UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Principal facts for gravity stations of the Broadwater, Montana Geothermal Area

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On October 31, November 1 and 3, 1978, forty-eight gravity stations were established near Helena, in the Broadwater geothermal area, west-central Montana (fig. 1).

Elevations for the stations were determined by transit level (R. Leonard, U.S. Geological Survey, written communication, 1978), and by benchmark or spot elevations shown on the U.S. Geological Survey topographic map of Helena at a scale of 1:62,500.

The gravity observations were made with a LaCoste-Romberg[1] gravity meter (number g-235) having a scale factor of about one milligal per division.

A base station was located at the Helena Municipal Airport at the beginning and end of each day (fig. 2). The observed gravity was referenced to the base station at the Helena Municipal airport (fig. 2), having a value based on the International Gravity Standardization Net, 1971 (Defense Mapping Agency Aerospace Center, 1974).

The Geodetic Reference System 1967 formula (International Association of Geodesy, 1967) was used to compute theoretical gravity.

The Bouguer anomaly was computed by use of the following U.S.G.S. computer programs:

1.) U.S.G.S. Gravity Reduction System (R. H. Godson, D. Dansereau, and R. Sweeney, unpublished data, 1978)

2.) Program Bouguer (R. H. Godson, U.S.G.S. unpublished data, 1978)

[1] Use of brand names in this report is for decriptive purposes only, and in no way constitutes endorsement by the U.S. Geological Survey.

Terrain, tidal, and drift corrections were made with the above two programs. All corrections were made from each station to a distance of 167 kilometers. Densities of 2.67 g/cm^3 and 2.50 g/cm^3 were used in computing the Bouguer anomaly.

