RESIDUAL GRAVITY ANALYSIS OF SELECTED CROSS SECTIONS
OF THE HANFORD RESERVATION

by

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to

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ABSTRACT

Gravity data were collected along selected sites on the Hanford reservation. Residual gravity profiles were calculated. These data were then modeled using the Talwani two-dimensional gravity model. Analysis of these models suggests the location of several buried stream channels. The northern channel is believed to represent the ancestral Columbia when it flowed through a synclinal trough between Gable Mountain and Gable Butte, and the southern channel is believed to reflect a previous location of the Yakima River.

INTRODUCTION

PURPOSE AND SCOPE

This study expands the work previously reported by Deju and Richard¹ along selected profiles on the Hanford reservation. Gravity data were gathered along these profiles with a 200- to 1,000-foot station spacing. These data were gathered during the summer of 1975 and were subsequently analyzed. The resultant residual gravity profiles are examined to determine:

1. The locations of potential buried stream channels;
2. The character of the bedrock surface;
3. The value of detailed gravity profiles to improve the knowledge of the bedrock surface.

Error analysis and field verification of the results were conducted to assure credibility of the conclusions.

PREVIOUS WORK

The original Bouguer gravity study of the area was conducted by Peterson.^{2,3} Deju and Richard¹ further refined the above data by removing the topographic and regional gravity effects. All these studies have an average station density of less than one station per square mile and totally lack data in some key areas.

The previous work established areas where there could be a buried stream channel or where there were lows in the basalt bedrock surface. Because of the sparsity of data, additional gravity studies were needed to refine the definition of these anomalies.

GRAVITY STUDY

INTRODUCTORY COMMENTS

Five different sites were defined for detailed residual gravity profiles (Figure 1). These were:

1. Gable Mountain Profile (Figure 1, Profile A-B);
2. Gable Butte Profile (Figure 1, Profile C-D);
3. North-South Gable Mountain-Gable Butte Profile (Figure 1, Profile E-F);

4. Yakima Barricade Profile (Figure 1, Profile G-H); and,
5. 300 Area Profile (Figure 1, Profile I-J).

Profiles 1, 2, and 3 were selected because the original study by Deju and Richard¹ indicated possible buried stream channels and a bedrock high to the south of Gable Mountain and Gable Butte. The station spacing was selected to assure enough detail to identify any buried bedrock channels that may be present. Profile 4 was selected to add detail to a major basalt bedrock low shown in the former study. Because this was a large low, altimeter elevation control and a coarser station density gave adequate results. The site of Profile 5 is the location of a possible outlet of one of the buried stream channels from the Pasco Basin. As this would be a major channel, a coarse station density and altimeter elevation control were also adequate to delineate the channel.

The first two profiles had a 200-foot station spacing and an elevation accuracy of ± 0.01 foot. The third profile had a 300-foot station spacing with the same elevation control. Profiles 4 and 5 were reconnaissance profiles. Profile 4 had a station spacing of about 500 feet, and Profile 5 had a station spacing of about 1,000 feet. Elevations for these stations were determined to an accuracy of ± 3 feet with a Paulin Altimeter. A total of 348 stations were investigated to determine gravity variations along these profiles.

FIELD PROCEDURES

The stations of Profiles 1 through 3 were taped with a 100-foot tape and surveyed with a Zeis Ni-1 level to an elevation accuracy of ± 0.01 foot. The stations of Profile 4 were also located with a tape, but the elevations were established with a Paulin Altimeter. The altimeter survey was conducted in early morning on meteorologically quiet days. The surveys were completed before there was a temperature inversion. This provided the most stable altimeter operation. Drift curves for the altimeter were constructed from multiple base station readings. These curves were then compared with the drift of the barometer of the Battelle-Northwest Meteorological Station for consistency. Except for possible individual station errors, this survey yielded an elevation accuracy of ± 3 feet. The station spacing of Profile 5 was located with distances measured with a field vehicle odometer and then further located using roads, section lines, and other political features.

The elevations were also determined using an altimeter, but, in this case, after the temperature inversion. The drift curve was constructed in the same way as Profile 4 and again compared to the Battelle-Northwest Meteorological Station barometer. This profile has the same accuracy as Profile 4. It should be noted, however, that wind gusts did exist during the recording of Stations 25 through 35 and these gusts could have caused some errors in the elevation readings.

