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Survey of helium in natural water wells and springs in southwest Montana and vicinity and Imperial Valley, California Part III - Jan. 1 - Dec. 31, 1980

By

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Survey of helium in natural water wells and springs in southwest Montana and vicinity and Imperial Valley, California
Part III - January 1-December 31, 1980

This is a continuing report on an earthquake-prediction project based on helium analysis of water from wells and springs. The two previous reports, Open-File 80-181 and 80-1257, covered the period from September 1977 through December 1979, and gave the helium contents from springs and wells located in and near southwestern Montana. This report is for 1980 data and presents, in Fig. 3 through 46, the helium contents from seventeen stations in southwestern Montana and vicinity and from seven new stations in the Imperial Valley of southern Calfornia. A few stations did not send in samples for the complete year or were discontinued during the year. Some collectors in Montana moved away, but we were able to secure replacements. This accounts for station names changes, and for gaps in the data. A brief description of all stations is given in Table 1, and their location is shown on maps of Figures 1 and 2.

The method of sample collecting and analyzing on a mass spectrometer as given in Open-File Report 80-181 has remained the same for this period. The method of calculating the data is the same except for three small changes. These changes are explained below and consist of (1) correcting the data for the presence of helium in the "empty" Vacutainer; (2) reporting total helium, rather than the amount of helium above that in ambient air, as has been done previously; and (3) recalibration of reference gases. We had not been correcting the data for the residual helium in the Vacutainer vials. These vials as manufactured contain one-fifth of an atmosphere of air. We have found that these vials differentially absorb helium from the outside air, mainly through the rubber stopper. At the beginning of each month the helium contents are measured from five unused vials that were manufactured at the same time as the vials used in collecting water samples. The average helium

content in these five vials is subtracted from the helium content measured in each unknown sample. This Vacutainer blank was 730 parts per billion per milliliter of sample water in July and gradually increased to 850 ppb/ml in December. This correction is shown on the graphs of each station beginning about April 19 (Julian day 110). Because this value is relatively small, there appears to be little change on the graphs except for stations 301, 308, 311, 312, 313, 319, 321, 344, 346, and 347, which had low helium contents. This apparent decrease in helium concentration is noted on these station graphs by an asterisk (*).

In previous reports the helium contents shown on the graphs were those above that of ambient air, which contains 5.24 ppm helium. The graphs beginning July 1 (Julian day 183) show the total amount of helium in each sample, rather than the amount above ambient air.

In previous reports we have calculated the helium contents by comparing them to only two reference gases that were calibrated by comparing them with two standard gases that were analyzed by the U.S. Bureau of Mines (USBM) Research and Analytical Services Laboratory in Amarillo, Texas. We used ambient air having a constant concentration of 5.24 ppm as a low reference point, and a gas analyzed in our laboratory to contain 9.7 ppm of helium as a high reference point. These two gases were used to measure helium in low helium samples. The high helium samples from stations 300, 317, and 318 were compared to ambient air and a high reference gas analyzed to contain 4,300 ppm of helium. These two reference gases have too large a spread in helium contents to make very accurate analyses of many of our water samples.

We prepared 85 cubic foot compressed air cylinders containing various amounts of helium and had them analyzed for helium by the USBM Laboratory. These primary standards contain 8.2, 11.7, 80, 380, 1450, and 7700 ppm of

helium. We then prepared four 220-cubic-foot compressed-air cylinders that contained helium in concentrations in the range of the unknown samples. We determined the helium concentrations of these secondary reference gases by plotting the spectrometer chart values on a calibration graph on which are plotted on a straight line the USBM primary standard gases. These secondary reference gases contain 10.9, 54.3, 219, and 1012 ppm of helium. We also used ambient air as a reference gas. Two secondary reference gases that were higher and lower in helium concentration than each unknown sample were used as points to determine the helium content of each water sample. These gases were used to calculate the helium in the samples that were analyzed beginning July 1 (Julian day 183). These corrections gave more accurate results relative to each other station, but were no improvement in the absolute concentrations.

Station 312 shows a decreasing amount of helium, especially since April 19 (Julian day 110). We suspected that the concentration dropped to that of ambient air. We made a conclusive test which proved this to be the case. This test consisted of evacuating two sets of Vacutainers so they contained no helium. One set was filled with about 9 milliliters of water from Station 312 in each vial. The other set was filled with about 9 milliliters per vial of distilled water that had been exposed to air for a long time to insure that the helium dissolved in the water was in equilibrium with air. When analyses were conducted on the two sets of samples, each set contained precisely the same amount of helium. We, therefore, concluded that the water from Station 312 must be exposed to the air for sufficient time to allow it to come to equilibrium with ambient air. The water level in the warm pool at Mammouth Hot Springs from which this station's samples were taken had dropped considerably during the year 1980. Most of the helium reported before April 19 was due to helium already present in the Vacutainer before filling.

The data for the first two months of station 314 is very irratic. We are not sure what caused the large fluctuations which decreased during the last half of the year. Refer to the comments on this station in Table 1 regarding sampling from a new well. Station 316 reported a large variation through most of the year, but the value seemed to have become stable toward the end of the year. We cannot explain these changes.

There are numerous cases of sudden changes in helium content of the water samples, but with a few exceptions, there are very few stations showing any long-term changes that have not been accounted for by the previously mentioned three changes in methods of data calculation. Most of these departures from the expected helium concentration of each station tend to be lower and may be due to loss of some helium in collecting and transferring the sample to the Vacutainer.

Because there is such a large range in helium concentration from station to station, three scales are used on the graphs (Fig. 3 through 46). These are shown as 0-3000 ppb/ml, 0-30 ppm/ml, and 0-400 ppm/ml. In comparing data from various stations, be careful to take these three scales into account.

During 1980 the National Earthquake Information Service reported seven earthquakes having a magnitude of 3.0 or greater occurred in Montana and vicinity, and 30 earthquakes occurred in the Imperial Valley, California. Table 2 lists the seven earthquakes having a magnitude greater than 4.0 as well as the dates of occurrence and the location of the epicenters. There was only one (southwest of Gardiner, Montana) earthquake in the Montana area. Three quakes occurred on June 9 (Julian day 161), and the epicenters were located southeast of El Centro, California. The dates of these seven earthquakes are indicated by tick marks and Julian dates on the respective graphs. With the possible exception of Station 349, there does not appear to

be a relation between large helium concentration changes and earthquake occurrence up to three weeks before or after the quakes. Rodia Station 349 does appear to show a decrease in helium abundance beginning about 30 days prior to the earthquakes that occurred on Julian days 219 and 305. We do not observe any significant changes in helium prior to the Julian day 55 or 161 earthquakes.

The collection and analysis of samples from all of the stations is continuing.

ACKNOWLEDGMENTS

Guida Veronda joined the project on a part time basis, and has acted as liaison between the field collectors and the laboratory. She has been instrumental in enlarging the collection network in Montana, and beginning the new network in California.

We wish to thank all of the collectors who have made this continuing research effort possible.

Table 1.--Localities of helium-sampling stations

Station No.	Station Name	Address	Comments
300	Miller	Dick Miller River Route, Box 490 Gardiner, Montana 69030	58.5 m (192 ft) deep; well pump at 50.3 m (165 ft); pumped continuously at 7.6 lpm (2 gmp); water temp. 67°C, (153° F). This well is about 300 m (984 ft) from a small warm spring, and 1000 m (3281 ft) from La Duke Hot Springs, a large hot spring. The water is high in fluorine and iron.
301	Beer	Paul Hantelman U.S.G.S. Box 1049 West Yellowstone, Montana 59758	61 m (200 ft) deep; water source for service facility at Yellowstone National Park.
305	McAtee	Leonard McAtee Cameron, Montana 59720	61 m (200 ft) deep; domestic water supply.
307	Hunter's	Harold Johnson Box 132 Springdale, Montana 59082	Hunter's Hot Springs
308	Lapp	Allen L. Lapp Box 503 West Yellowstone, Montana 59758	Town well, 67.7 m (222 ft) deep; cased to 45.7 m (150 ft).
309	Povah	Pat Povah Deep Well Ranch West Yellowstone, Montana 59758	274 m (900 ft) well, artesian flow with 1.8 m (6 ft) head.
310	Chico	Mrs. Jean Weeter Pray, Montana 59065	Hot spring.
311	Ralston	Mrs. Claudette Ralston Route 1 Emigrant, Montana 59027	45.7 m (150 ft) deep; fully cased; 45.5-56.8 lpm (12-15 gpm); water temp. is 10°C (50°F).
312	Bathtub	Paul Miller River Route, Box 490 Gardiner, Montana 59030	Large warm pool at top of Mammoth Hot Springs; Yellowstone National Park.
313	Orr	Wesley Orr Ennis National Fish Hatchery Ennis, Montana 59729	Flowing Spring; 1515 lpm 400 gpm); water temp. is 12°C (54°F).

Table 1.-Localities of helium-sampling stations (Cont'd)

Station No.	Station Name	Address	Comments
314	Bozeman	E. M. Drake 133 Lower Rainbow Road Bozeman, Montana 59715	Wells that tap Bozeman Hot Spring; Up to Julian day 233 samples came from a 114.3 m (375 ft) deep well; after Julian day 309 samples came from a 167.6 m (550 ft) deep well having a flow of 2841 lpm (750 gpm); water temp. is 53.9°C (129°F).
316	Blakeley	Shirley Blakeley Route 38 Box 2249 Livingston, Montana 59047	119 m (390 ft) fully cased well.
317	MacMillan	Richard MacMillan P. O. Box 761 Ennis, Montana 59729	Domestic well, 42.7 m (140 ft) deep; 113.8 lpm (30 gpm) flow; water contains H_2S; temp. is 53.3°C (128°F).
318	Thexton	Alex Yenny P. O. Box 748 Ennis, Montana 59729	Thexton Hot Springs; water temp. is 84°C (184°F).
319	Stands	Mrs. Alvin Stands Pray, Montana 59065	68 m (223 ft) deep well; cased for 30.5 m (100 ft).
321	Murphy	Jim Murphy Ox Yoke Ranch Emigrant, Montana 59027	79.2 m (260 ft) deep well; perforated from 45.7-68.6 m (150-225 ft).
322	Kamps	George Kamps Route 38 P. O. Box 2071 Livingstone, Montana 59047	33.5 m (110 ft) fully cased well.
343	Blevins	Roy Blevins 5605 Butters Road Brawley, CA 92227	Old well of unknown depth, dug 50 years ago; temp. about 60°C (140°F).
344	Bowles	Mrs. Charles Bowles Box 74 Calipatria, CA 92233	356 m (1167 ft) deep artesian well; cased to 305 m (1000 ft); 663 lpm (175 gpm); temp. is 46.3°C (106°F).
345	Hagen	Julia Hagen 2190 East Titsworth Road Brawley, CA 92227	About 305 m (1000 ft) deep well; temp. is about 38°C (100°F).

Table 1.--Localities of helium-sampling stations (Cont'd)

Station No.	Station Name	Address	Comments
346	Mulberry	Mr. Casey's Class Roddy Smith, Peter Villalobos, and Ronnie Gibson Mulberry School 1391 East Rutherford Road Brawley, CA 92227	Well depth unknown; temp. about 43°C (110°F).
347	Jeska	Johanna Jeska Holt Ave. Store 5449 Butters Road Brawley, CA 92227	Old well of unknown depth; drilled in 1930's; fully cased.
348	White	Mrs. Dorothy White P. O. Box 184 Ocotillo, CA 92259	88.4 m (290 ft) deep well.
349	Rodia	Jim Rodia P. O. Box 86 Ocotillo, CA 92259	183 m (600 ft) deep well; temp. is 33°C (92°F).

Table 2.--Earthquakes in reporting areas in 1980

Julian date	Calendar date	Latitude N.	Longitude W.	Region	Magnitude
51	Feb. 20	44.81°	110.90°	Fawn Pass, WY	4.7
56	Feb. 25	33.52°	116.55°	N.W. of Ocotillo, CA	5.5
161	June 9	32.22°	114.99°	S.E. of El Centro, CA	6.1
161	June 9	32.30°	115.15°	S.E. of El Centro, CA	4.5
161	June 9	32.35°	115.23°	S.E. of El Centro, CA	4.4
219	Aug. 6	31.88°	116.20°	S.W. of Ocotillo, CA	4.2
305	Oct. 31	32.67°	115.59°	S. of El Centro, CA	4.5

REFERENCES

Doering, W. P. and Friedman, I., 1980, Survey of helium in natural wells and springs in Montana and vicinity: U.S. Geological Survey Open-File Report 80-181, 42 p.

Doering, W. P. and Friedman, I., 1980, Survey of helium in natural water wells and springs in southwest Montana and vicinity, Part II--July 1-Dec. 31, 1979: U.S. Geological Survey Open-File Report 80-1257, 18 p.

U.S. Geological Survey, 1980, Preliminary determination of epicenters, monthly listing, January, February, June, August, and October, five publications: U. S. Geological Survey National Earthquake Information Service, 16 p., 12 p., 20 p., 11 p., and 21 p.

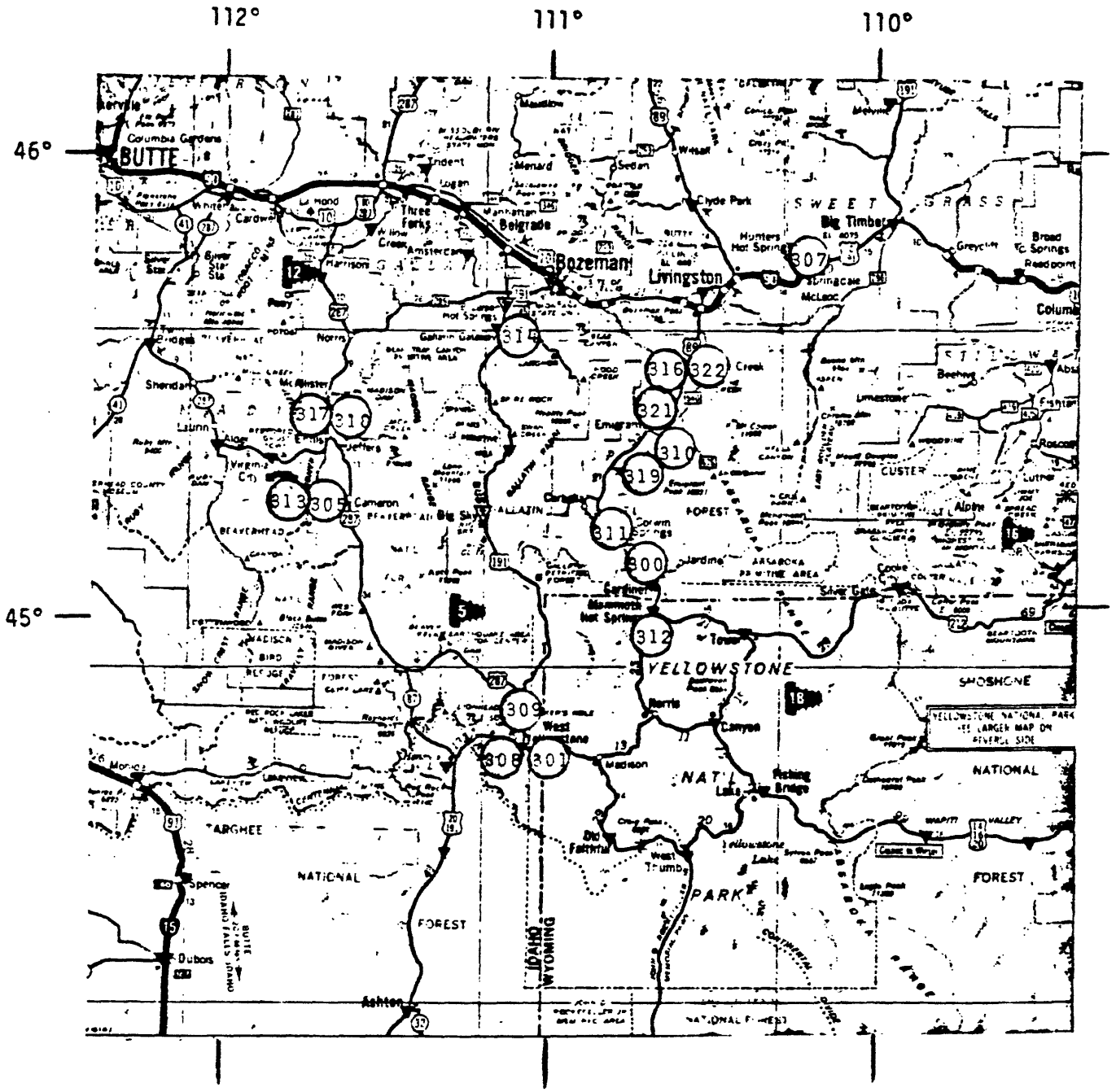

Figure 1.--Helium sampling stations (shown by number) in Montana and vicinity. Scale approximately 1:1,550,000 (1 inch to 24.6 miles).