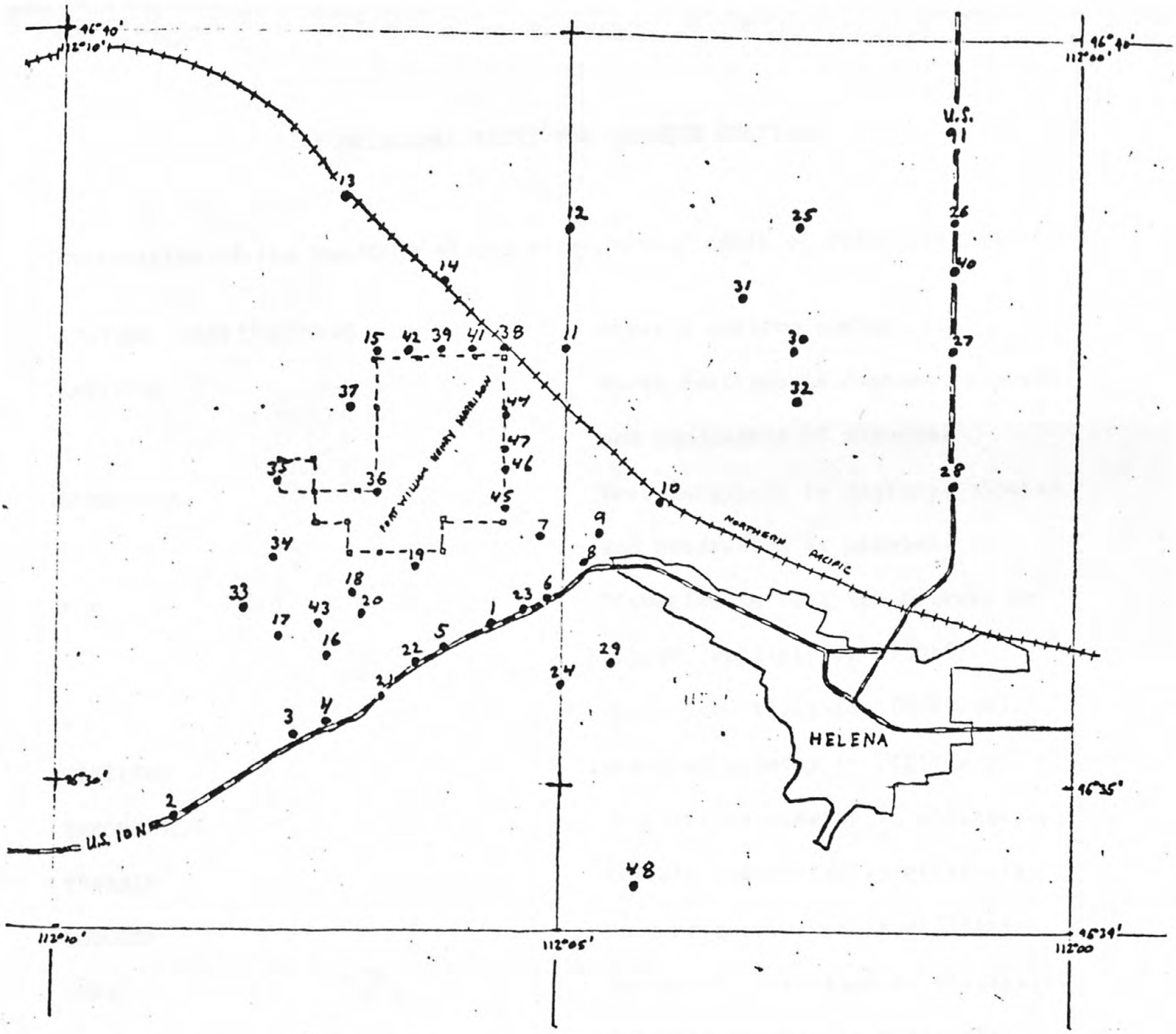


Fig. 1 GRAVITY STATION LOCATION MAP
BROADWATER GEOTHERMAL AREA
HELENA, MONTANA

N

MONTANA
QUADRANGLE LOCATION

Gravity Station
Railroad
Highway

SCALE
MILES
KILOMETERS

PRINCIPAL FACTS FOR GRAVITY STATIONS

Explanation of the headings of the accompanying table of principal facts:

STATION IDENTIFICATION	Gravity station number.
LATITUDE	North latitude in degrees, minutes and hundredths of minutes.
LONGITUDE	West longitude in degrees, minutes and hundredths of minutes.
ELE	Elevation in feet (to convert to meters, multiply by 0.3048).
ST	State identification (Montana).
OBSERVED	Observed gravity in milligals.
THEORETICAL	Theoretical gravity in milligals.
TERRAIN	Terrain correction in milligals.
BOUGUER	Bouguer correction in milligals.
CURV	Curvature correction in milligals.
FREE AIR	Free-air anomaly in milligals.
COMPLETE-BOUGUER	Bouguer anomaly in milligals, based on densities of 2.67 and 2.50.