All gravity data were gathered with a Lacoste and Romberg gravity meter that has a reading precision of ± 0.01 milligal. Station 0-1 of the Gable Mountain Profile was used as the prime base station. This station was tied into the Richland Airport base station of Peterson³ with three loops to assure a correct tie. This tie gives Station 0-1 an observed gravity value of 980.68962 centimeters per square second. The first station of each profile was established as a secondary base station and tied into Station 0-1 of the Gable Mountain Profile with three loops to assure a correct tie. Tidal variation and instrument drift were removed from the readings by returning to the base station every two hours and plotting a drift curve from these readings.

DATA CORRECTIONS

The following field data corrections were made to examine the relative gravity anomalies caused by shallow density variations.

1. Corrections that move all field data to a common datum (450-foot elevation in this report):
 - a. Free air correction (0.09406 milligal per foot)--this correction added if the datum is below the elevation of the field point;
 - b. Bouguer correction (0.0127 x density per foot)--this correction is subtracted if the datum is below the elevation of the field station; a density of unsaturated glaciofluvial materials (1.7 grams per cubic centimeter) was used for this reduction.
2. Corrections that remove variations caused by differences in the time of the reading and the horizontal location of the station:
 - a. Drift and tidal effects--this correction is determined by reading a base station value every two hours, plotting this variation as a function of time, and removing this time variation from all station values;

- b. Horizontal location corrections--this correction is a latitude correction; gravity increases to the north and decreases to the south. The magnitude of this change is $1.307 \sin 2\theta$ milligals per mile, where θ is the latitude. If the station is south of the base station, this value must be added; if north, subtracted.
3. Corrections for irregular terrain--this correction adds the values to the field data that eliminate errors in the Bouguer anomaly caused by valleys and hills adjacent to the field station. This requires the use of an overlay on a topographic map, the establishment of an average elevation for each of many sectors in the overlay, multiplying these elevations by constants, adding all these numbers together and multiplying the resultant number by a constant that is a ratio of the density of the basalt (2.86 grams per cubic centimeter) to 2.0 grams per cubic centimeter (this ratio is 1.43). Dobrin⁴ describes this method in detail. Where these corrections were made in this report, they were taken from a map produced this way by Deju and Richard.¹
4. Removal of deep-seated variations--this is more qualitative than all other corrections and is thus subject to a larger error. This study removed the regional variation from all profiles, except the one at the Yakima Barricade, by using a third order polynomial surface constructed from data points exclusive of data over known areas of thick cover over the basalt surface. The polynomial data are subtracted from the terrain-corrected data to produce residual surfaces representative of the shallow density variations. The Yakima Barricade Profile was too close to the edge of the map for the residual surface to be valid. For this reason, the deep-seated effects were assumed to vary uniformly from one end of the profile to the other.

ERROR ANALYSIS AND LIMITATIONS

Quantitative evaluation of the profiles is difficult because accurate average density measurements of glaciofluvial material and the Ringold Formation are not available. The Talwani, et al.,⁵ two-dimensional gravity model was used to calculate the geologic profiles of the gravity profiles. The controls for these models are as follows:

1. Gravity data--error in data is shown by error flags on Plate 1;
2. Well logs--all wells that reached bedrock depth were used in the original bedrock profile;
3. A density contrast of .65 grams per cubic centimeter between water-saturated glaciofluviatile and Ringold Formation materials to the basalt.

There is no way to determine:

1. The percent error in density;
2. Precise depths to the basalt surface along the gravity profiles;
3. The amount the profiles deviate from the assumptions for the two-dimensional model.

For these reasons, the following results must be considered qualitative.

RESULTS

GABLE MOUNTAIN PROFILE

Table 1 in the Appendix lists the relative Bouguer and residual gravity anomalies for the stations of the Gable Mountain Profile (see Figure 1 for profile location). Comparison of the residual anomaly of this profile to the residual gravity map of the Hanford reservation¹ shows general agreement. This profile cuts across an anticlinal structure in the basalt. The residual anomaly shows steps (see Plate 1). These steps are believed to be caused by buried basalt cliffs.

GABLE BUTTE PROFILE

Table 2 in the Appendix lists the relative Bouguer and residual gravity anomalies for the stations of the Gable Butte Profile (see Figure 1 for profile location). Comparison of this profile to the residual gravity map of the Hanford reservation¹ shows general agreement, as did the Gable Mountain Profile. The residual anomaly also cuts across the same bedrock high (see Plate 1).