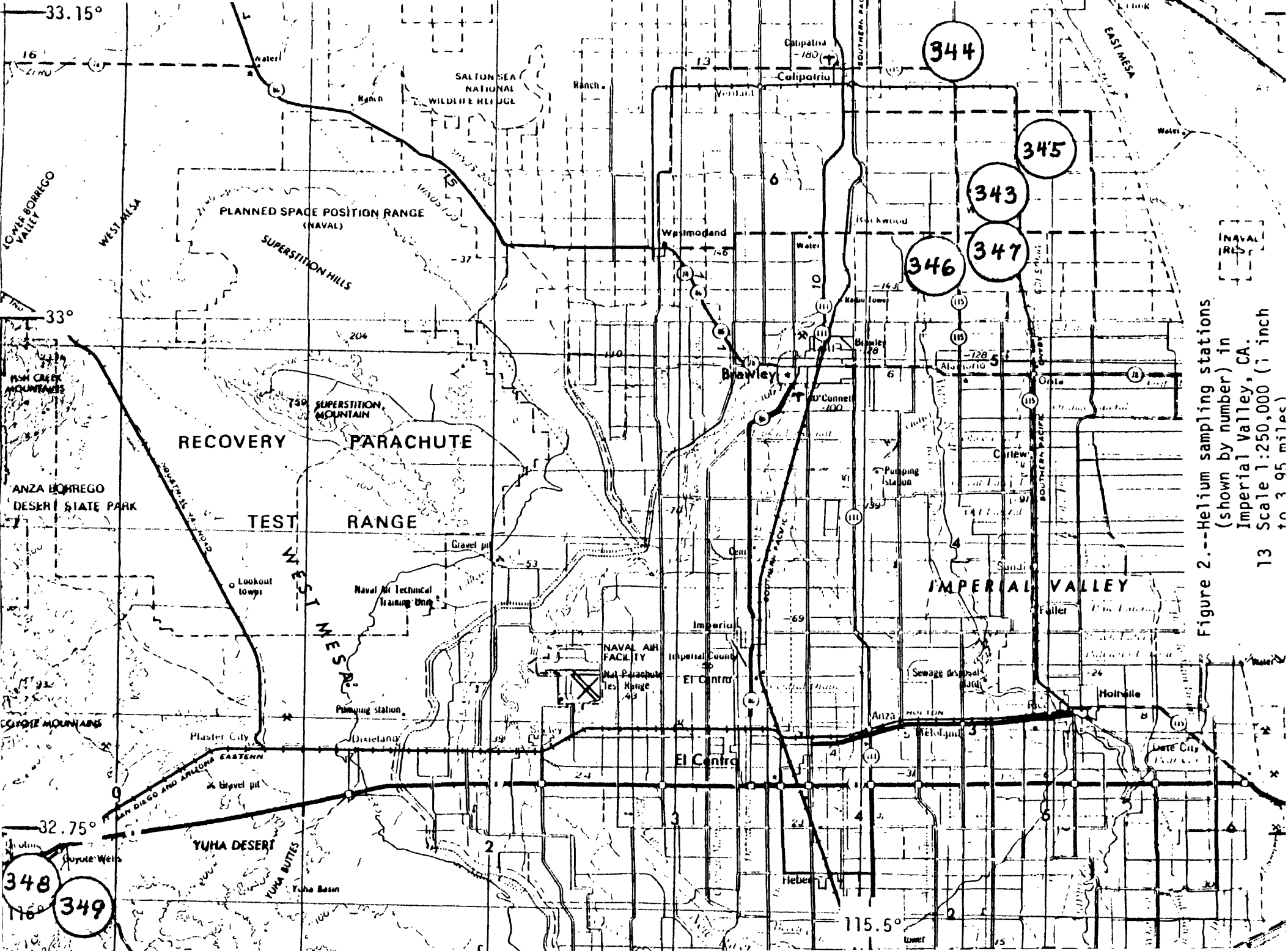

Figure 2.--Helium sampling stations (shown by number) in Imperial Valley, CA. Scale 1:250,000 (1 inch to 3.95 miles)

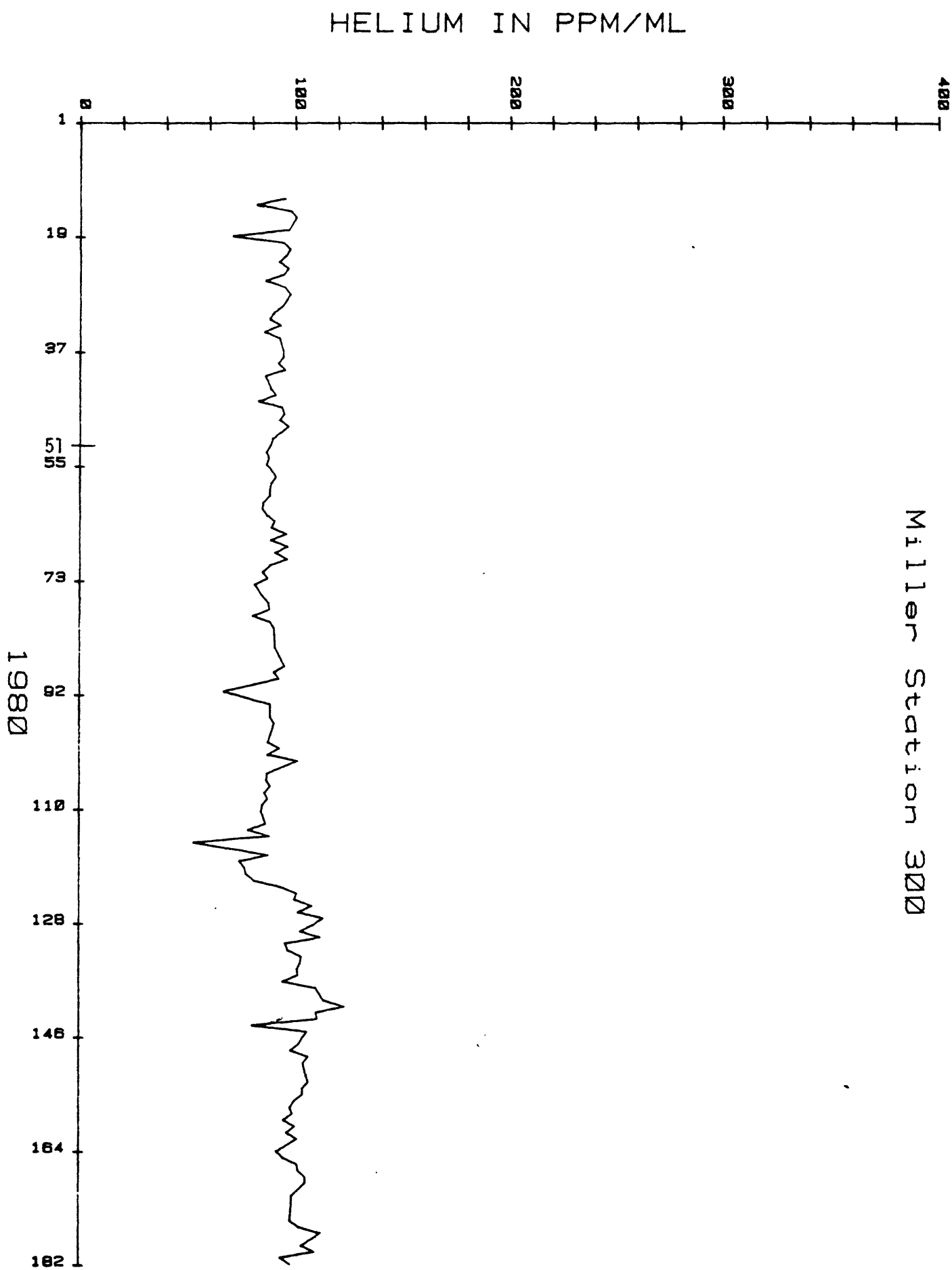

Figure 3.--Helium concentrations in water samples, Gardiner, Montana, January through June, 1980.

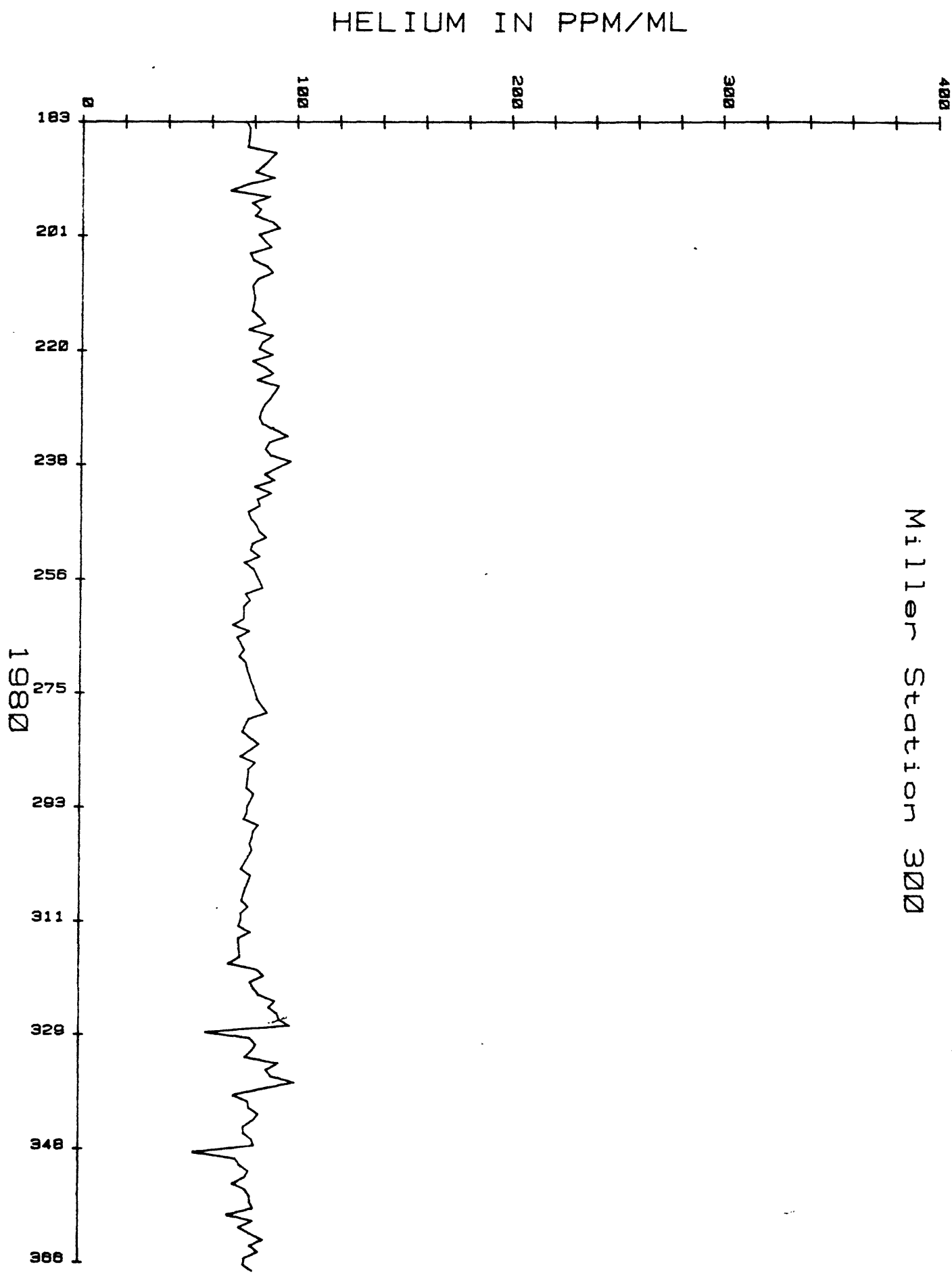

Figure 4.--Helium concentrations in water samples, Gardiner, Montana, July through December, 1980.

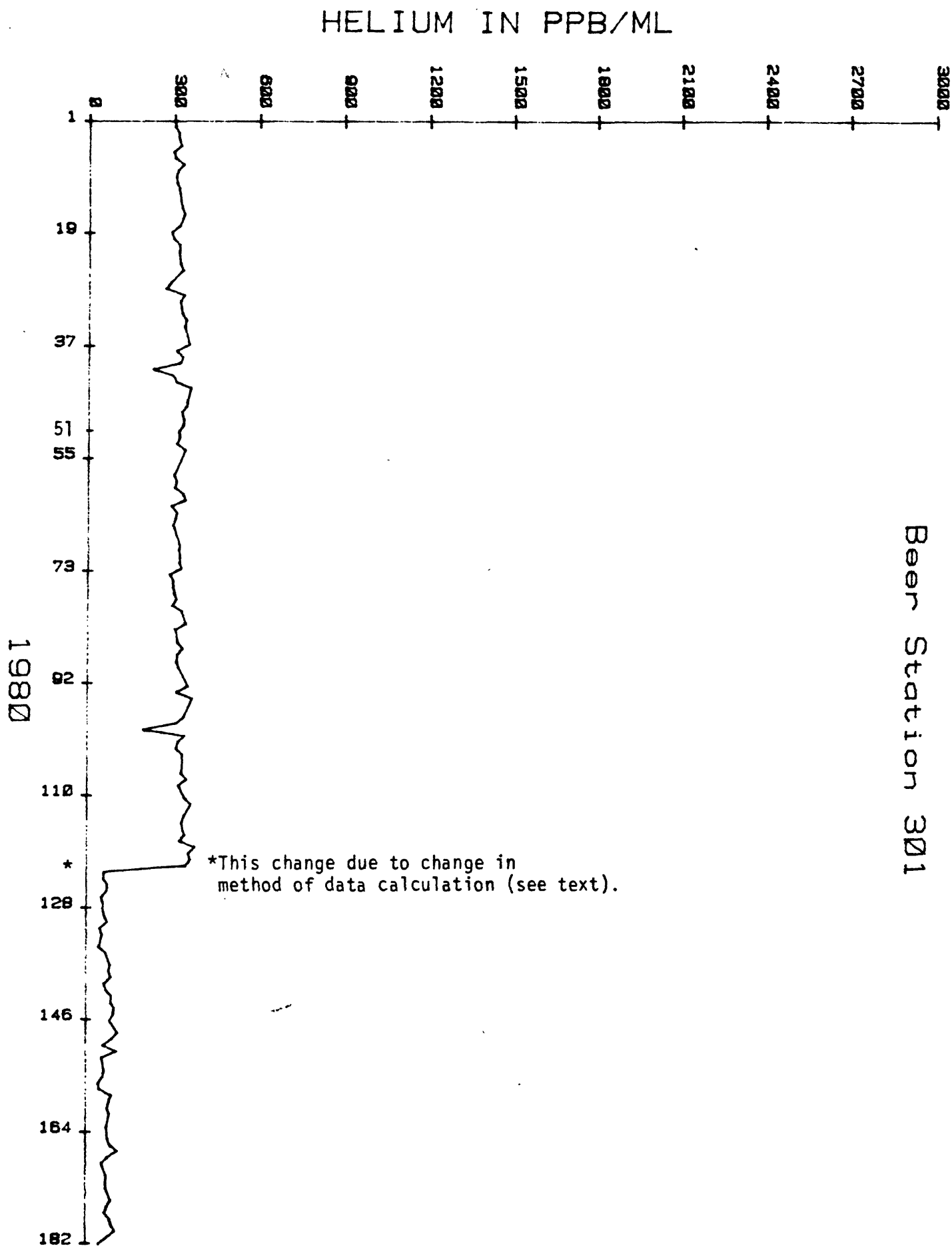

Figure 5.--Helium concentrations in water samples, West Yellowstone, Montana, January through June, 1980.

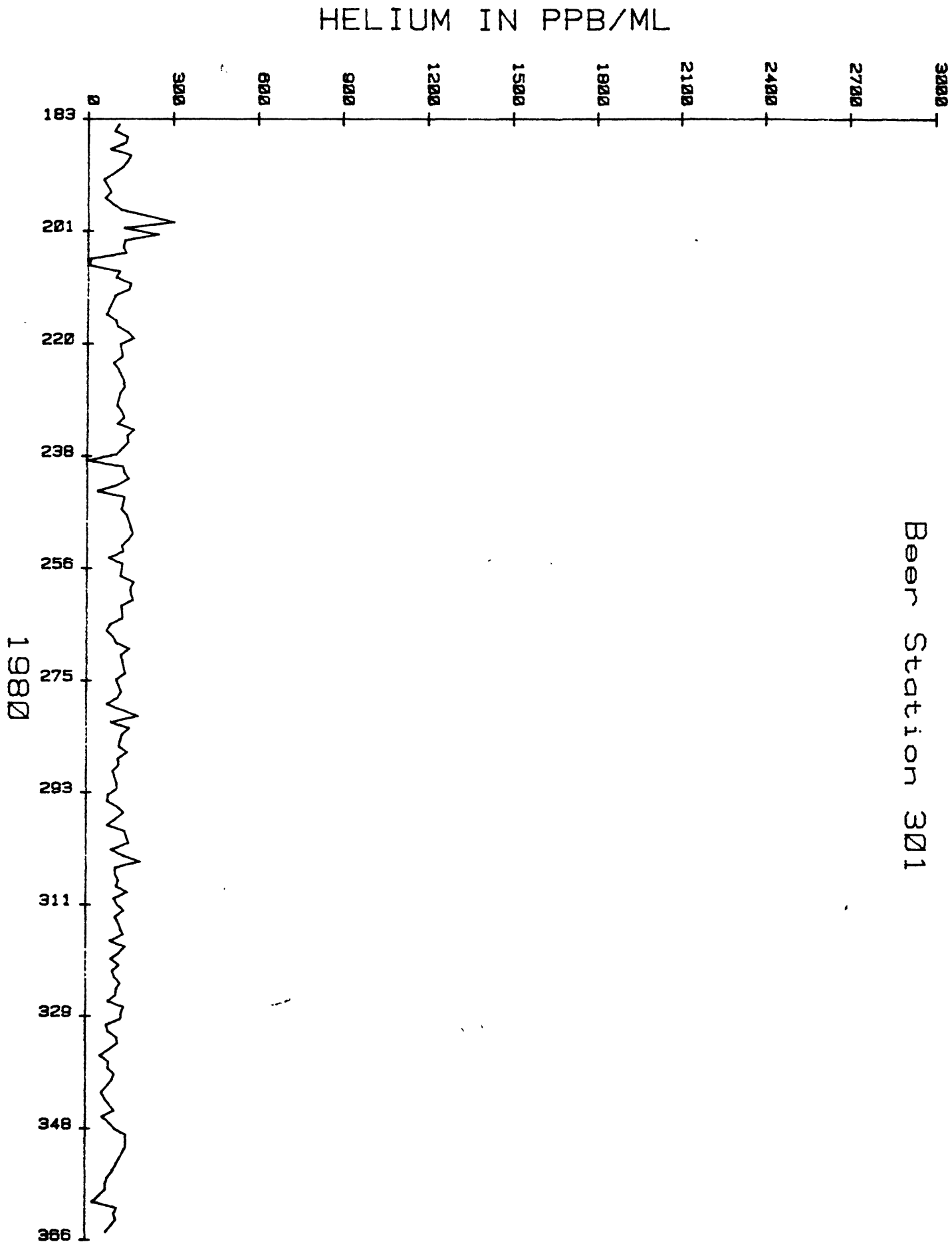

Figure 6.--Helium concentrations in water samples, West Yellowstone, Montana, July through December, 1980.