BROADWATER GRAVITY STATIONS
GATHERED BY M. SENTERFIT 1978
Meter ID: G-735 Date: 08/15/79

Table 1. -- Bouguer Gravity Data for the Broadwater, Montana geothermal area

STATION IDENTIFICATION		LOCATIONS					GRAVITY		CORRECTIONS			ANOMALIES	
		LATITUDE		LONGITUDE		ELE ST	OBSERVED	THEORETICAL	TERRAIN	BOUGUER	CURV	SPECIAL	FREE AIR	COMPLETE-BOUGUER d1=2.67	d2=2.50
proj	sta-id	deg	min	deg	min	(in ft)									
	HELENA AIRPORT														
00356:	BASE STA	46	36.50	-111	59.50	3872.0 mt	980363.26	980764.56	0.54	-132.06	-1.24	0.00	-37.27	-170.03	-161.58
00356:	1	46	36.03	-112	5.64	3992.0 mt	980354.58	980763.85	1.69	-136.16	-1.26	0.00	-33.96	-169.69	-161.05
00356:	2	46	34.76	-112	8.82	4162.0 mt	980339.99	980761.94	2.90	-141.95	-1.29	0.00	-30.66	-171.00	-162.06
00356:	3	46	35.27	-112	7.63	4099.0 mt	980347.22	980762.70	2.70	-139.81	-1.28	0.00	-30.12	-168.50	-159.69
00356:	4	46	35.35	-112	7.28	4080.2 mt	980347.23	980762.83	3.38	-139.16	-1.27	0.00	-31.99	-169.05	-160.33
00356:	5	46	35.60	-112	6.15	4022.0 mt	980351.37	980763.51	2.37	-137.18	-1.26	0.00	-34.01	-170.08	-161.42
00356:	6	46	36.22	-112	5.12	3972.0 mt	980358.43	980764.14	1.40	-135.47	-1.25	0.00	-32.28	-167.60	-158.99
00356:	7	46	36.65	-112	5.20	3981.0 mt	980359.75	980764.79	1.06	-134.42	-1.25	0.00	-34.52	-169.12	-160.55
00356:	8	46	36.48	-112	4.77	3941.0 mt	980360.59	980764.53	1.26	-134.42	-1.25	0.00	-33.42	-167.62	-159.27
00356:	9	46	36.69	-112	4.64	3930.0 mt	980361.21	980764.84	0.97	-134.04	-1.25	0.00	-34.15	-168.47	-159.92
00356:	10	46	36.87	-112	3.04	3896.0 mt	980364.49	980765.12	0.75	-132.68	-1.24	0.00	-34.34	-167.71	-159.22
00356:	11	46	37.83	-112	5.02	3913.0 mt	980365.76	980766.56	0.73	-133.46	-1.24	0.00	-32.92	-166.90	-158.36
00356:	12	46	38.75	-112	5.00	3995.0 mt	980362.73	980767.95	0.62	-136.26	-1.26	0.00	-29.62	-166.52	-157.80
00356:	13	46	38.92	-112	7.24	4085.0 mt	980359.44	980768.20	0.93	-139.33	-1.28	0.00	-24.72	-164.39	-155.50
00356:	14	46	38.28	-112	6.20	4009.0 mt	980362.31	980767.24	0.70	-136.74	-1.26	0.00	-28.02	-165.32	-156.58
00356:	15	46	37.84	-112	6.89	4048.0 mt	980357.60	980766.58	0.86	-138.07	-1.27	0.00	-28.40	-166.88	-158.06
00356:	16	46	36.60	-112	7.33	4721.0 mt	980309.71	980765.02	5.24	-161.02	-1.38	0.00	-11.48	-168.63	-156.63
00356:	17	46	35.95	-112	7.80	4650.0 mt	980314.62	980763.73	1.83	-158.60	-1.37	0.00	-11.96	-170.09	-160.03
00356:	18	46	36.51	-112	7.05	4570.0 mt	980317.83	980764.58	2.19	-155.87	-1.35	0.00	-17.11	-172.15	-162.27
00356:	19	46	36.40	-112	6.42	4470.0 mt	980326.51	980764.41	2.39	-152.46	-1.34	0.00	-17.66	-169.07	-159.43
00356:	20	46	36.09	-112	7.97	4218.0 mt	980340.55	980763.93	2.30	-143.86	-1.30	0.00	-26.83	-169.69	-160.59
00356:	21	46	35.58	-112	6.80	4047.0 mt	980347.42	980763.17	3.30	-138.07	-1.27	0.00	-35.27	-171.27	-162.61