NORTH-SOUTH GABLE MOUNTAIN-GABLE BUTTE PROFILE

Table 3 in the Appendix lists the relative Bouguer and residual gravity anomaly for the stations of this profile (see Figure 1 for profile location).

Comparison of this profile to the residual gravity map of the Hanford reservation¹ shows only partial agreement (see Plate 1). This profile is perpendicular to an anticlinal structure in the basalt. Deju and Richard¹ show the structure as a major anticline that is to the south of Gable Mountain and Gable Butte. This profile shows the structure as a double anticline with a minor syncline between. Gable Mountain projects into the northern anticline and the southern anticline is at the same position as the one shown by Deju and Richard.¹ Plate 1 shows the magnitude of the anomaly. This profile demonstrates that the gravity does relate to the surface expressions of the basalt, but that there is a buried, more dominant structure to the south of Gable Mountain.

YAKIMA BARRICADE PROFILE

Table 4 in the Appendix lists the relative Bouguer and residual gravity anomaly for the stations of this profile (see Figure 1 for profile location). Though this profile was a reconnaissance study with significant errors in individual station values caused by errors in horizontal positioning and elevation errors, it shows significant results (see Plate 1). The profile has a 3.6-milligal anomaly with a ± 1.4 -milligal error per station reading. The low is at the site of the Cold Creek synclinal axis. The residual gravity map of the Hanford reservation¹ shows a 3- to 6-milligal low that delineates the Cold Creek synclinal structure. This profile continues this low into Cold Creek Valley where it is confined between Umtanum and Yakima ridges.

300 AREA PROFILE

Table 5 in the Appendix lists the values of the relative Bouguer and residual gravity anomaly for the stations of this profile (see Figure 1 for profile location). This profile, like the Yakima Barricade Profile, had significant horizontal position and elevation errors--producing an estimated ± 1.3 -milligal error. As in the previous profile, there is a significant gravity low that coincides with the position of the axis of the Cold Creek syncline on the residual gravity map of the Hanford reservation¹ (see Plate 1).

TWO-DIMENSIONAL GRAVITY MODEL RESULTS

The above profiles were modeled using the Talwani⁵ original computer program for two-dimensional gravity models. This program computes the gravity effects of each N-sided vertical polygon in the model on specific field points. It then plots the gravity profile that would exist if the geology is as described in the model. For the model to be correct, the following conditions must be satisfied:

1. The actual body causing the anomaly must be long enough relative to its width to be considered infinite in the long dimension;
 2. The body must be totally below or above the elevation of the gravity station;
 3. Either the density, contrast of the material within the polygon to the surrounding material, or the shape of the polygon must be known.
- Conditions 1 and 2 are reasonably well satisfied, but the error in these conditions cannot be quantitatively established. Condition 3 is not well satisfied. In most cases, well data are far enough from the specific profile to be of little value and density estimates of the material covering the basalt surface are subject to significant, but unknown, error.

Because of the unknowns listed above, the models shown in Figure 2 must be considered valid only if the following assumptions are valid:

1. The water table during the gravity measurements was as shown in the December 1975 water table map of the Hanford reservation;⁶
2. The density of unsaturated glaciofluvial material is 1.7 grams per cubic centimeter;
3. The density of water-saturated materials above the basalt is 0.65 gram per cubic centimeter lower than the basalt density;
4. The basalt surface is predictable and can be projected from known well sites to the profiles.

As all these conditions cannot be proven valid for any profile, the profiles must be considered as one of several possible causes of the gravity variations. Figure 2 shows the geologic profiles that the author believes exist based on the above assumptions.

