057	249.972	- .040	- 4.554	.073	245.451
19	6690.0	2039.11	2109	253.854	- .039	- 4.590	.059	249.284
20	6770.0	2063.50	2118	256.453	- .038	- 4.614	.049	251.850
21	6940.0	2115.31	2129	261.824	- .037	- 4.665	.036	257.158
22	7005.0	2135.12	2139	263.976	- .035	- 4.684	.024	259.281
23	7065.0	2153.41	2148	265.867	- .033	- 4.702	.014	261.146
24	7300.0	2225.04	2200	273.038	- .031	- 4.771	.000	268.236
25	7300.0	2225.04	2206	273.035	- .029	- 4.771	- .007	268.228
26	6770.0	2063.50	2228	256.535	- .023	- 4.614	- .032	251.866
27	6240.0	1901.95	2251	240.126	- .015	- 4.454	- .059	233.598

28	5725.0	1744.98	2309	224.780	- .008	- 4.294	- .080	220.398
29	5167.0	1574.90	2342	207.061	.006	- 4.117	- .118	202.832
30	4500.0	1371.60	0007	184.190	.017	- 3.897	- .147	180.163
31	4000.0	1219.20	0027	165.926	.027	- 3.725	- .170	162.058
32	2117.0	645.26	0111	93.763	.048	- 2.955	- .221	90.635
33	580.0	176.78	0154	27.439	.066	- 1.424	- .271	25.810
34	580.0	176.78	1613	27.382	.006	- 1.424	.036	26.000
35	661.5	201.63	1631	31.960	.008	- 1.585	.036	30.419
36	770.0	234.70	1643	37.393	.009	- 1.772	.036	35.666
37	926.2	282.31	1656	43.650	.010	- 1.999	.036	41.697
38	1140.0	347.47	1708	52.641	.010	- 2.250	.036	50.437
39	1290.0	393.19	1717	59.339	.010	- 2.396	.036	56.989
40	1290.0	393.19	1740	59.326	.008	- 2.396	.036	56.974
41	1400.0	426.72	1749	64.208	.007	- 2.491	.036	61.760
42	1615.0	492.25	1801	73.282	.005	- 2.653	.036	70.670
43	2000.0	609.60	1817	88.805	.002	- 2.892	.032	85.947
44	2095.0	638.56	1827	92.882	- .001	- 2.943	.029	89.967
45	2117.0	645.26	1834	93.673	- .002	- 2.955	.027	90.743
46	2185.0	665.99	1842	96.581	- .004	- 2.990	.025	93.612
47	2310.0	704.09	1851	101.869	- .007	- 3.052	.023	98.833
48	2430.0	740.66	1858	106.939	- .009	- 3.108	.021	103.843
49	2890.0	880.87	1914	125.786	- .015	- 3.308	.016	122.479
50	3164.1	964.42	1925	136.470	- .017	- 3.418	.013	133.048
51	3310.0	1008.89	1934	141.751	- .020	- 3.474	.011	138.268
52	3455.0	1053.08	1943	146.886	- .023	- 3.528	.008	143.343
53	3600.2	1097.34	1951	152.051	- .025	- 3.582	.006	148.450
54	3800.0	1158.24	2001	158.879	- .028	- 3.654	.003	155.200
55	4000.0	1219.20	2013	165.911	- .032	- 3.725	.000	162.154
56	3600.2	1097.34	2030	152.082	- .037	- 3.582	- .005	148.458
57	3164.1	964.42	2047	136.504	- .041	- 3.418	- .009	133.036
58	2430.0	740.66	2122	107.040	- .048	- 3.108	- .019	103.865
59	2117.0	645.26	2138	93.796	- .050	- 2.955	- .023	90.768
60	1615.0	492.25	2155	73.401	- .052	- 2.653	- .028	70.668
61	926.2	282.31	2225	43.763	- .052	- 1.999	- .036	41.676
62	580.0	176.78	2244	27.499	- .050	- 1.424	- .062	25.963

Table 6.--Water well 5a, Nevada Test Site, Nye County, Nevada. Logged

April 4, 1978. Well coordinates N-738,361 E-707,514. Ground

level datum, elevation 3092 ft (942 m)

Station	Depth		Time	Uncorrected gravity	Tide correction	Terrain correction	Drift correction	Corrected gravity
	ft	m						
1	858.0	261.52	1621	66.055	0.027	2.250		68.332
2	826.8	252.01	1635	65.081	.035	2.201		67.317
3	780.0	237.74	1644	63.711	.040	2.126	N	65.877
4	740.0	225.55	1658	62.503	.047	2.061	E	64.611
5	705.0	214.88	1710	61.534	.052	2.004	G	63.590
							L	
6	650.0	198.12	1719	59.746	.055	1.913	I	61.714
7	600.0	182.88	1728	57.923	.058	1.830	G	59.811
8	550.0	167.64	1741	56.081	.062	1.745	I	57.888
9	488.0	148.74	1754	53.650	.064	1.639	B	55.353
10	450.0	137.16	1804	52.247	.065	1.572	L	53.884
							E	
11	396.1	120.73	1815	50.175	.066	1.477		51.718
12	350.1	106.71	1828	48.357	.066	1.393	D	49.816
13	294.0	89.61	1842	46.086	.065	1.289	R	47.440
14	256.0	78.03	1858	44.525	.062	1.217	I	45.804
15	211.0	64.31	1914	42.662	.058	1.129	F	43.849
							T	
16	156.8	47.79	1930	40.362	.053	1.017		41.432
17	95.0	28.96	1943	37.977	.047	0.881		38.905
18	294.0	89.61	2018	46.121	.029	1.289		47.439
19	550.0	167.64	2032	56.130	.021	1.745		57.896
20	705.0	214.88	2046	61.487	.013	2.004		63.504
21	858.0	261.52	2058	66.080	.005	2.250		68.335



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