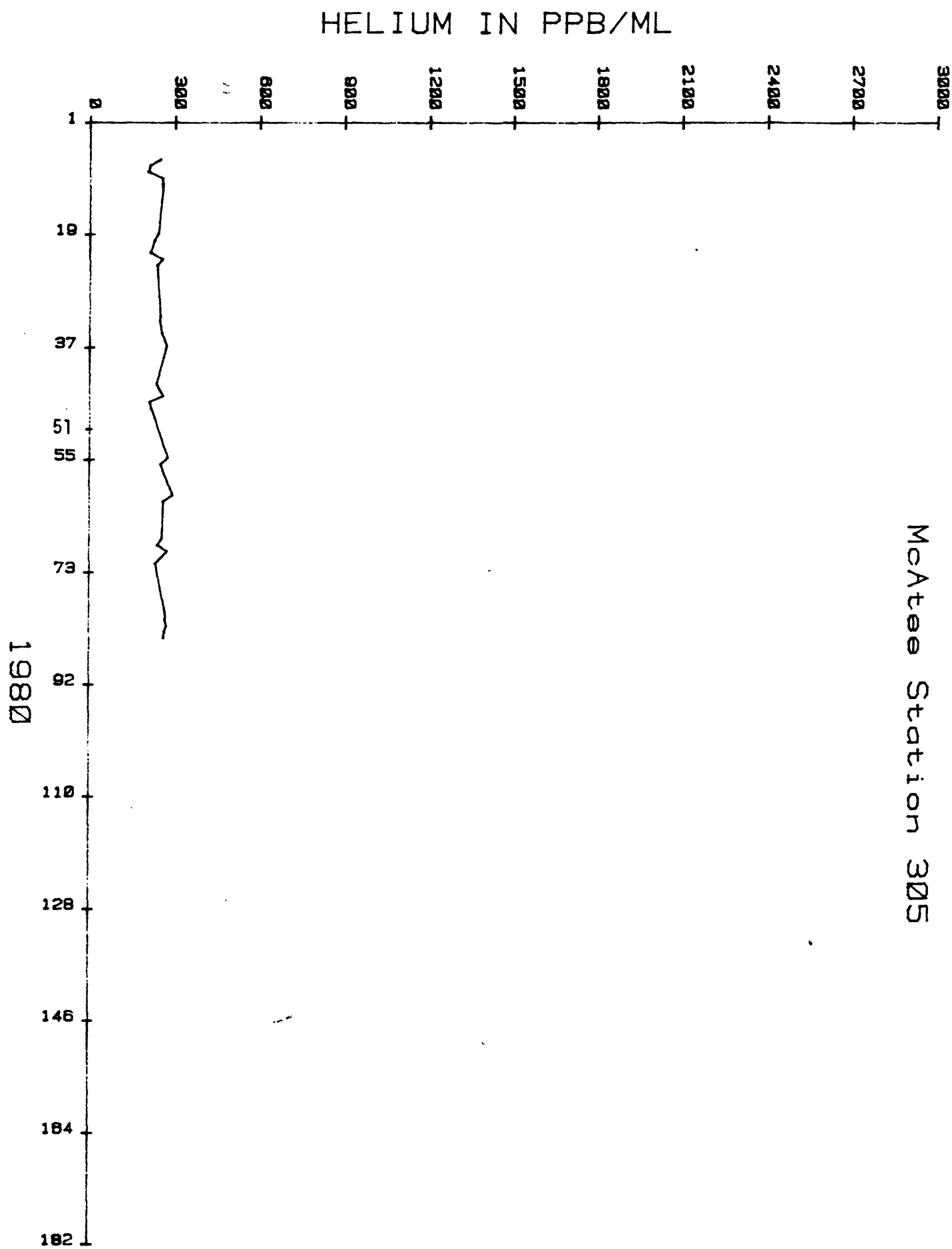

Figure 7.--Helium concentrations in water samples, Cameron, Montana, January through June, 1980.

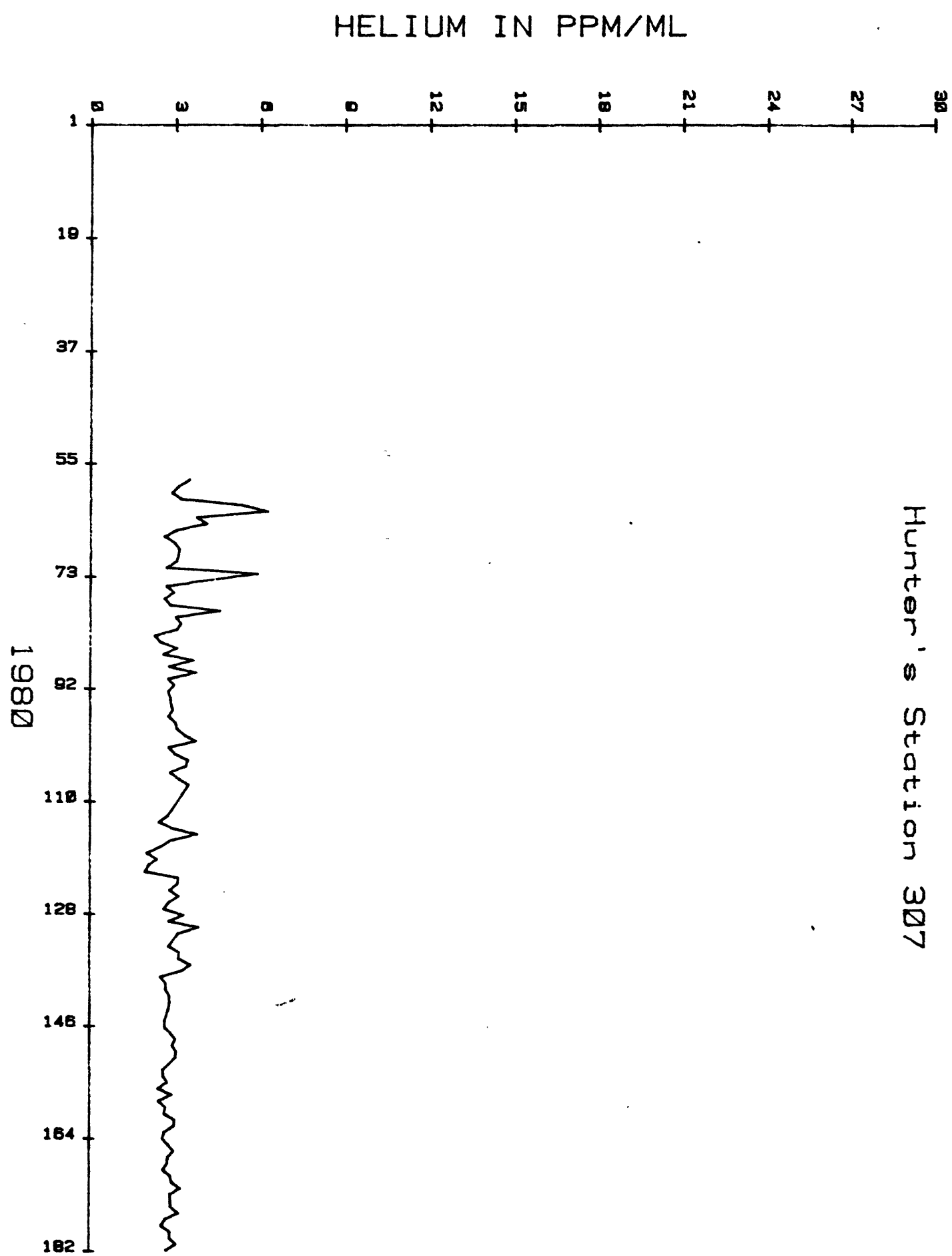

Figure 8.--Helium concentrations in water samples, Springdale, Montana, January through June, 1980.

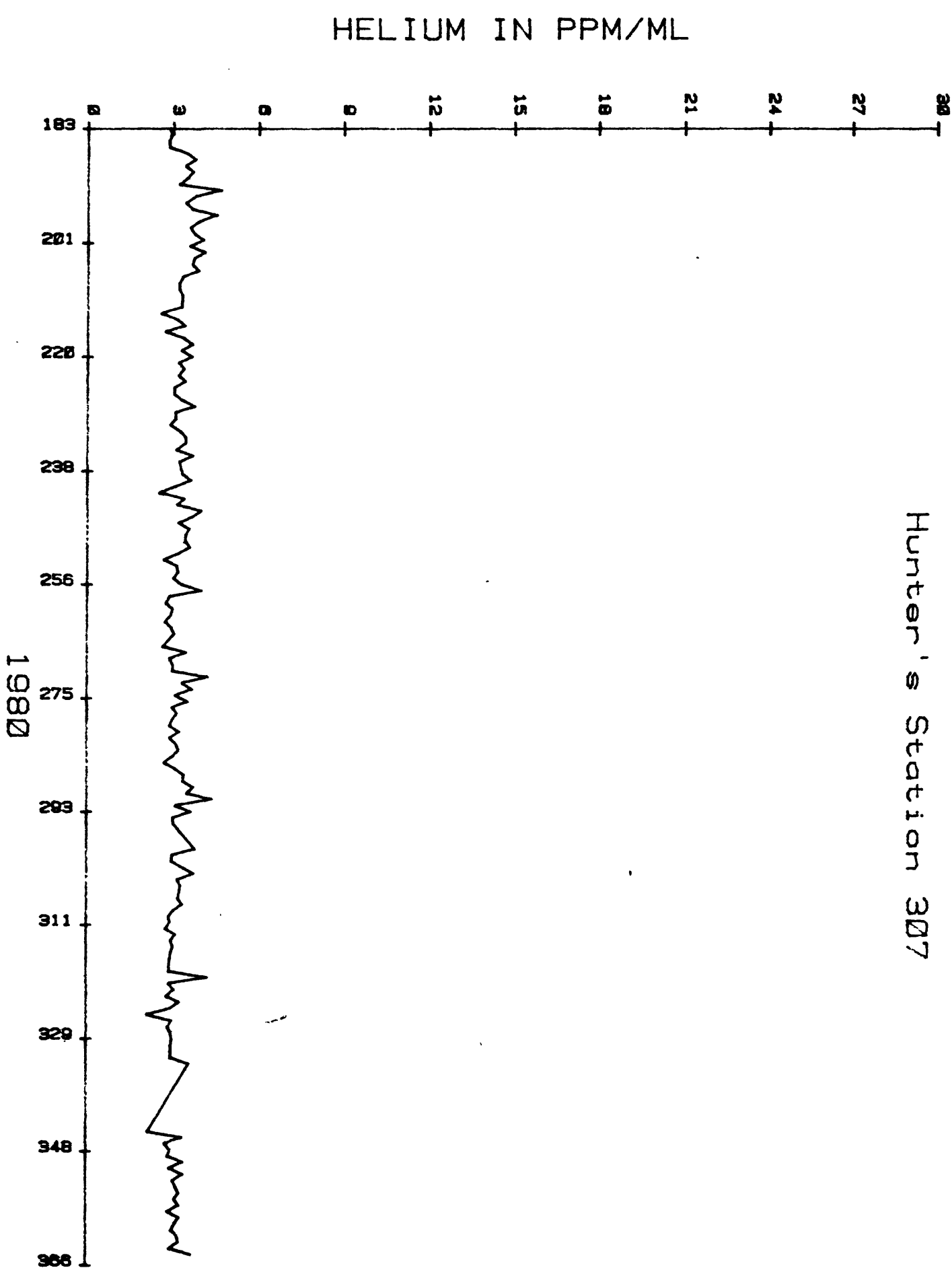

Figure 9.--Helium concentrations in water samples, Springdale, Montana, July through December, 1980.

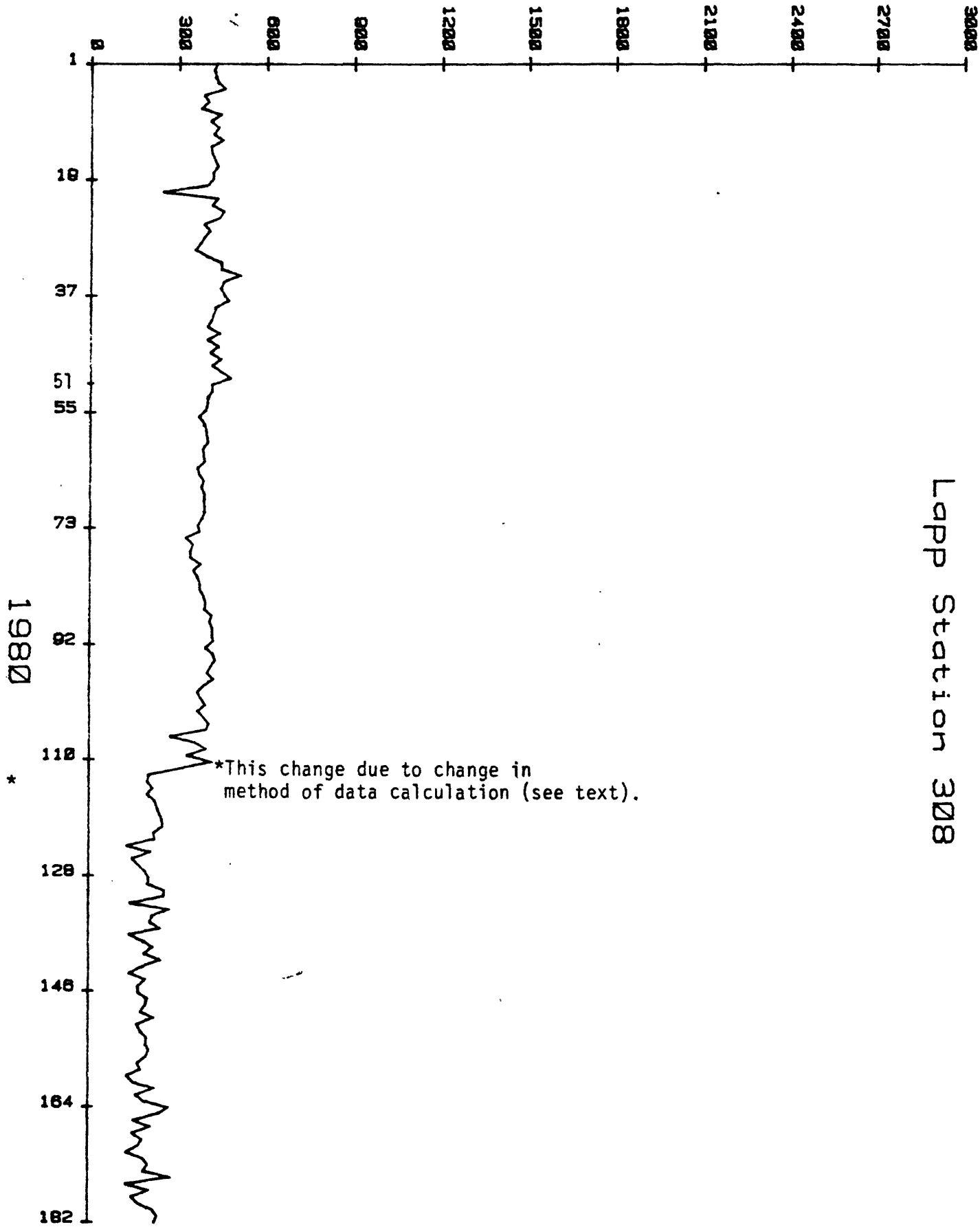

Figure 10.--Helium concentrations in water samples, West Yellowstone, Montana, January through June, 1980.

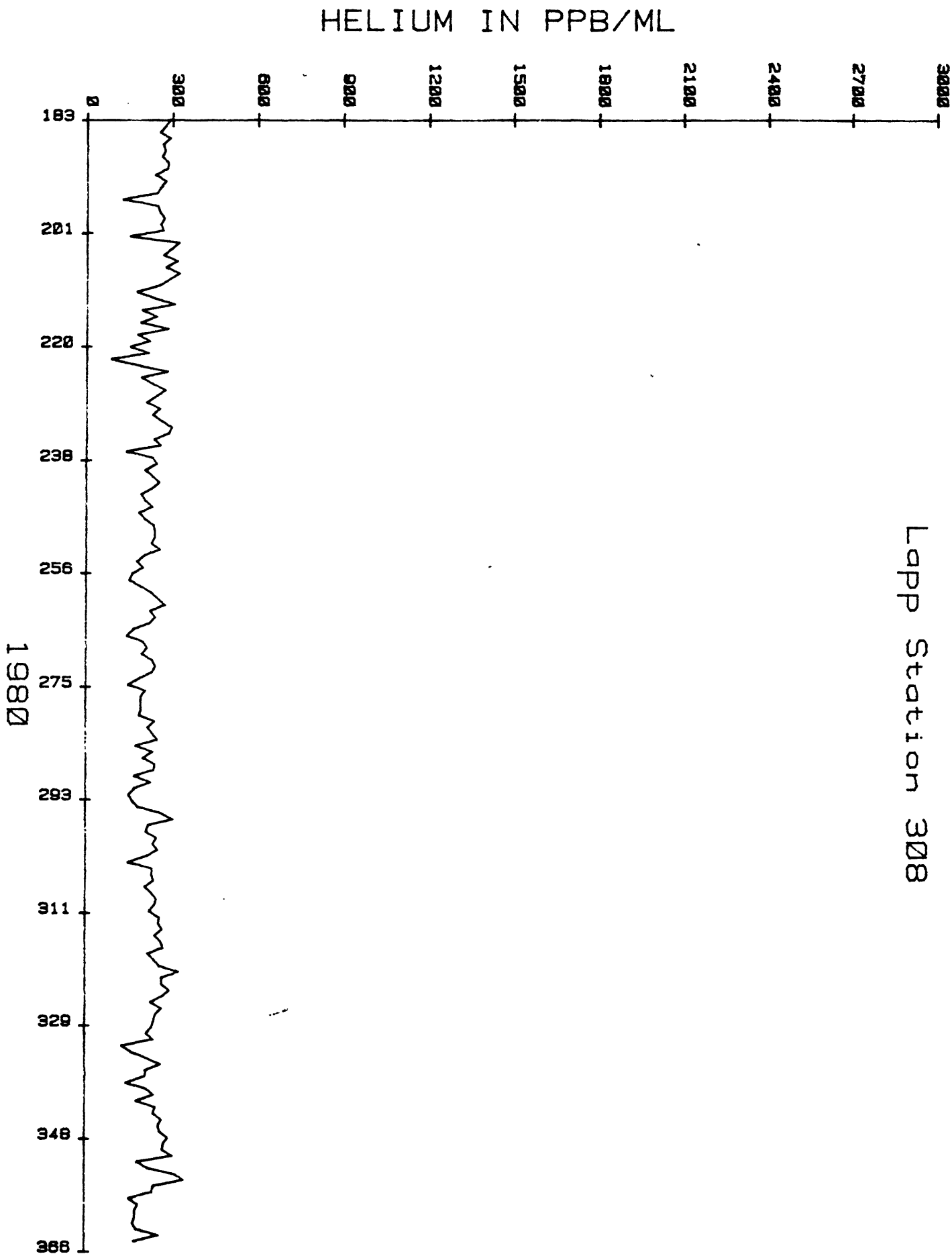

Figure 11.--Helium concentrations in water samples, West Yellowstone, Montana, July through December, 1980.