FIGURE 2

TWO-DIMENSIONAL GRAVITY MODELS OF THE PROFILE SHOWN ON FIGURE 1

A-B = GABLE MOUNTAIN, C-D = GABLE BUTTE, E-F = NORTH-SOUTH GABLE MOUNTAIN-GABLE BUTTE,
G-H = YAKIMA BARRICADE, I-J = 300 AREA

CONCLUSIONS

This study has verified the existence of gravity lows at selected sites in the Hanford reservation. The lows are considered to mainly reflect differences in the depth to the basalt surface. These lows probably were sites of ancestral river systems. As such, they would be filled with coarse, better sorted materials than the average basin fill and, therefore, be sites of highly permeable deposits. Figure 3 shows two ancestral river valleys suggested by this study. The northern one may have been an ancestral Columbia channel, whereas the southern one may have been an ancestral Yakima channel. The locations of these channels appear to be supported also by the residual gravity map of the Hanford reservation¹ and the bedrock contour map of the Hanford reservation by Summers and Deju.⁷

The gravity data and surface geology suggest that the channel going between Gable Mountain and Gable Butte may have flowed through a synclinal trough, then cut south across a presently buried anticlinal structure into the Cold Creek syncline. Geologic data in Cold Creek Valley indicate that the Yakima River probably occupied this valley in the past. If so, it would have followed the Cold Creek syncline as shown in Figure 3.

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FIGURE 3

LOCATION OF POSSIBLE BURIED RIVER CHANNELS SUGGESTED BY
THE GRAVITY PROFILES SHOWN IN FIGURE 1 AND THE RESIDUAL GRAVITY MAP
OF THE HANFORD RESERVATION¹

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APPENDIX

TABLE 1

GABLE MOUNTAIN GRAVITY PROFILE DATA

Distance East of A, Profile A-B, Figure 1 (in feet)	Elevation (in feet)	Relative Bouguer Gravity Anomaly (in mgal)	Regional Gravity Correction (in mgal)	Residual Gravity Anomaly (in mgal)
0	561.21	8.06	0	8.06
200	561.23	7.98	+.01	7.99
400	561.22	7.97	+.02	7.99
600	558.82	7.80	+.03	7.83
800	554.26	7.86	+.04	7.90
1000	549.99	7.93	+.05	7.98
1200	548.21	7.95	+.06	8.01
1400	548.37	8.00	+.07	8.07
1600	548.74	7.96	+.07	8.03
1800	549.11	8.02	+.08	8.10
2000	549.73	8.06	+.09	8.15
2200	550.19	8.09	+.10	8.19
2400	550.79	8.13	+.10	8.23
2600	551.81	8.21	+.11	8.32
2800	552.52	8.26	+.12	8.38
3000	553.44	8.33	+.13	8.46
3200	554.25	8.39	+.14	8.53
3400	555.03	8.51	+.14	8.66
3600	555.21	8.52	+.15	8.67
3800	555.65	8.55	+.16	8.71
4000	556.01	8.51	+.17	8.68
4200	556.57	8.64	+.17	8.81
4400	556.57	8.61	+.18	8.79
4600	554.48	8.62	+.19	8.80
4800	549.43	8.62	+.20	8.82
5000	542.44	8.58	+.20	8.78
5200	537.40	8.73	+.21	8.94
5400	535.73	8.61	+.22	8.83
5600	535.58	8.65	+.22	8.87
5800	536.14	8.74	+.23	8.97
6000	536.50	8.70	+.24	8.94
6200	536.84	8.68	+.25	8.93
6400	537.74	8.70	+.25	8.95
6600	539.18	8.73	+.26	8.99
6800	540.65	8.71	+.27	8.98
7000	542.02	8.77	+.28	9.05
7200	543.49	8.83	+.29	9.12
7400	544.75	8.80	+.29	9.09
7600	545.24	8.76	+.30	9.06
7800	547.64	8.79	+.31	9.09
8000	548.45	8.68	+.31	8.99
8200	548.52	8.70	+.32	9.02
8400	548.77	8.62	+.33	8.95
8600	548.77	8.60	+.34	8.94
8800	548.69	8.66	+.35	9.01
9000	549.03	8.76	+.36	9.12
9200	549.17	8.81	+.36	9.17
9400	550.52	8.99	+.37	9.46

Table 1 (continued)