00356:	22	46	35.79	-112	6.42	4020.0 mt	980351.24	980763.49	2.58	-137.11	-1.26	0.00	-34.30	-170.10	-161.45
00356:	23	46	36.13	-112	5.35	3975.0 mt	980357.77	980764.00	1.55	-135.58	-1.26	0.00	-32.52	-167.80	-159.18
00356:	24	46	35.69	-112	5.06	4245.0 mt	980339.92	980763.33	1.42	-144.79	-1.30	0.00	-24.31	-168.98	-159.77
00356:	25	46	38.75	-112	2.70	3795.0 mt	980379.16	980767.95	0.58	-129.44	-1.22	0.00	-31.99	-162.07	-153.79
00356:	26	46	38.67	-112	1.15	3749.0 mt	980377.02	980768.13	0.46	-127.87	-1.21	0.00	-38.63	-167.25	-159.07
00356:	27	46	37.69	-112	1.15	3781.0 mt	980371.96	980766.66	0.49	-128.96	-1.22	0.00	-39.21	-168.90	-160.64
00356:	28	46	37.00	-112	1.15	3845.0 mt	980367.34	980765.31	0.58	-131.14	-1.23	0.00	-36.47	-168.27	-159.88
00356:	29	46	35.68	-112	4.52	4237.0 mt	980342.31	980763.63	1.43	-144.51	-1.30	0.00	-22.97	-167.36	-158.17
00356:	30	46	37.89	-112	2.75	3815.0 mt	980373.51	980766.66	0.59	-130.12	-1.22	0.00	-34.47	-165.23	-156.90
00356:	31	46	36.27	-112	3.54	3838.0 mt	980372.74	980767.23	0.63	-130.90	-1.23	0.00	-33.65	-165.15	-156.78
00356:	32	46	37.57	-112	2.75	3820.0 mt	980371.35	980766.17	0.64	-130.29	-1.23	0.00	-35.67	-166.55	-158.22
00356:	33	46	36.14	-112	8.15	4485.0 mt	980326.03	980764.02	0.87	-152.97	-1.34	0.00	-16.34	-169.78	-160.01
00356:	34	46	36.44	-112	7.94	4520.0 mt	980326.92	980764.47	0.81	-154.16	-1.35	0.00	-12.61	-167.31	-157.46
00356:	35	46	36.93	-112	7.84	4270.0 mt	980341.62	980765.21	1.26	-145.64	-1.31	0.00	-22.15	-167.83	-158.56
00356:	36	46	36.93	-112	6.86	4091.0 mt	980352.98	980765.21	1.03	-139.53	-1.28	0.00	-27.61	-167.39	-158.49
00356:	37	46	37.53	-112	7.15	4113.0 mt	980353.67	980766.11	0.86	-140.28	-1.28	0.00	-25.76	-166.46	-157.50
00356:	38	46	37.84	-112	5.62	3949.0 mt	980363.87	980766.58	0.74	-134.69	-1.25	0.00	-31.44	-166.64	-158.03
00356:	39	46	37.84	-112	6.27	3991.0 mt	980359.75	980766.58	0.79	-136.12	-1.26	0.00	-31.61	-168.20	-159.50
00356:	40	46	38.40	-112	1.15	3764.0 mt	980375.63	980767.42	0.47	-128.38	-1.21	0.00	-37.91	-167.03	-158.81
00356:	41	46	37.84	-112	5.95	3968.0 mt	980362.34	980766.58	0.76	-135.34	-1.25	0.00	-31.18	-167.01	-158.36
00356:	42	46	37.84	-112	6.52	4016.0 mt	980358.09	980766.58	0.79	-136.97	-1.26	0.00	-30.92	-168.36	-159.61
00356:	44	46	37.37	-112	5.60	3945.0 mt	980363.18	980765.87	0.83	-134.55	-1.25	0.00	-31.80	-166.77	-158.18
00356:	45	46	36.88	-112	5.62	3946.0 mt	980359.38	980765.13	1.04	-134.65	-1.25	0.00	-34.57	-169.44	-160.85
00356:	46	46	37.10	-112	5.60	3951.0 mt	980360.21	980765.46	0.89	-134.76	-1.25	0.00	-33.80	-168.91	-160.31
00356:	47	46	37.23	-112	5.60	3947.0 mt	980362.37	980765.66	0.86	-134.62	-1.25	0.00	-32.21	-167.22	-158.63
00356:	48	46	34.26	-112	4.32	4414.0 mt	980326.91	980761.19	2.77	-150.55	-1.33	0.00	-19.30	-168.41	-158.91