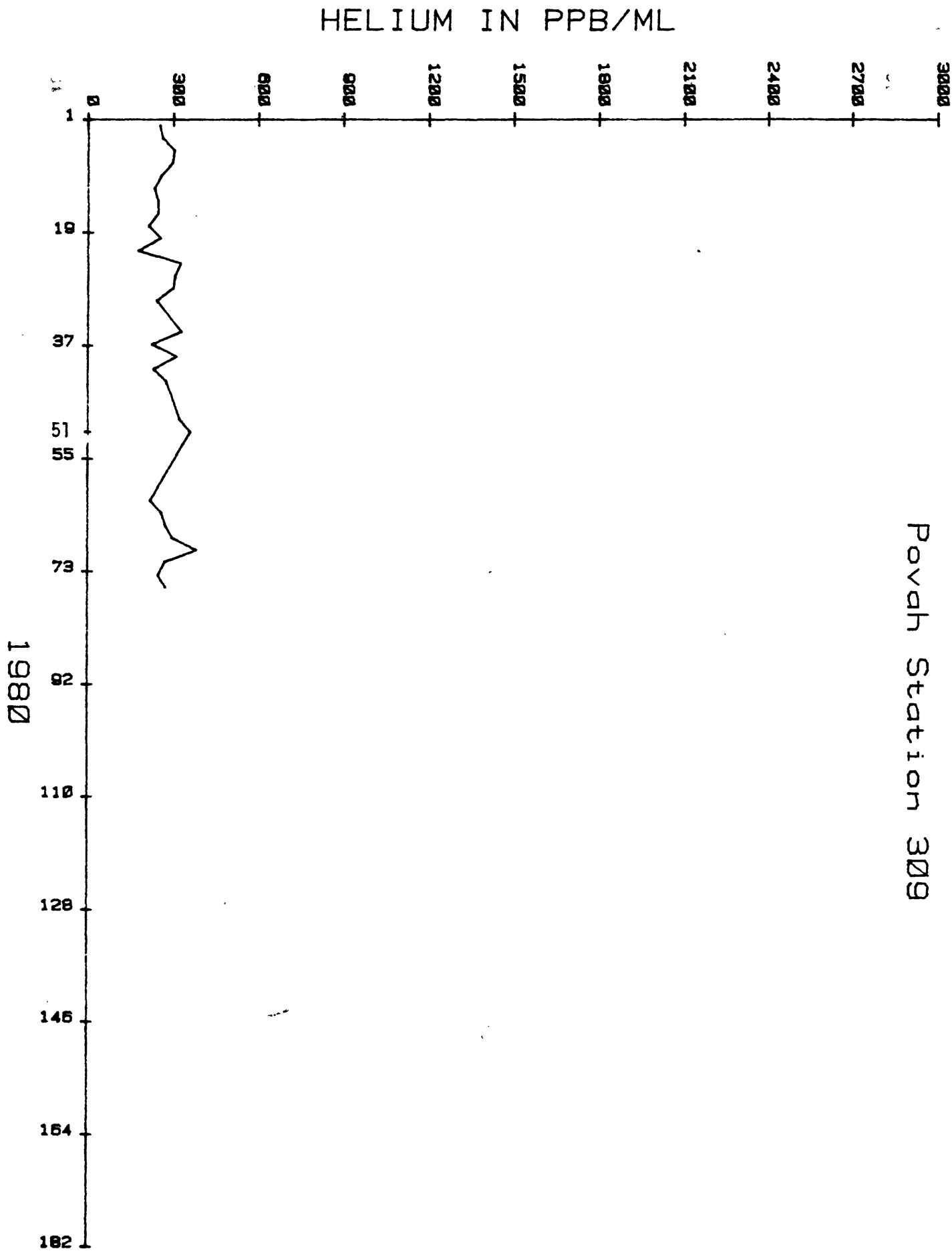

Figure 12.--Helium concentrations in water samples, West Yellowstone, Montana, January through June, 1980.

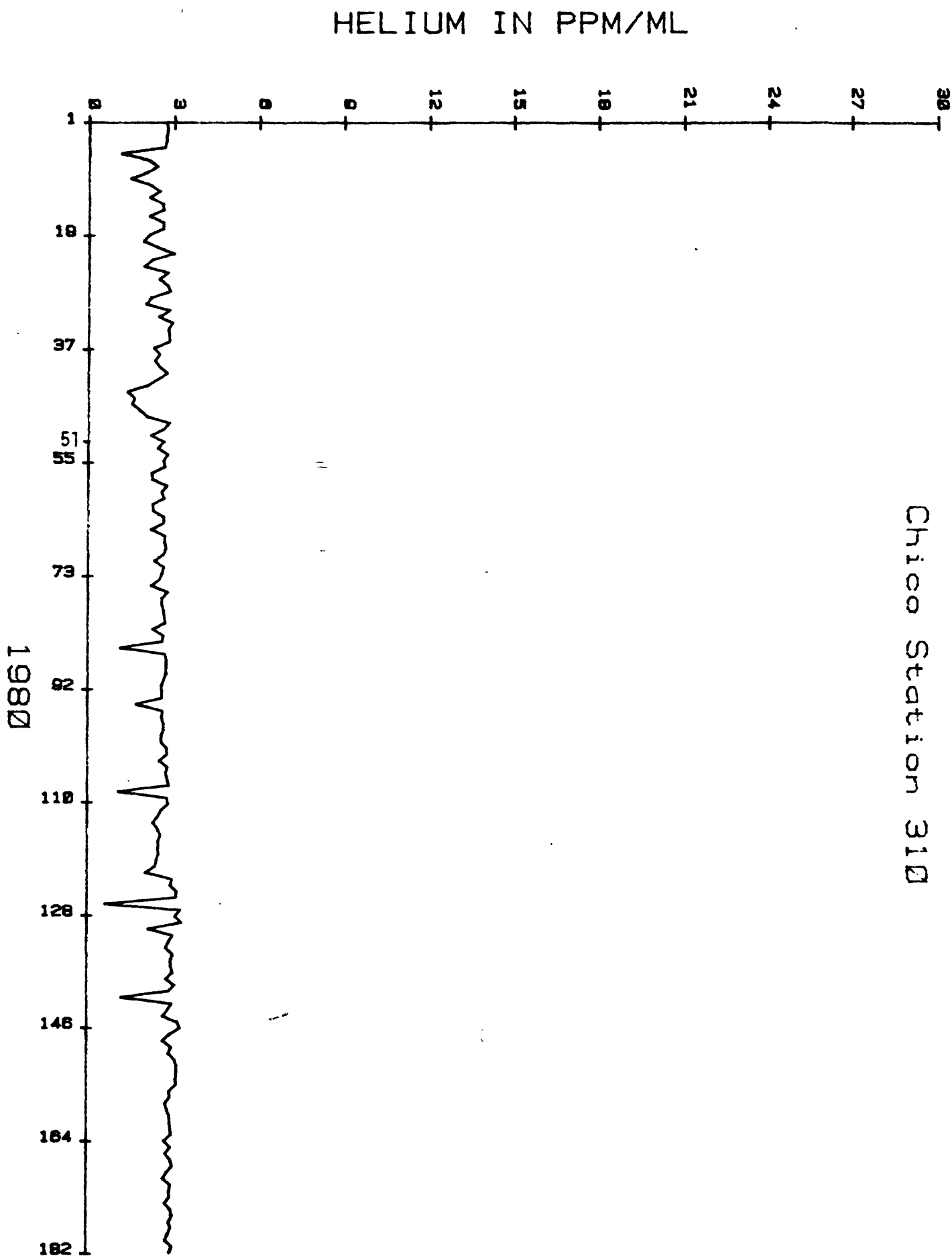

Figure 13.--Helium concentrations in water samples, Pray, Montana, January through June, 1980.

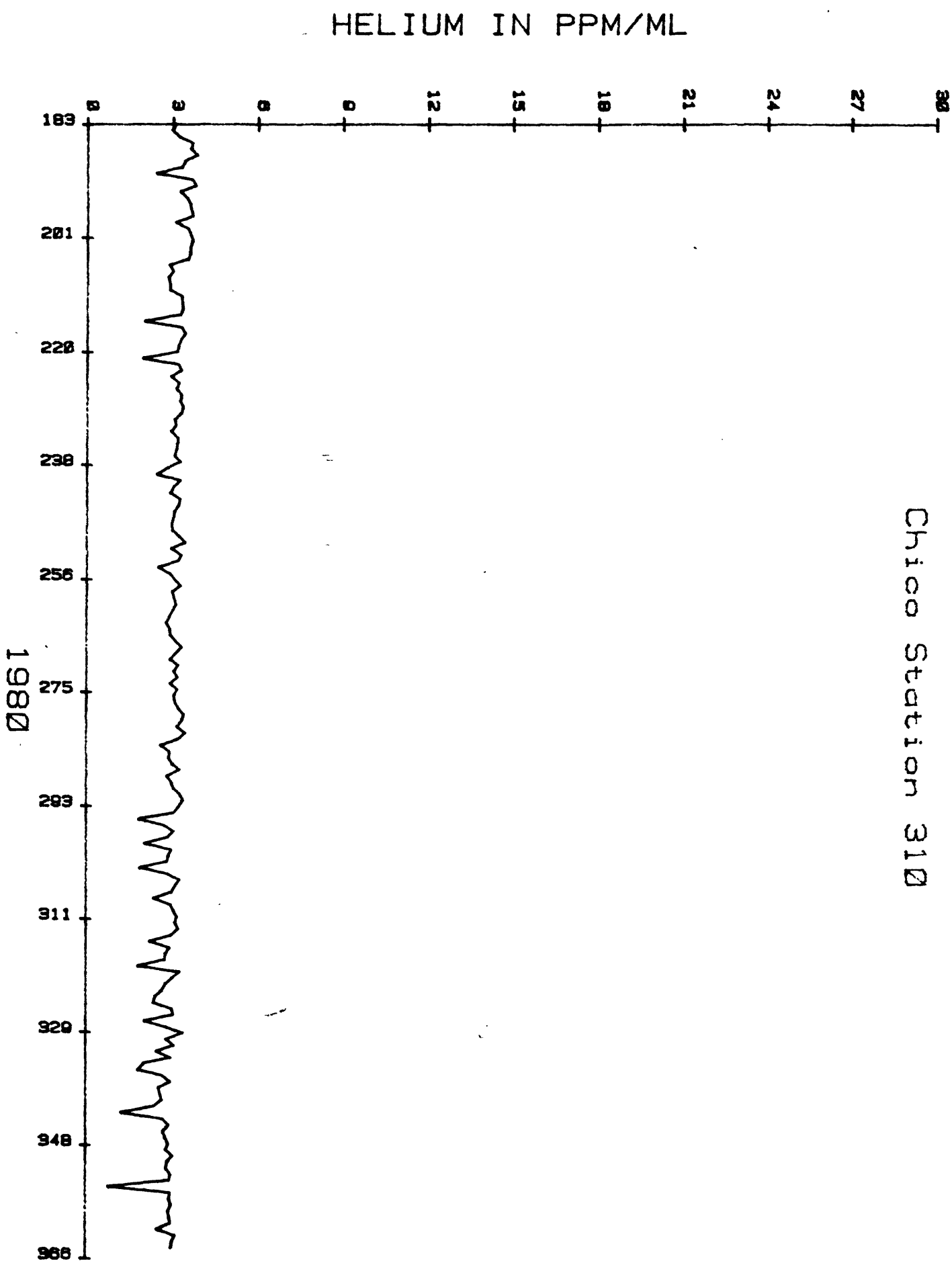

Figure 14.--Helium concentrations in water samples, Pray, Montana, July through December, 1980.

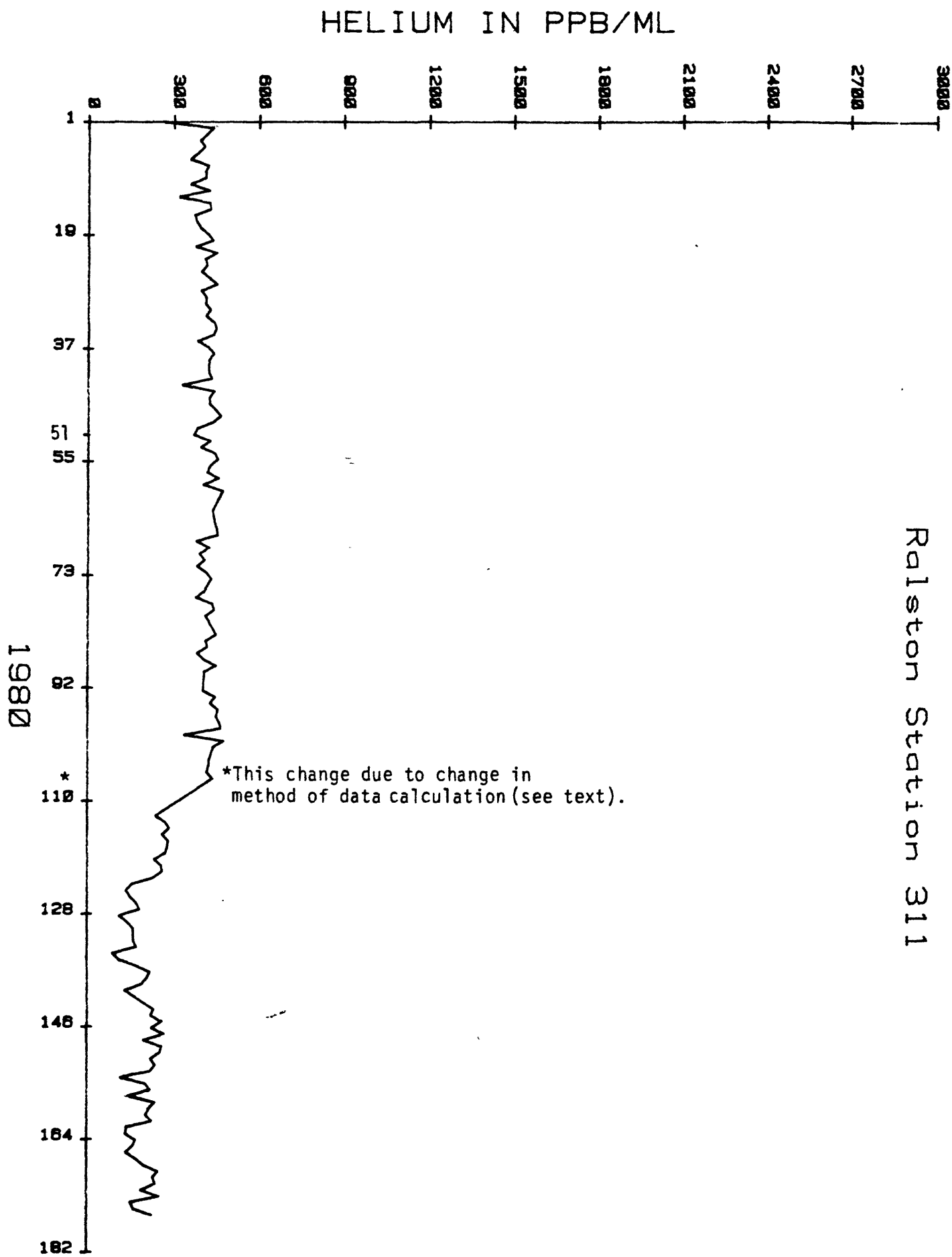

Figure 15.--Helium concentrations in water samples, Emigrant, Montana, January through June, 1980.

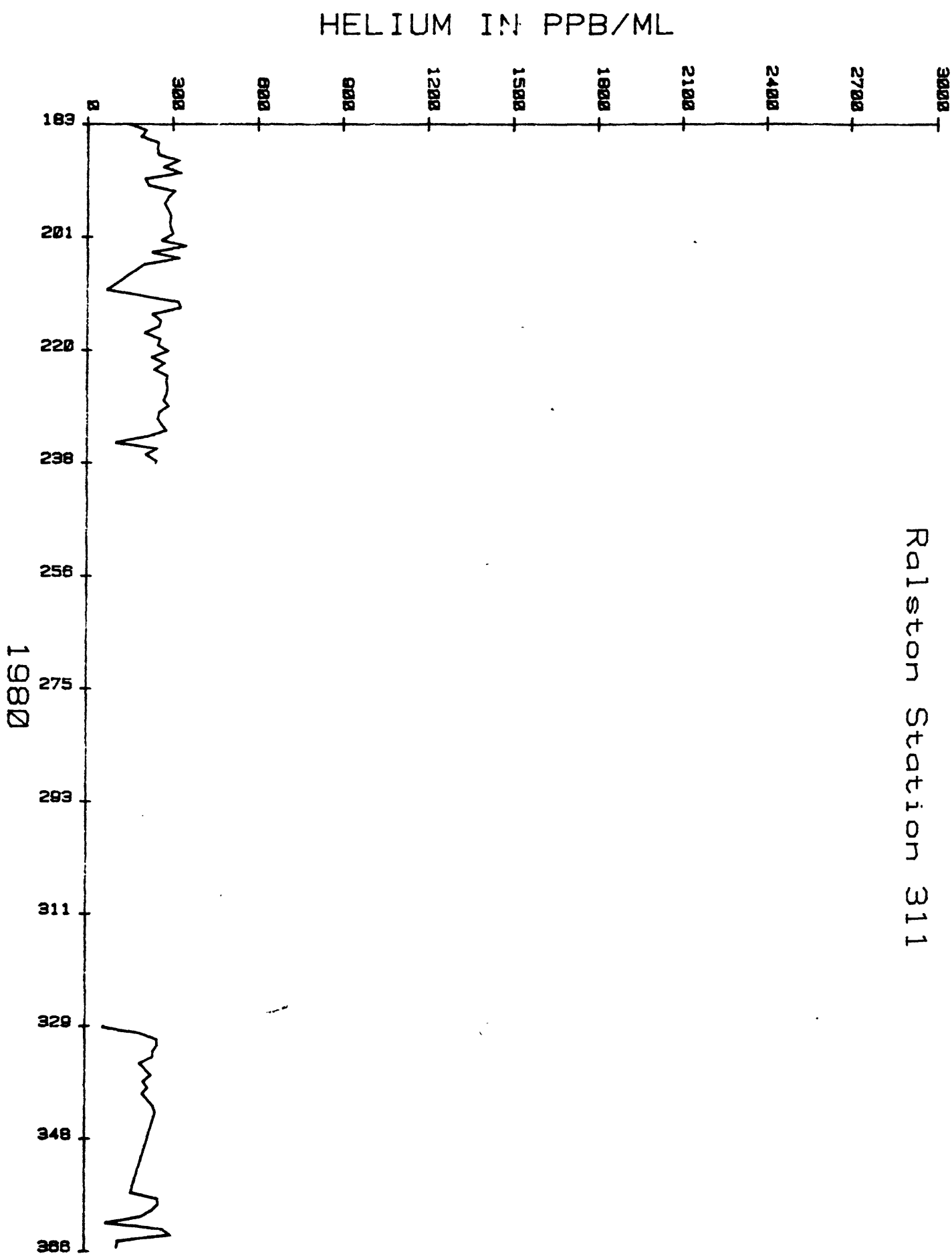

Figure 16.--Helium concentrations in water samples, Emigrant, Montana, July through December, 1980.