Distance East of A, Profile A-B, Figure 1 (in feet)	Elevation (in feet)	Relative Bouguer Gravity Anomaly (in mgal)	Regional Gravity Correction (in mgal)	Residual Gravity Anomaly (in mgal)
9600	547.82	8.93	+.37	9.30
9800	547.66	8.90	+.38	9.28
10000	547.52	8.77	+.39	9.16
10200	547.50	8.70	+.40	9.10
10400	547.71	8.73	+.40	9.13
10600	547.90	9.37	+.41	9.78
10800	537.14	9.78	+.41	10.19
11000	516.88	9.66	+.42	10.18
11200	504.15	9.55	+.42	9.97
11400	495.95	9.57	+.43	10.00
11600	486.84	9.89	+.44	10.33
11800	476.87	9.73	+.45	10.18
12000	470.77	9.49	+.46	9.95
12200	465.22	9.02	+.47	9.49
12400	464.55	8.81	+.48	9.29
12600	464.67	8.72	+.49	9.21
12800	464.12	8.67	+.49	9.16
13000	463.75	8.63	+.50	9.13
13200	454.18	8.02	+.52	8.54
13400	454.04	7.92	+.54	8.46
13600	455.05	7.92	+.57	8.49
13800	456.49	7.94	+.59	8.53
14000	458.00	7.92	+.62	8.54
14200	459.09	7.97	+.64	8.61
14400	460.68	7.83	+.67	8.50
14600	462.30	7.77	+.70	8.47
14800	463.70	7.65	+.72	8.37
15000	465.20	7.73	+.74	8.47
15200	456.66	6.99	+.77	7.76
15400	461.38	7.20	+.80	8.00
15600	458.86	6.90	+.82	7.72
15800	460.86	6.95	+.85	7.80

TABLE 2

GABLE BUTTE GRAVITY PROFILE DATA

Distance East of C, Profile C-D, Figure 1 (in feet)	Elevation (in feet)	Relative Bouguer Gravity Anomaly (in mgal)	Regional Gravity Correction (in mgal)	Residual Gravity Anomaly (in mgal)
0	741.85	5.69	+.90	6.59
200	738.09	5.77	+.88	6.65
400	734.09	5.79	+.86	6.65
600	729.61	5.78	+.83	6.61
800	725.54	5.78	+.81	6.59
1000	722.82	5.85	+.78	6.63
1200	720.30	5.79	+.76	6.55
1400	717.52	5.92	+.74	6.66
1600	714.69	5.92	+.71	6.63
1800	712.33	5.96	+.68	6.64
2000	708.62	6.01	+.66	6.65
2200	703.68	6.10	+.63	6.73
2400	698.18	6.04	+.60	6.64
2600	693.82	6.10	+.60	6.70
2800	691.35	6.09	+.59	6.68
3000	689.90	6.14	+.58	6.72
3200	688.32	6.15	+.58	6.73
3400	687.06	6.16	+.57	6.72
3600	685.86	6.15	+.56	6.71
3800	684.35	6.13	+.55	6.68
4000	683.93	6.33	+.54	6.87
4200	682.48	6.35	+.53	6.88
4400	681.20	6.39	+.52	6.91
4600	679.84	6.40	+.51	6.91
4800	678.33	6.42	+.50	6.91
5000	677.08	6.48	+.49	6.97
5200	675.66	6.53	+.48	7.01
5400	674.01	6.56	+.47	7.01
5600	670.85	6.60	+.46	7.06
5800	666.37	6.71	+.45	7.16
6000	663.20	6.75	+.45	7.20
6200	661.96	6.75	+.44	7.19
6400	661.60	6.81	+.43	7.24
6600	660.67	6.85	+.42	7.27
6800	659.87	6.76	+.41	7.17
7000	659.28	6.82	+.40	7.18
7200	658.88	6.89	+.39	7.28
7400	658.23	6.94	+.38	7.32
7600	658.25	7.01	+.37	7.38
7800	659.41	7.06	+.36	7.42
8000	657.33	7.03	+.35	7.38
8200	656.06	7.10	+.34	7.44
8400	654.51	7.10	+.33	7.43
8600	653.27	7.25	+.32	7.57
8800	652.35	7.30	+.31	7.61
9000	652.77	7.35	+.30	7.65
9200	653.35	7.40	+.29	7.69
9400	654.07	7.45	+.28	7.73
9600	654.93	7.56	+.27	7.83

Table 2 (continued)