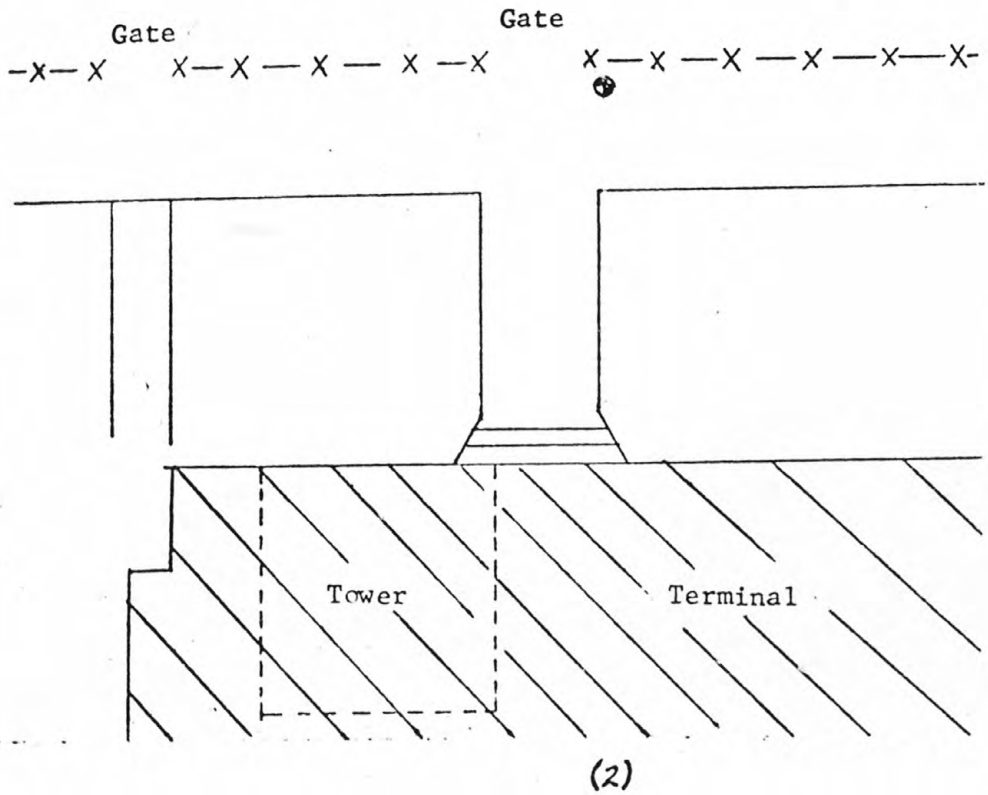
GRAVITY BASE STATION

LATITUDE	STATION DESIGNATION
46° 36.5' N (1)	HELENA
LONGITUDE	
111° 59.5' W (1)	
ELEVATION	**COUNTRY/STATE**
1180.5 METERS (1)	USA/Montana

REFERENCE CODE NUMBERS		ADOPTED GRAVITY VALUE	
ACIC 0475-0		g= 980 363.50 mgals	
IGC 15661J			
WA 31			
		ESTIMATED ACCURACY	DATE
		± 0.1 mgals	MONTH/YEAR Aug/1968

DESCRIPTION AND/OR SKETCH

Station is located at Helena, Mont., Municipal Airport, at the gate of the barrier, on the ramp side of the terminal building, opposite the terminal exit to planes, on the asphalt. (1)



(2)

Figure 2.--Helena Municipal Airport base station statistics.

REFERENCE SOURCE

(1) 01355 (2) 05100

References

Defense Mapping Agency Aerospace Center, 1974, World Relative Gravity Reference Network, North America, Part 2: Defense Mapping Agency Aerospace Center Reference Publication 25, with supplement updating gravity values to the International Gravity Standardization Net 1971, 1635 p.

International Association of Geodesy, 1967, Geodetic Reference System, 1967: International Association of Geodesy Special Publication 3, 74 p.