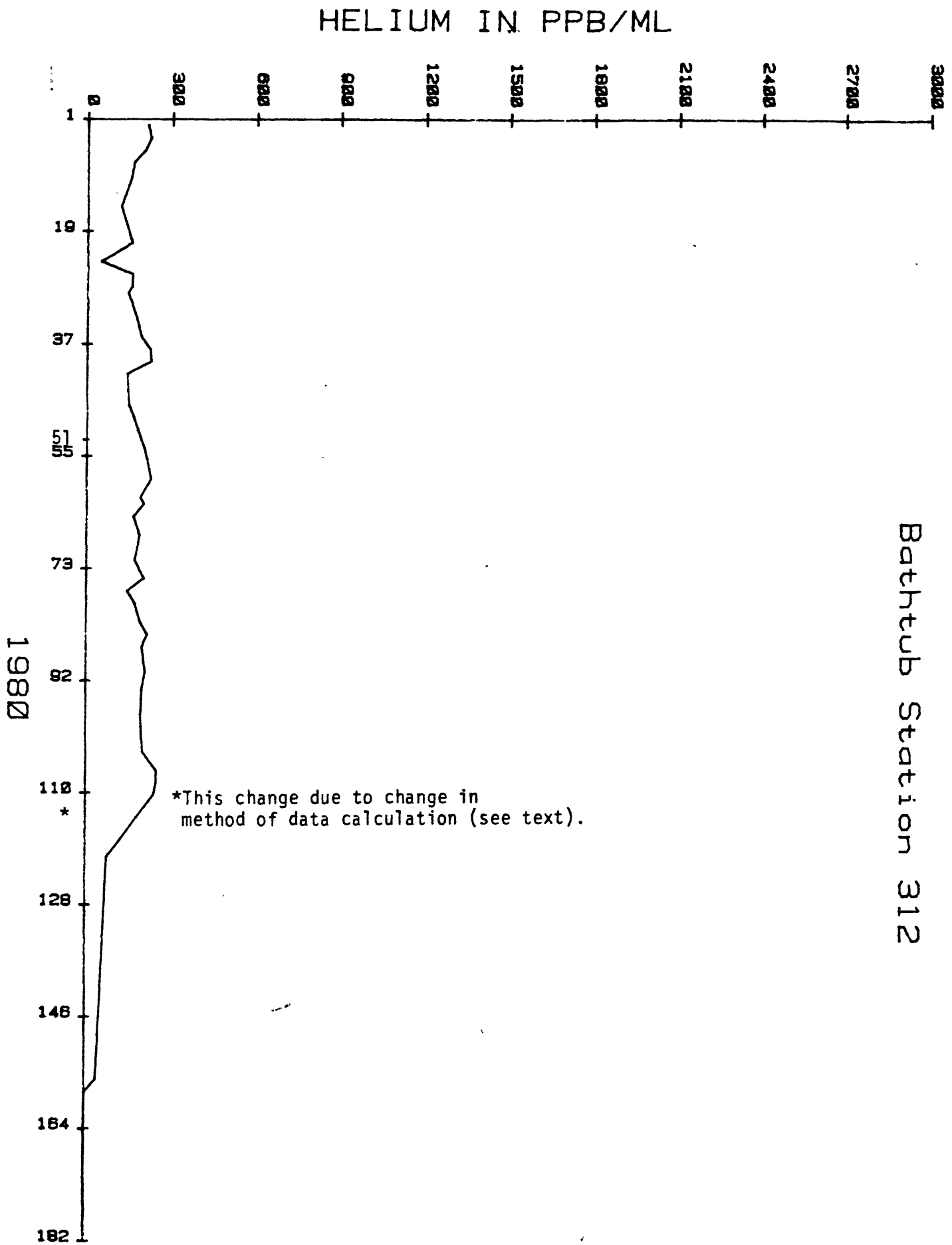

Figure 17.--Helium concentrations in water samples, Yellowstone National Park, Wyoming, January through June, 1980.

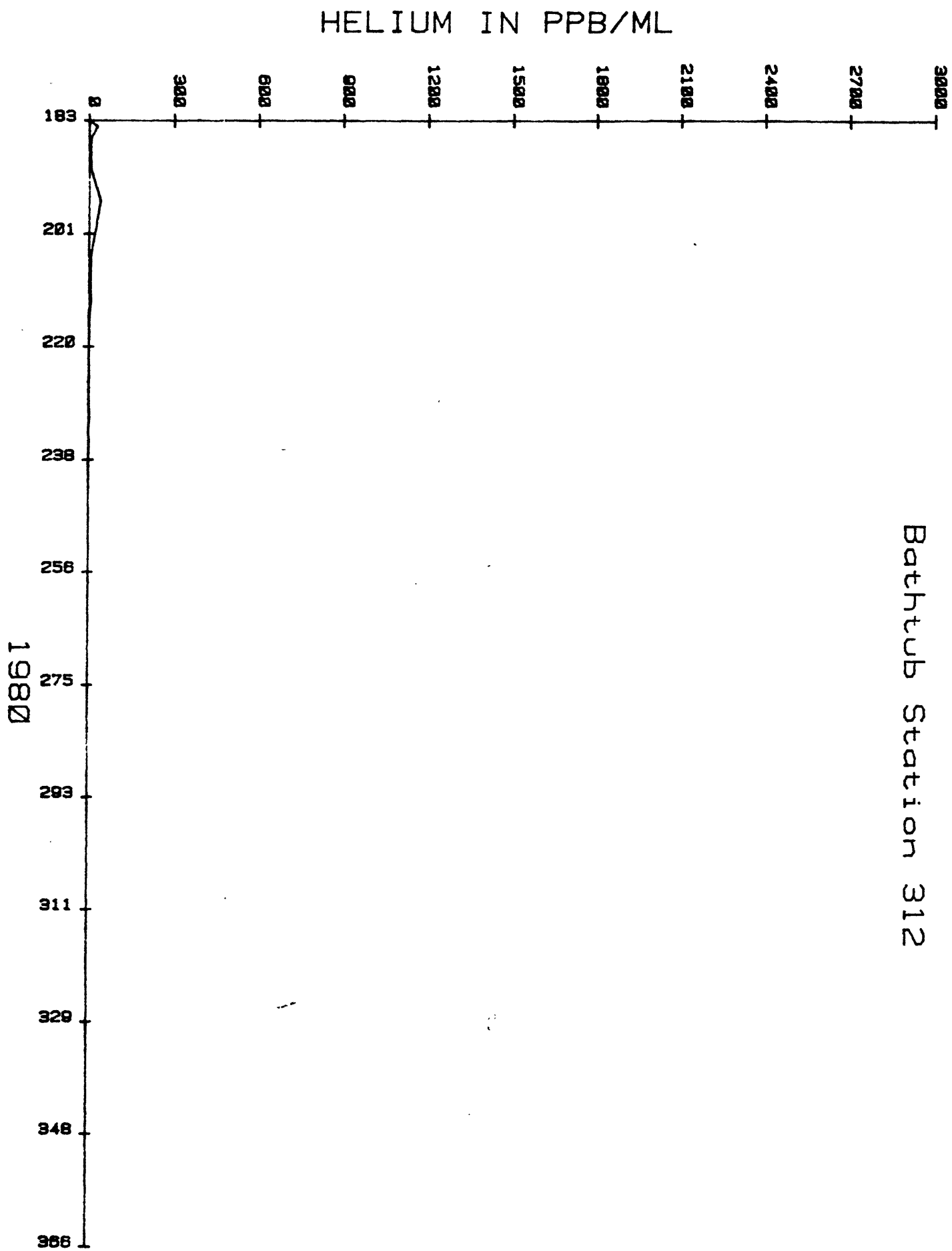

Figure 18.--Helium concentrations in water samples, Yellowstone National Park, Wyoming, July through December, 1980.

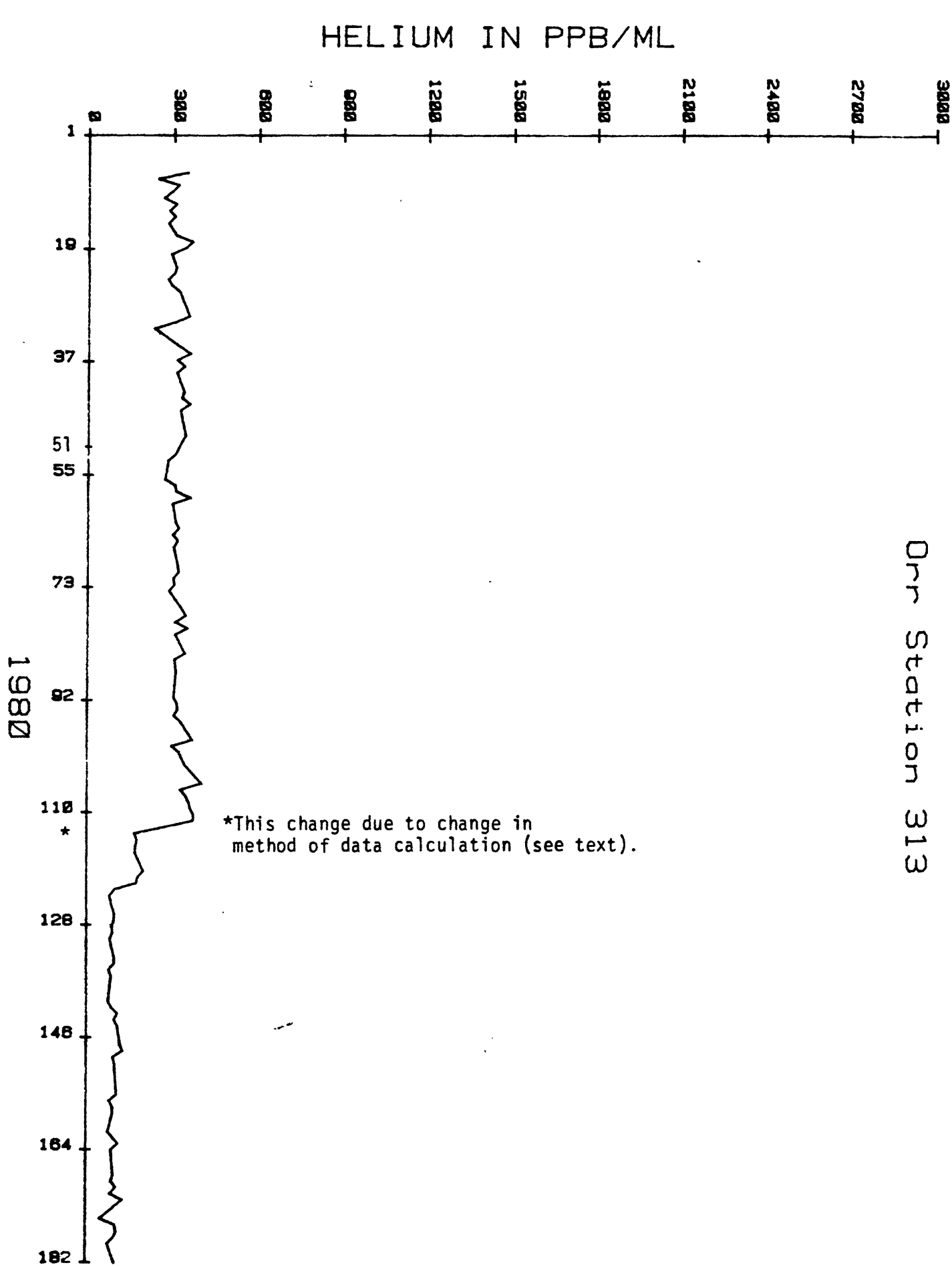

Figure 19.--Helium concentrations in water samples, Ennis, Montana, January through June, 1980.

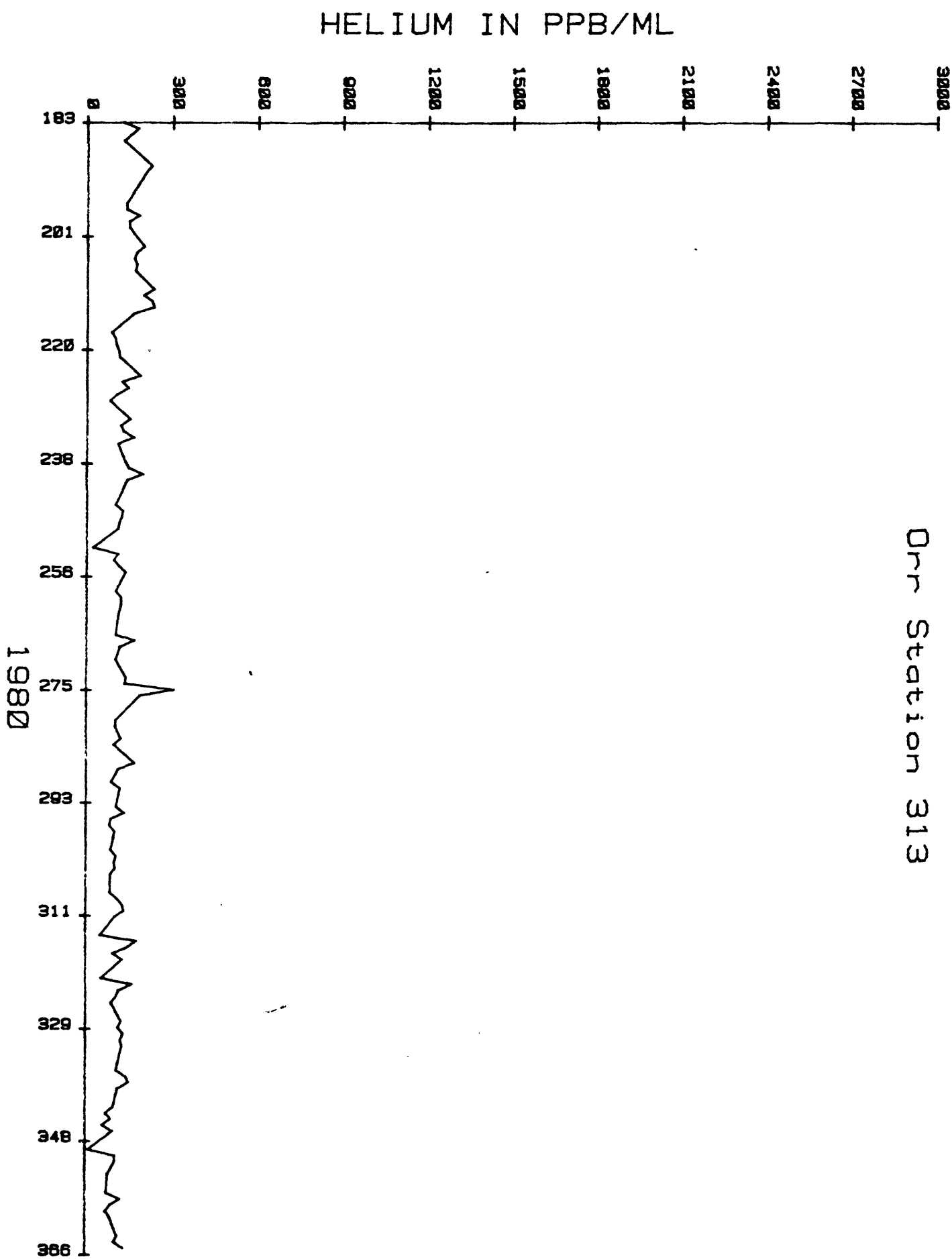

Figure 20.--Helium concentrations in water samples, Ennis, Montana, July through December, 1980.

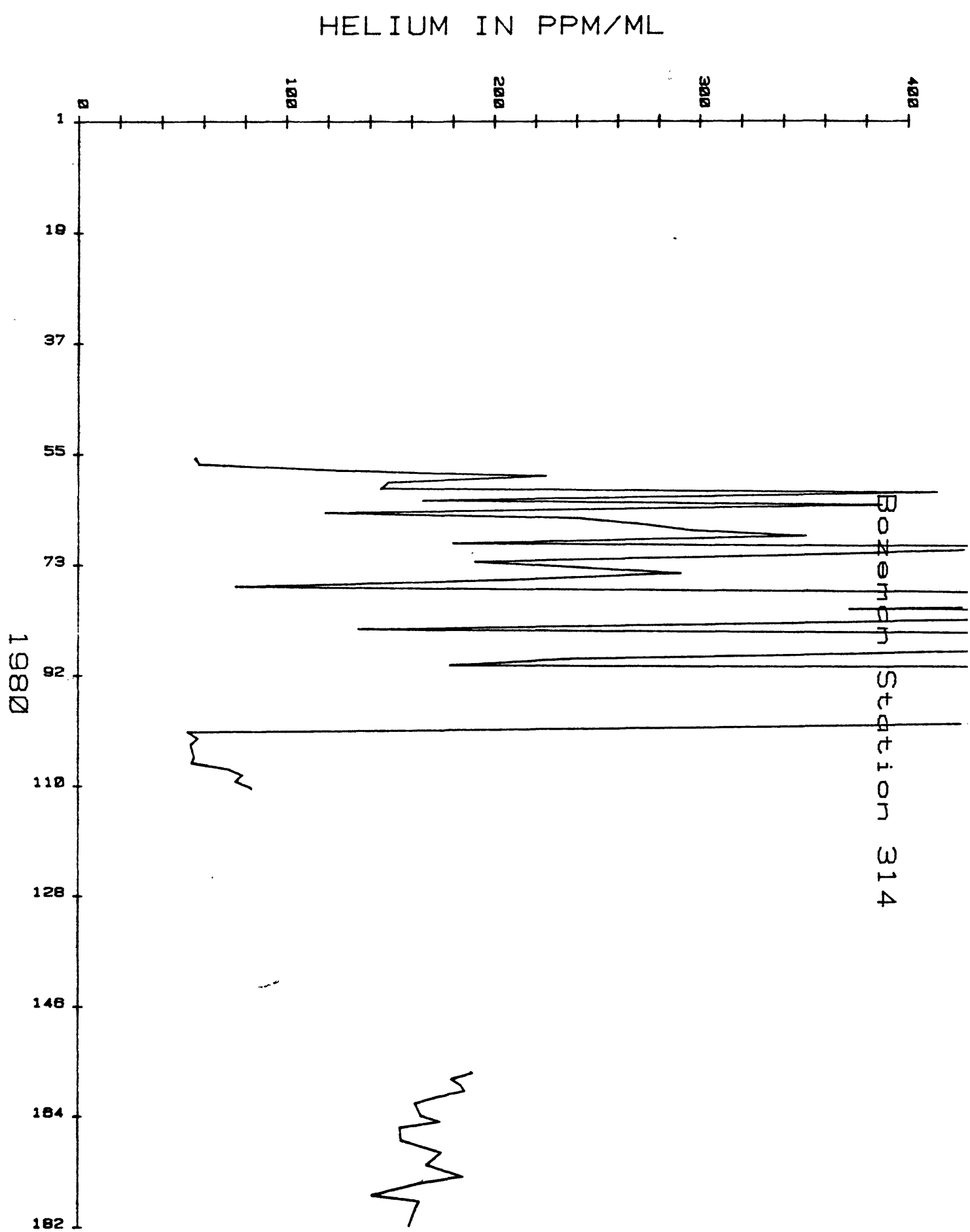

Figure 21.--Helium concentrations in water samples, Bozeman, Montana, January through June, 1980.