Distance East of C, Profile C-D, Figure 1 (in feet)	Elevation (in feet)	Relative Bouguer Gravity Anomaly (in mgal)	Regional Gravity Correction (in mgal)	Residual Gravity Anomaly (in mgal)
9800	655.28	7.61	+.26	7.87
10000	654.37	7.63	+.26	7.89
10200	653.59	7.65	+.25	7.90
10400	653.12	7.68	+.24	7.91
10600	652.38	7.71	+.23	7.94
10800	652.53	7.81	+.22	8.03
11000	650.78	7.74	+.21	7.95
11200	650.06	7.73	+.20	7.93
11400	649.33	7.65	+.20	7.85
11600	648.88	7.70	+.19	7.89
11800	648.86	7.60	+.18	7.78
12000	648.78	7.64	+.17	7.81
12200	648.84	7.72	+.17	7.89
12400	648.76	7.84	+.16	8.00
12600	648.24	7.99	+.15	8.14
12800	647.42	8.07	+.14	8.21
13000	646.54	8.07	+.13	8.20
13200	646.16	8.12	+.12	8.24
13400	645.65	8.15	+.11	8.26
13600	645.14	8.16	+.10	8.26
13800	644.50	8.19	+.09	8.28
14000	643.72	8.21	+.08	8.29
14200	643.32	8.26	+.07	8.33
14400	642.00	8.29	+.06	8.35
14600	641.74	8.24	+.05	8.29
14800	641.22	8.21	+.04	8.25
15000	640.08	8.33	+.03	8.36
15200	639.08	8.20	+.02	8.22
15400	638.88	8.39	+.01	8.40
15600	638.05	8.44	0	8.44
15800	636.64	8.42	0	8.42

TABLE 3

NORTH-SOUTH GABLE MOUNTAIN-GABLE BUTTE GRAVITY PROFILE DATA

Distance South of E, Profile E-F, Figure 1 (in feet)	Elevation (in feet)	Relative Bouguer Gravity Anomaly (in mgal)	Regional Gravity Correction (in mgal)	Residual Gravity Anomaly (in mgal)
0	533.46	4.99	+.55	5.54
300	534.73	4.95	+.54	5.49
600	535.26	4.91	+.54	5.45
900	536.09	4.86	+.53	5.39
1200	536.52	4.73	+.52	5.25
1500	535.98	4.77	+.51	5.28
1800	537.19	4.65	+.50	5.15
2100	536.40	4.63	+.49	5.12
2400	535.45	4.73	+.49	5.22
2700	534.54	4.59	+.48	5.07
3000	533.93	4.51	+.48	4.98
3300	532.92	4.45	+.46	4.91
3600	532.04	4.45	+.45	4.90
3900	531.16	4.44	+.44	4.88
4200	529.43	4.44	+.44	4.88
4500	523.94	4.36	+.43	4.79
4800	515.34	4.38	+.42	4.80
5100	503.80	4.44	+.41	4.85
5400	496.93	4.53	+.40	4.93
5700	494.65	4.56	+.39	4.95
6000	494.05	4.62	+.39	5.01
6300	493.69	4.90	+.38	5.28
6600	492.84	5.17	+.37	5.54
6900	492.30	5.60	+.36	5.96
7200	491.85	6.44	+.35	6.79
7500	490.88	7.31	+.34	7.65
7800	490.44	7.75	+.34	8.09
8100	489.99	8.07	+.33	8.40
8400	489.13	8.25	+.32	8.57
8700	486.77	8.04	+.31	8.35
9000	485.93	8.17	+.30	8.47
9300	484.34	8.14	+.29	8.37
9600	482.88	8.20	+.29	8.49
9900	481.54	8.22	+.28	8.50
10200	481.78	8.33	+.27	8.60
10500	484.14	8.33	+.26	8.59
10800	486.89	8.14	+.25	8.39
11100	489.97	8.05	+.25	8.30
11400	492.36	7.86	+.24	8.10
11700	493.97	7.77	+.23	8.00
12000	493.85	7.54	+.22	7.76
12300	495.67	7.38	+.21	7.59
12600	503.74	7.26	+.20	7.46
12900	519.19	7.31	+.20	7.51
13200	534.96	7.46	+.19	7.65
13500	546.82	7.65	+.18	7.83
13800	555.25	7.99	+.17	8.16
14100	564.72	8.52	+.16	8.68
14400	566.39	8.53	+.16	8.69
14700	567.46	8.77	+.15	8.92
15000	568.35	9.03	+.14	9.17
15300	569.15	9.11	+.13	9.24

Table 3 (continued)