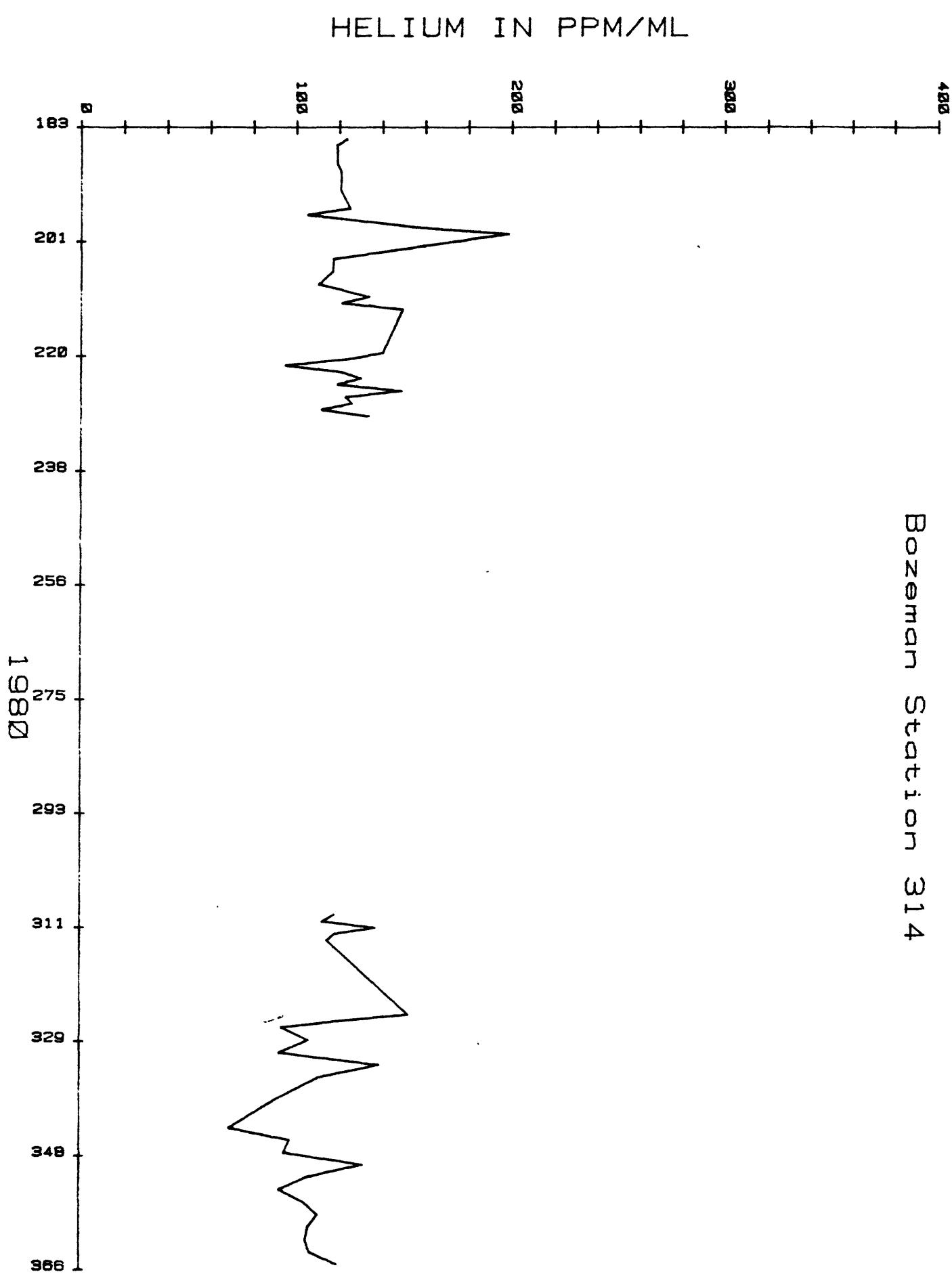

Figure 22.--Helium concentrations in water samples, Bozeman, Montana, July through December, 1980.

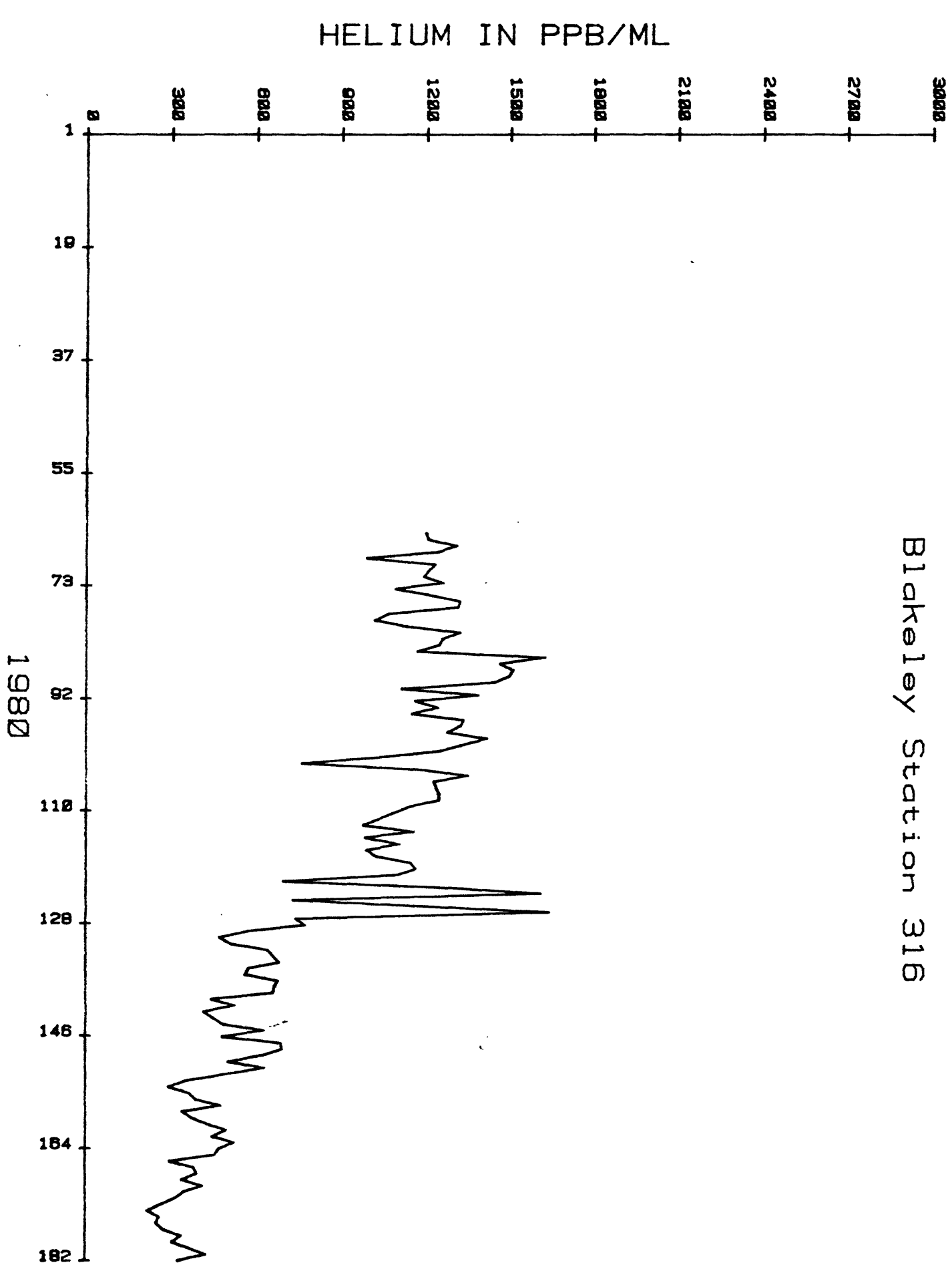

Figure 23.--Helium concentrations in water samples, Livingstone, Montana, January through June, 1980.

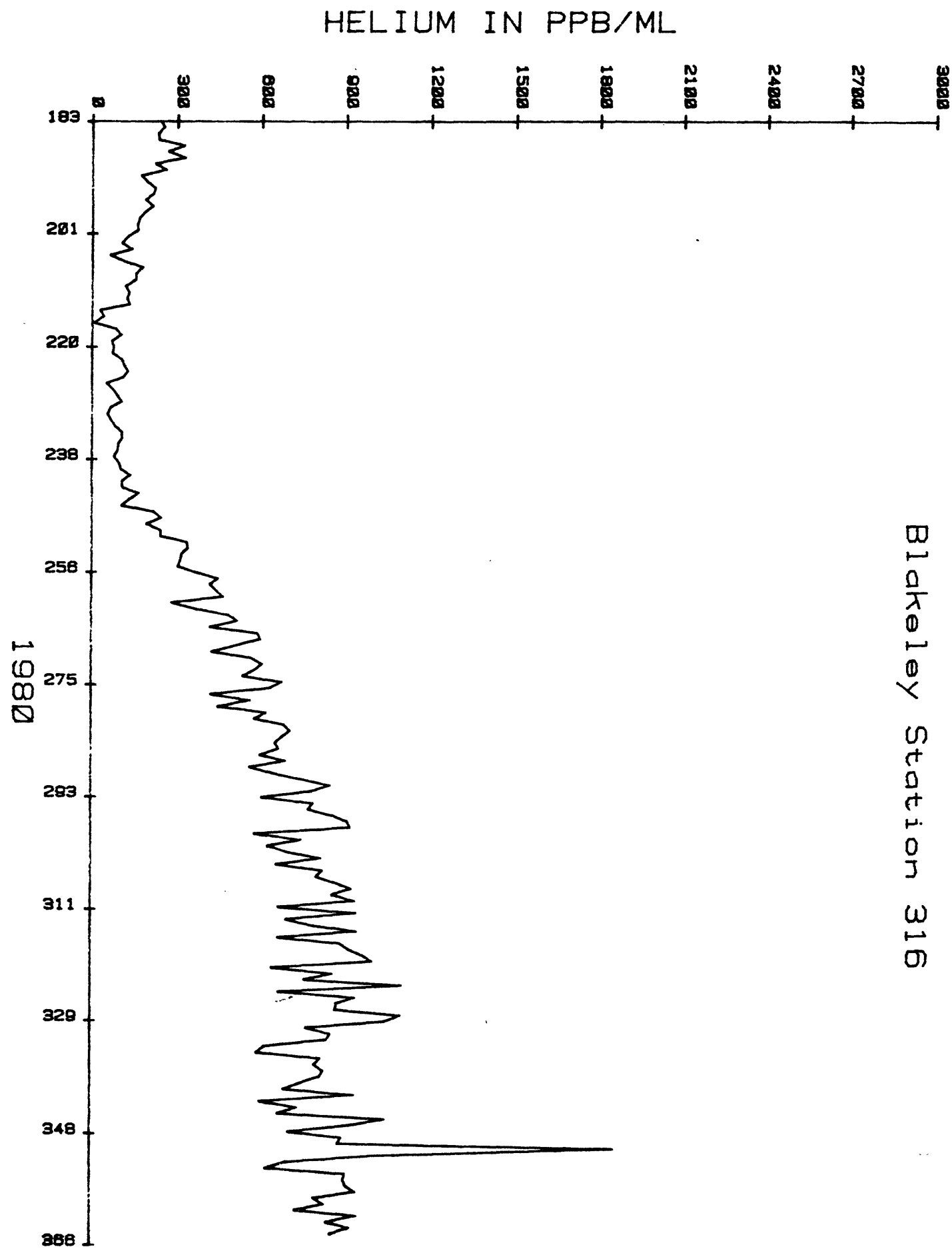

Figure 24.--Helium concentrations in water samples, Livingstone, Montana, July through December, 1980.

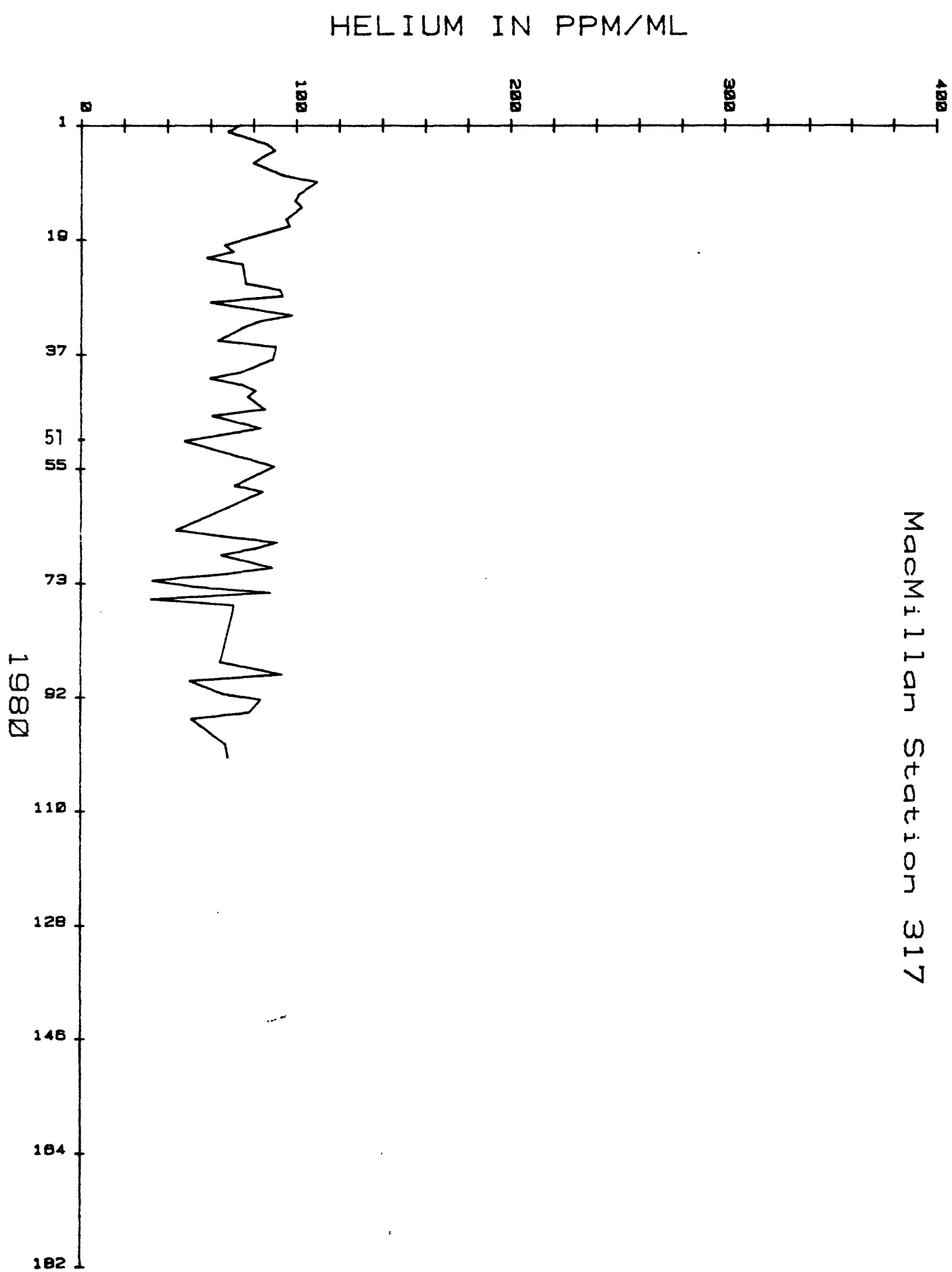

Figure 25.--Helium concentrations in water samples, Ennis, Montana, January through June, 1980.

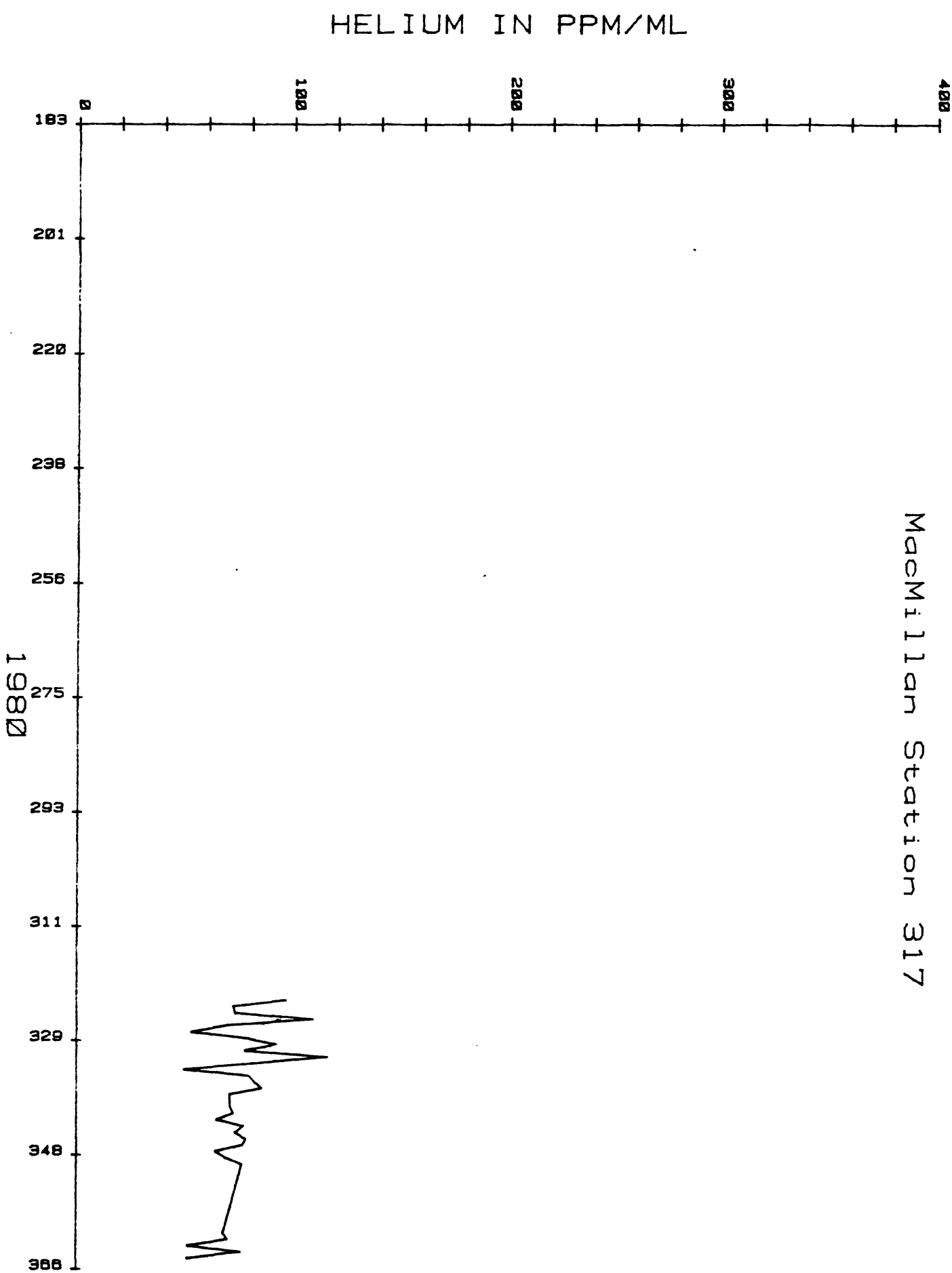

Figure 26.--Helium concentrations in water samples, Ennis, Montana, July through December, 1980.

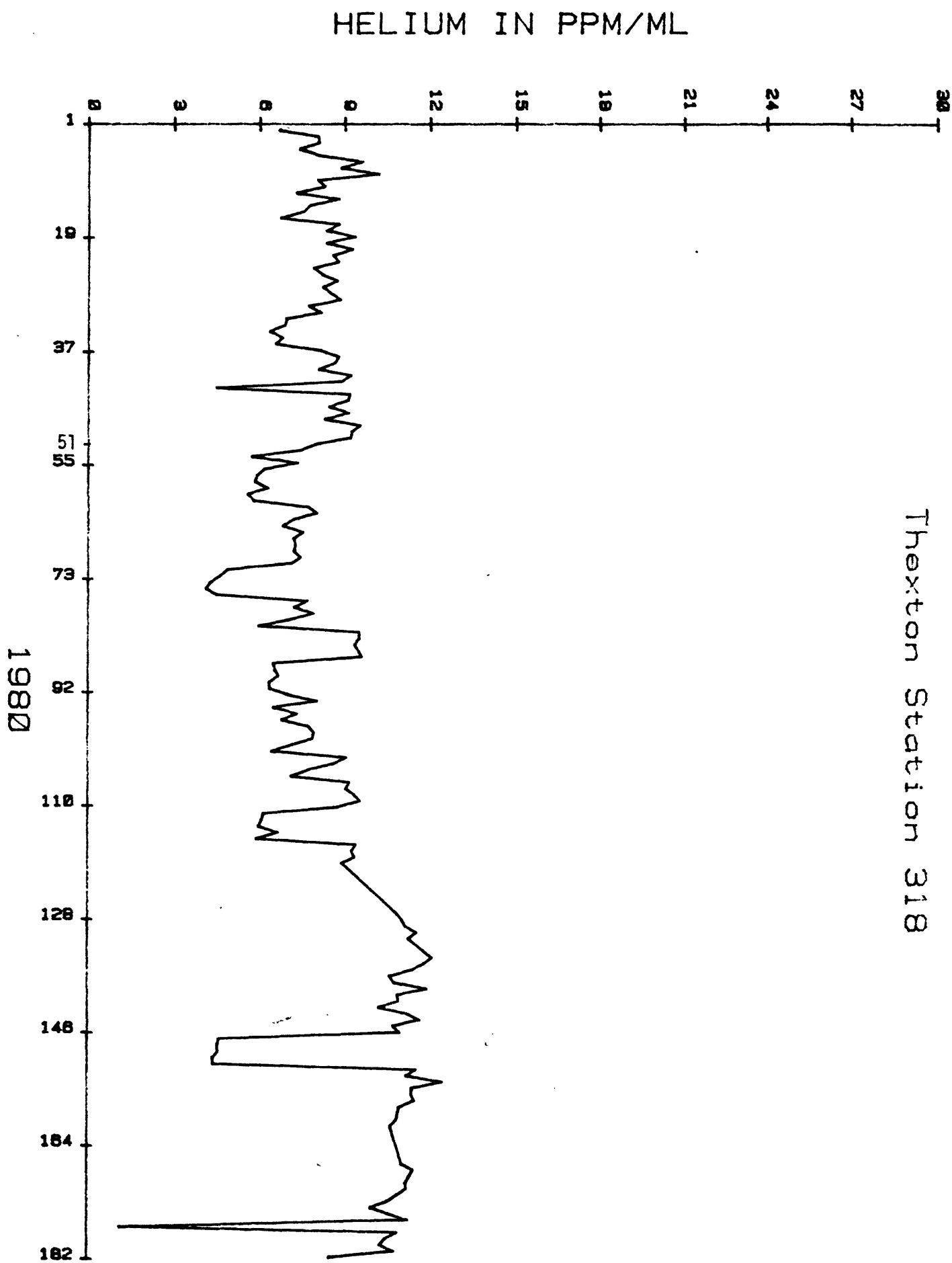

Figure 27.--Helium concentrations in water samples, Ennis, Montana, January through June, 1980.

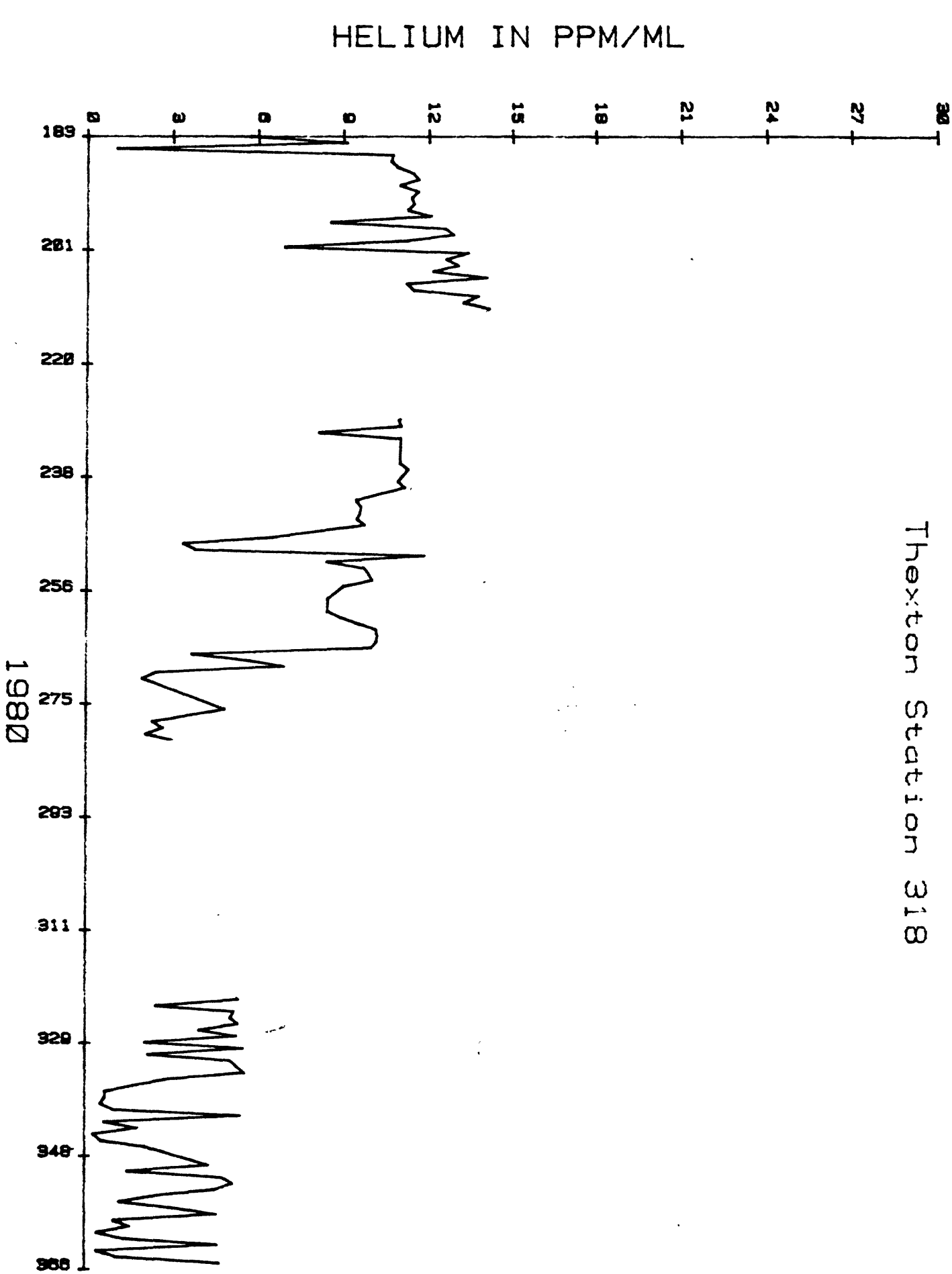

Figure 28.--Helium concentrations in water samples, Ennis, Montana, July through December, 1980.

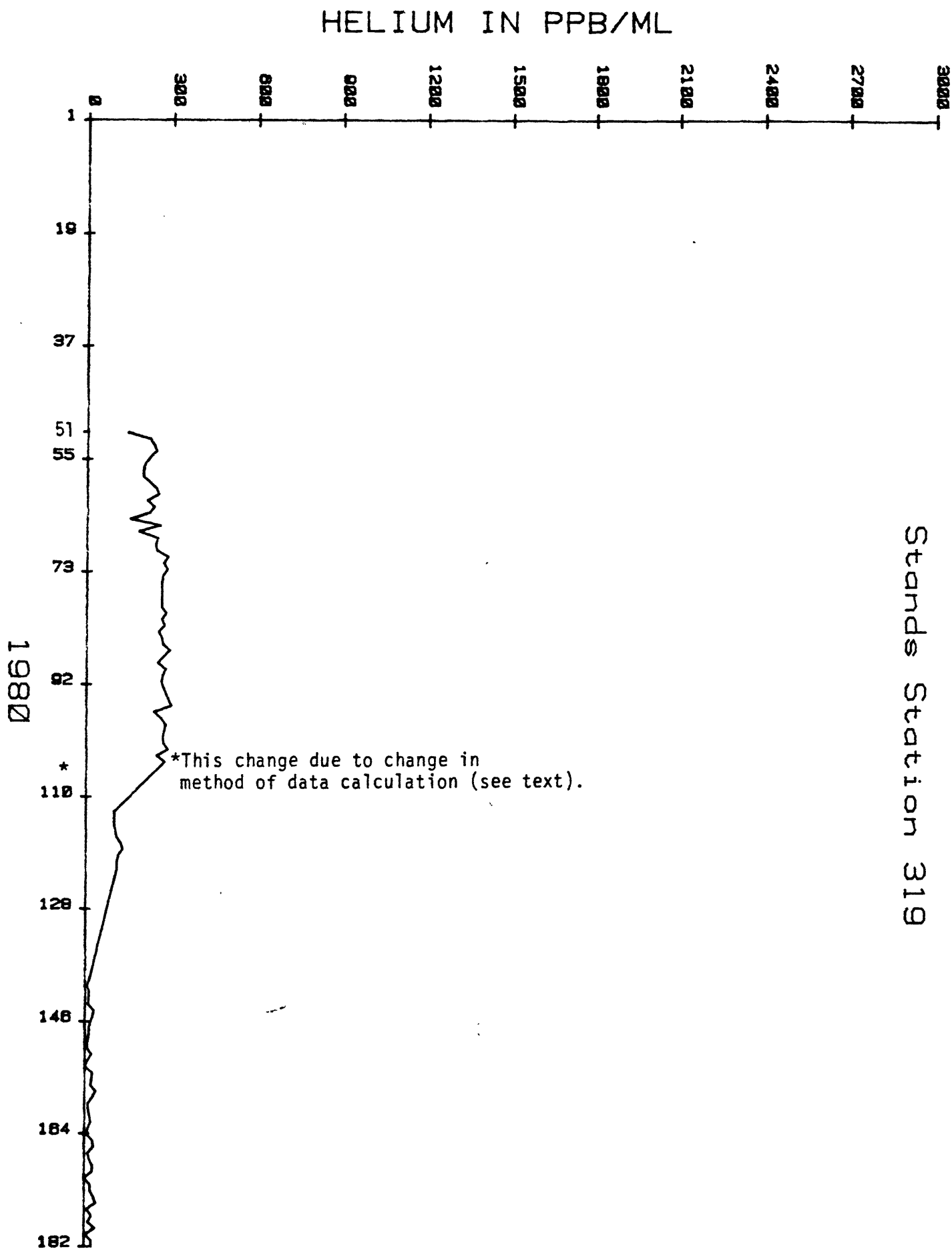

Figure 29.--Helium concentrations in water samples, Pray, Montana, January through June, 1980.

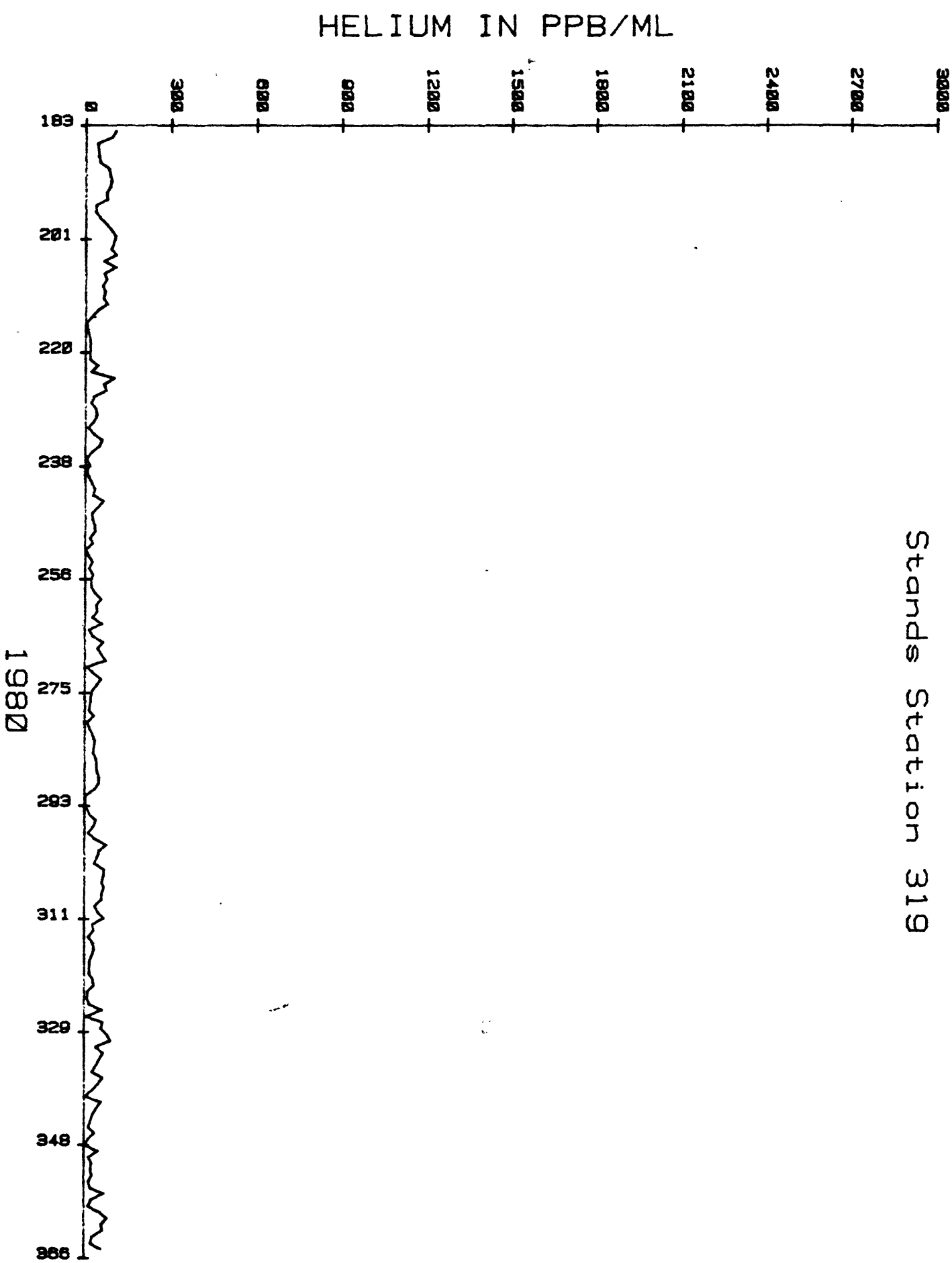

Figure 30.--Helium concentrations in water samples, Pray, Montana, July through December, 1980.

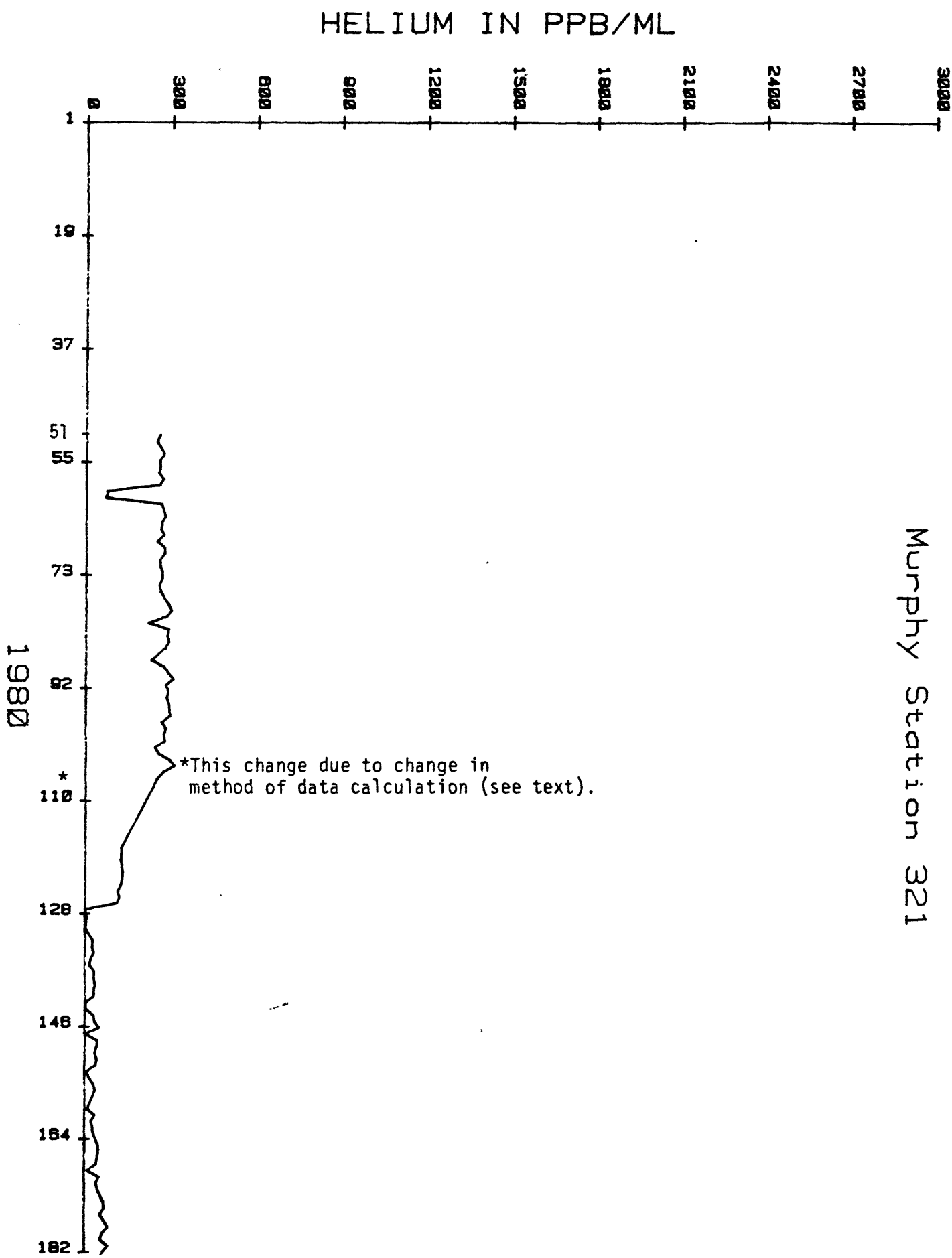

Figure 31.--Helium concentrations in water samples, Emigrant, Montana, January through June, 1980.