Distance South of E, Profile E-F, Figure 1 (in feet)	Elevation (in feet)	Relative Bouguer Gravity Anomaly (in mgal)	Regional Gravity Correction (in mgal)	Residual Gravity Anomaly (in mgal)
15600	570.06	9.19	+.12	9.31
15900	571.04	9.18	+.11	9.29
16200	571.81	9.19	+.11	9.30
16500	572.83	9.10	+.10	9.20
16800	573.69	9.17	+.09	9.26
17100	573.38	9.12	+.08	9.20
17400	572.34	9.07	+.07	9.14
17700	570.62	9.05	+.06	9.11
18000	568.30	9.01	+.06	9.07
18300	566.24	8.97	+.05	9.02
18600	565.58	8.86	+.04	8.90
18900	561.94	8.72	+.03	8.75
19200	559.68	8.77	+.02	8.79
19500	560.02	8.69	+.02	8.71
19800	561.16	8.72	+.01	8.73
20100	562.76	8.64	0	8.64
20400	564.32	8.71	-.01	8.70
20700	565.77	8.61	-.02	8.59
21000	567.39	8.58	-.03	8.55
21300	572.37	8.54	-.03	8.51
21600	584.87	8.35	-.03	8.32
21900	599.47	8.31	-.04	8.27
22200	602.14	7.59	-.05	7.52
22500	610.72	7.70	-.05	7.65
22800	618.52	7.76	-.06	7.70
23100	626.11	7.60	-.07	7.53
23400	634.67	7.55	-.08	7.47
23700	643.96	7.63	-.09	7.54
24000	652.48	7.51	-.10	7.42
24300	659.88	7.41	-.10	7.31
24600	666.78	7.39	-.11	7.28
24900	672.74	7.29	-.12	7.17
25200	678.62	7.25	-.13	7.12
25500	683.76	7.25	-.14	7.11
25800	689.54	7.22	-.15	7.07
26100	694.79	7.19	-.15	7.04
26400	698.41	7.13	-.16	6.97
26700	701.35	7.09	-.17	6.92
27000	704.24	6.92	-.18	6.74
27300	706.36	6.81	-.19	6.62
27600	707.05	6.76	-.20	6.56
27900	708.15	6.62	-.21	6.41
28200	711.16	6.62	-.21	6.41
28500	712.69	6.47	-.22	6.25
28800	715.04	6.27	-.23	6.04
29100	716.42	6.24	-.24	6.00
29400	716.76	6.22	-.25	5.97
29700	717.44	6.17	-.26	5.91
30000	717.30	6.05	-.26	5.79
30300	718.63	6.06	-.27	5.79
30600	723.82	5.99	-.28	5.71
30900	728.25	5.91	-.29	5.62
31200	725.76	5.85	-.30	5.55
31500	717.18	5.73	-.31	5.42
31800	708.84	5.69	-.31	5.38
32100	708.58	5.65	-.32	5.33
32400	716.56	5.41	-.33	5.08
32700	727.95	5.57	-.34	5.23

TABLE 4

YAKIMA BARRICADE GRAVITY PROFILE DATA

Distance South of G, Profile G-H, Figure 1 (in feet)	Elevation (in feet)	Relative Bouguer Gravity Anomaly (in mgal)	Topographic Correction (in mgal)	Topographically Corrected Bouguer Anomaly (in mgal)	Regional Gravity Correction (in mgal)	Residual Gravity Anomaly (in mgal)
0	782	5.96	.14	6.10	-3.00	3.10
500	786	5.76	.14	5.90	-3.07	2.83
1000	787	5.38	.15	5.53	-3.13	2.40
1500	794	5.81	.16	5.97	-3.20	2.77
2000	791	5.34	.17	5.41	-3.27	2.14
2500	796	5.73	.18	5.91	-3.33	2.58
3000	796	5.74	.19	5.93	-3.40	2.53
3500	798	5.53	.20	5.73	-3.47	2.26
4000	798	5.55	.21	5.56	-3.53	2.03
4500	801	5.47	.22	5.69	-3.60	2.09
5000	796	5.05	.23	5.28	-3.67	1.61
5500	803	5.44	.24	5.68	-3.73	1.95
6000	799	5.00	.25	5.25	-3.80	1.45
6500	802	5.02	.26	5.28	-3.87	1.41
7000	799	4.61	.27	4.88	-3.93	.95
7500	800	4.32	.28	4.60	-4.00	.60
8000	798	4.29	.29	4.58	-4.07	.51
8500	795	4.50	.30	4.80	-4.13	.67
9000	795	3.96	.31	4.27	-4.20	.07
9500	795	4.26	.32	4.58	-4.27	.31
10000	795	4.56	.33	4.89	-4.33	.56
10500	801	4.14	.34	4.48	-4.40	.08
11000	795	4.22	.35	4.57	-4.47	.10
11500	790	5.39	.36	5.75	-4.53	1.22
12000	782	5.06	.37	5.43	-4.60	.83
12500	793	5.30	.38	5.68	-4.67	1.01
13000	790	4.94	.39	5.39	-4.73	.66
13500	758	4.91	.40	5.31	-4.80	.51
14000	732	4.62	.40	5.02	-4.87	.25
14500	735	4.60	.40	5.00	-4.93	.07
15000	737	4.61	.40	5.01	-5.00	.01
15500	729	3.77	.40	4.17	-5.07	-.09
16000	730	3.85	.40	4.25	-5.13	-.88
16500	736	4.20	.40	4.60	-5.20	-.60
17000	746	4.85	.41	5.26	-5.27	-.01
17500	762	4.96	.41	5.37	-5.33	-.04
18000	777	4.86	.41	5.27	-5.40	-.13
18500	796	4.53	.41	4.94	-5.47	-.53
19000	783	5.66	.42	6.08	-5.53	.55
19500	798	4.88	.43	5.31	-5.60	-.29
20000	837	6.10	.44	6.54	-5.67	.87
20500	853	5.83	.45	6.28	-5.73	.55
21000	899	7.31	.46	7.77	-5.80	1.97
21500	920	7.99	.47	8.46	-5.87	2.59
22000	905	7.42	.48	7.90	-5.93	1.97
22500	903	8.71	.49	9.20	-6.00	3.20

TABLE 5

300 AREA GRAVITY PROFILE DATA

Distance West of I, Profile I-J, Figure 1 (in feet)	Distance South of I, Profile I-J, Figure 1 (in feet)	Elevation (in feet)	Relative Bouguer Gravity (in mgal)	Regional Gravity Correction (in mgal)	Residual Gravity Anomaly (in mgal)
2650	2350	393	-4.13	-0.59	-4.72
3000	2700	391	-4.15	-0.68	-4.83
3350	3050	378	-4.83	-0.77	-5.60
3800	3400	386	-4.20	-0.86	-5.06
4200	3750	388	-3.95	-0.95	-4.90
4700	4200	385	-3.72	-1.13	-4.85
5300	4700	377	-3.12	-1.32	-4.44
6100	5500	382	-3.15	-1.55	-4.70
6900	6250	386	-3.28	-1.73	-5.01
7750	6950	406	-3.47	-1.91	-5.38
8500	7650	423	-3.18	-2.09	-5.27
9400	8350	438	-3.13	-2.27	-5.40
10500	9150	439	-2.96	-2.36	-5.32
10550	9700	438	-3.20	-2.50	-5.70
7350	10150	394	-3.81	-1.77	-5.58
8100	10800	410	-3.62	-1.87	-5.48
8900	11400	414	-3.26	-2.40	-5.66
9650	12000	425	-3.40	-2.60	-6.00
10550	12750	433	-3.06	-2.91	-5.97
11200	13550	446	-2.79	-3.09	-5.88
11900	14250	443	-2.27	-3.20	-5.47
12550	15100	424	-3.24	-3.34	-6.58
13300	15850	436	-1.99	-3.48	-5.47
14350	16250	422	-2.32	-3.62	-5.94
15250	16750	429	-1.73	-3.76	-5.49
16000	16550	422	-1.88	-3.90	-5.78
16650	16250	413	-1.71	-4.00	-5.71
16650	18600	390	-0.92	-4.00	-4.92
17800	18700	388	-1.09	-4.10	-5.19
18950	18700	388	-0.86	-4.20	-5.06
20100	18750	386	-1.12	-4.30	-5.42
21100	18750	390	-0.40	-4.40	-4.80
21950	18750	390	-0.23	-4.50	-4.73
22400	19850	385	-0.67	-4.65	-5.32
22750	20600	410	-0.52	-4.75	-5.27
0	0	396	-4.09	0	-4.09