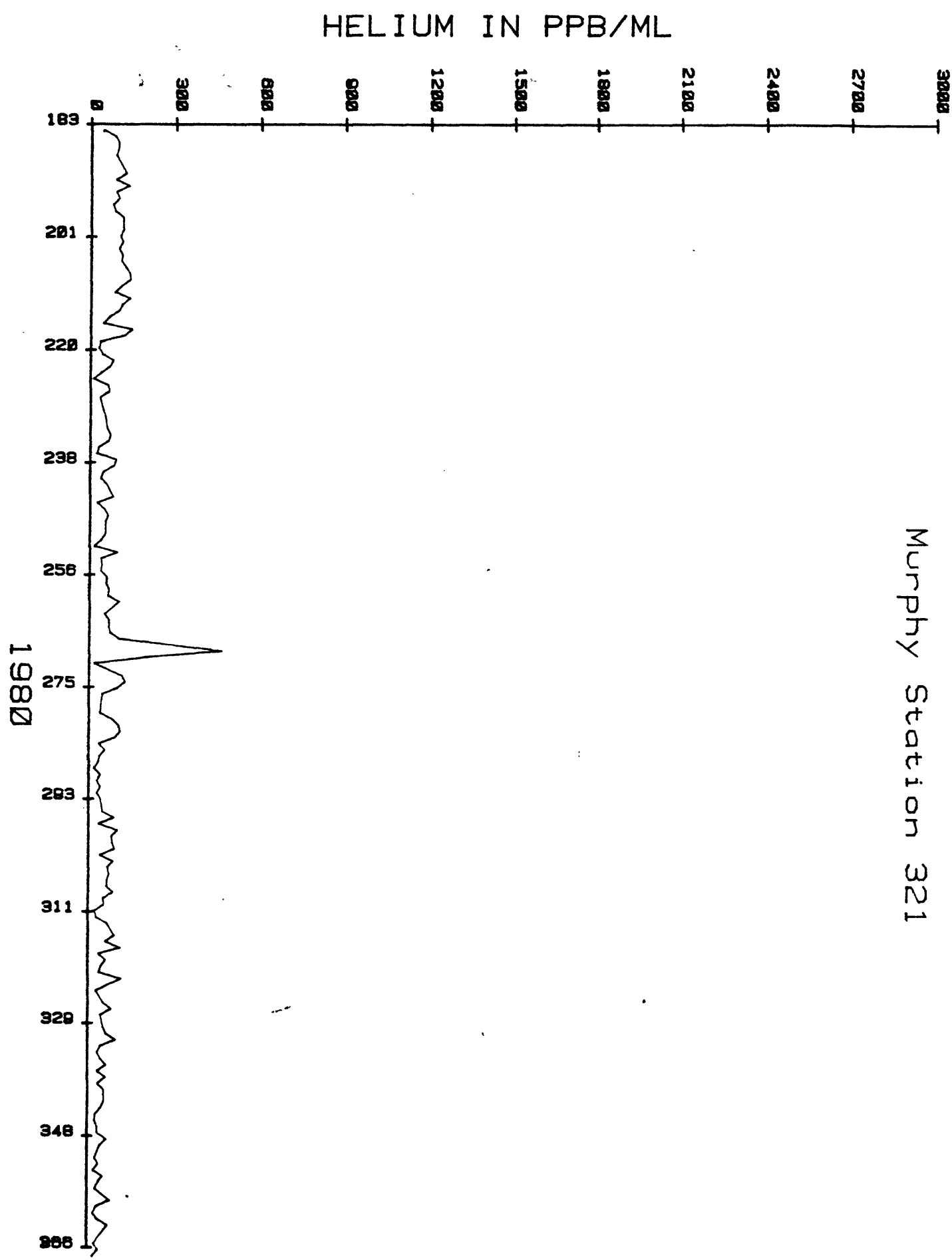

Figure 32.--Helium concentrations in water samples, Emigrant, Montana, July through December, 1980.

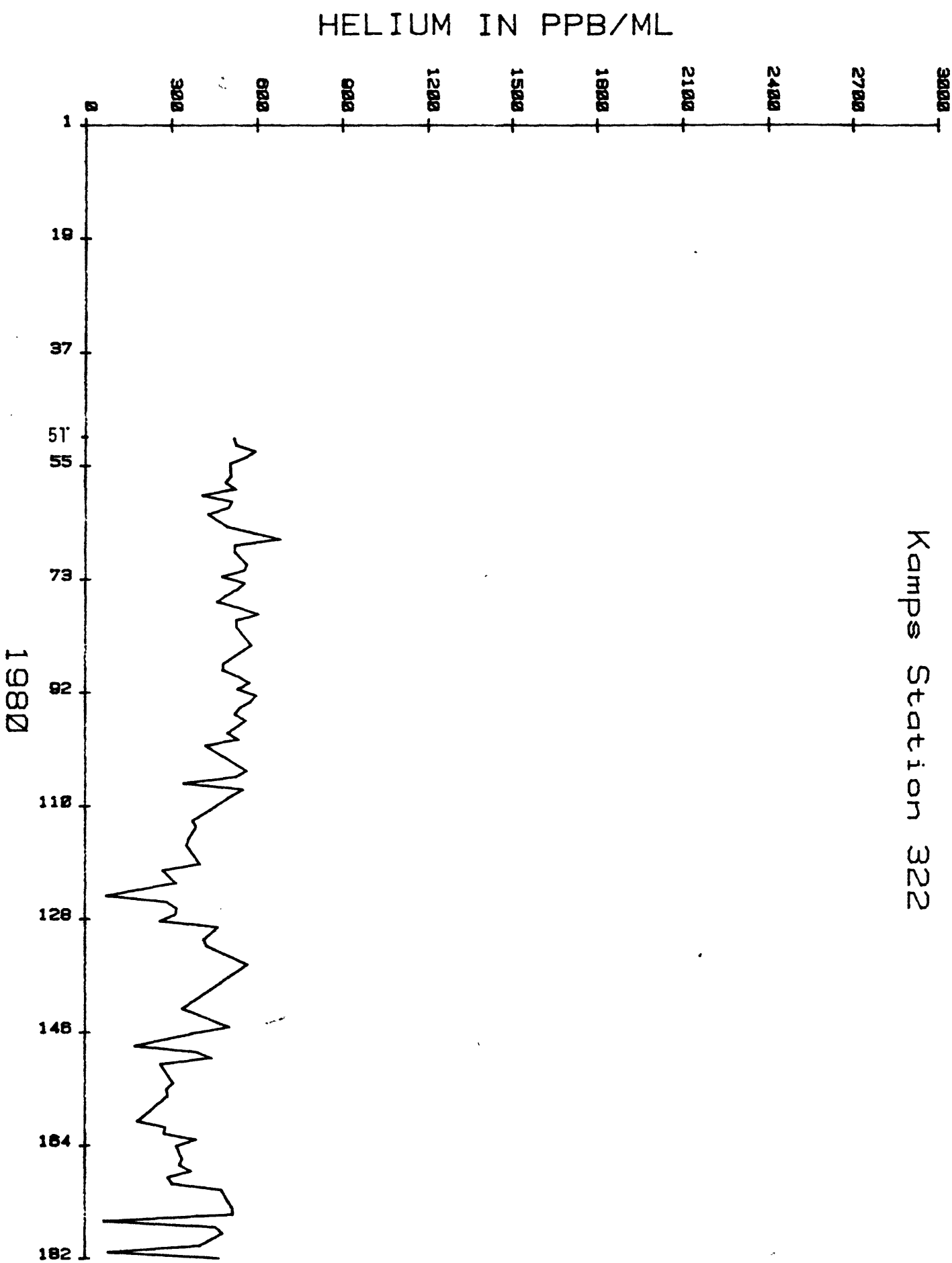

Figure 33.--Helium concentrations in water samples, Livingstone, Montana, January through June, 1980.

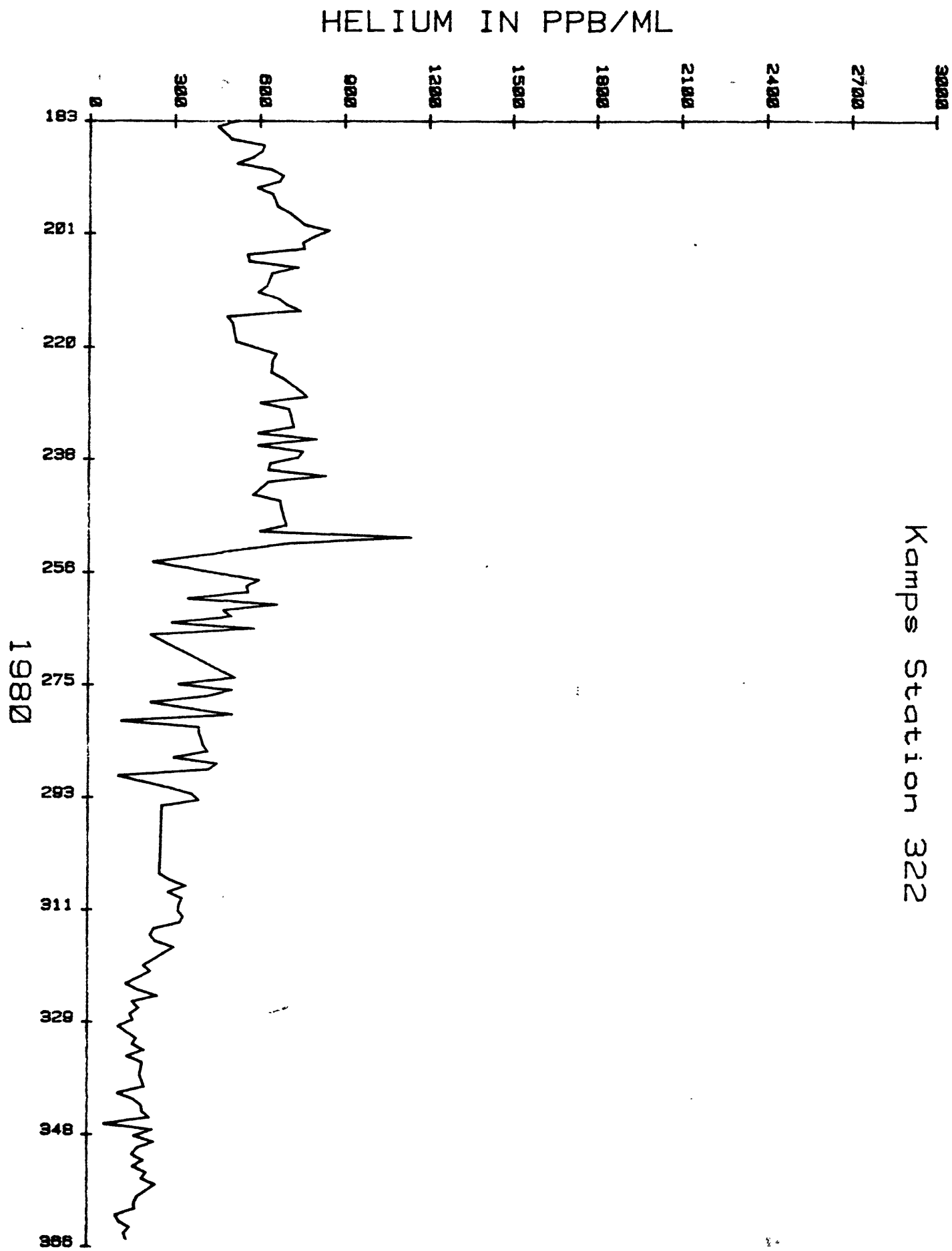

Figure 34.--Helium concentrations in water samples, Livingstone, Montana, July through December, 1980.

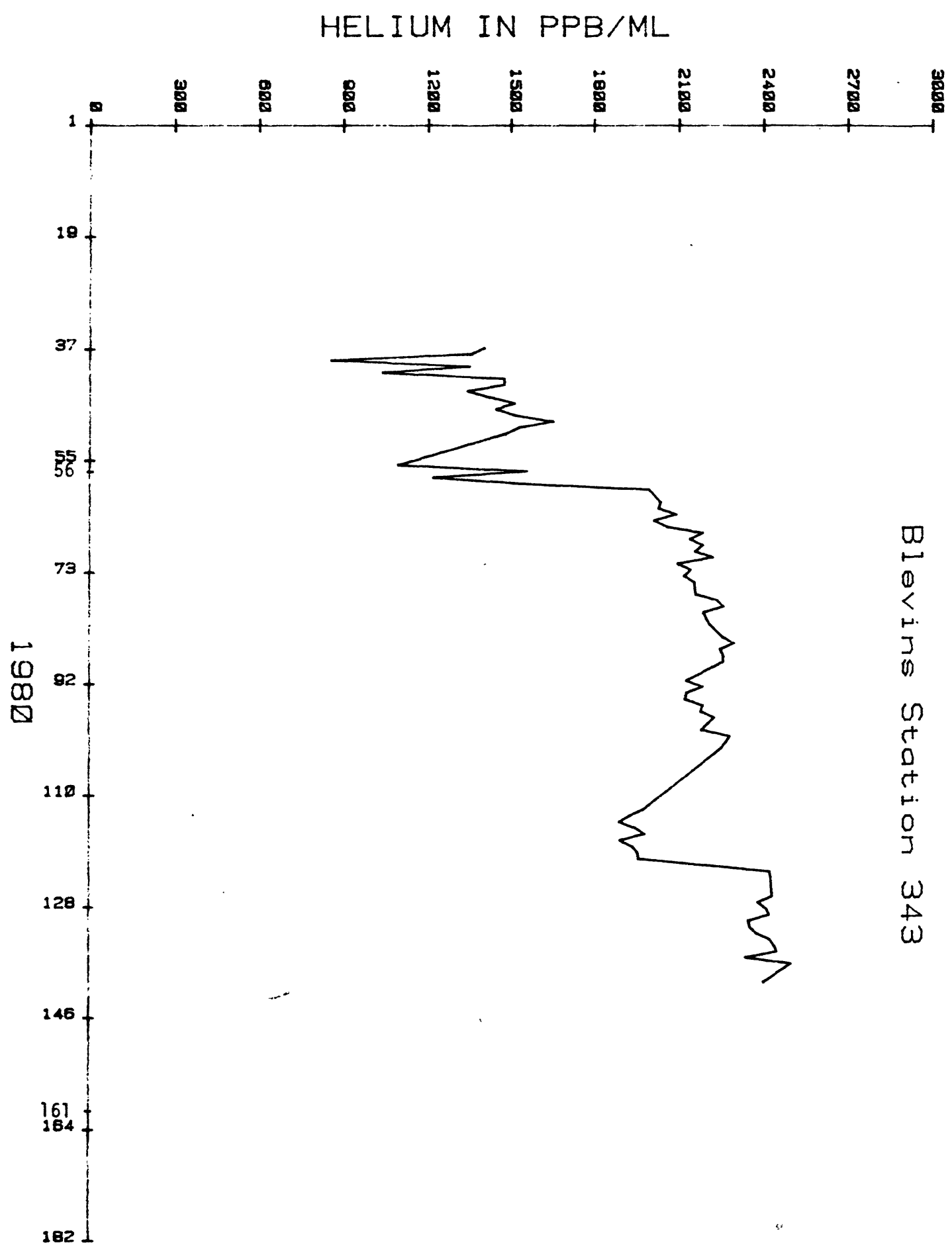

Figure 35.--Helium concentrations in water samples, Brawley, California, January through June, 1980.

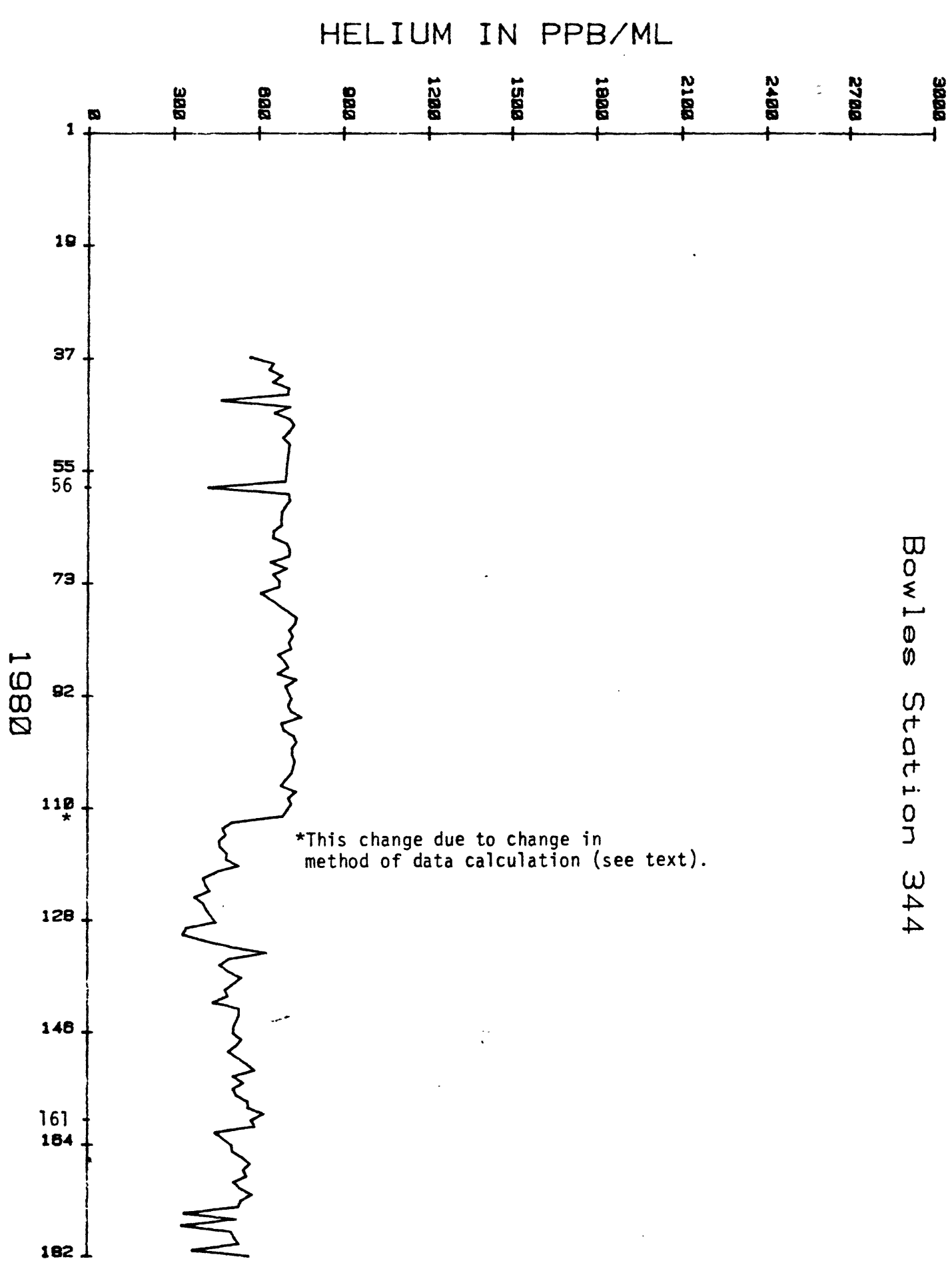

Figure 36.--Helium concentrations in water samples, Calipatria, California, January through June, 1980.

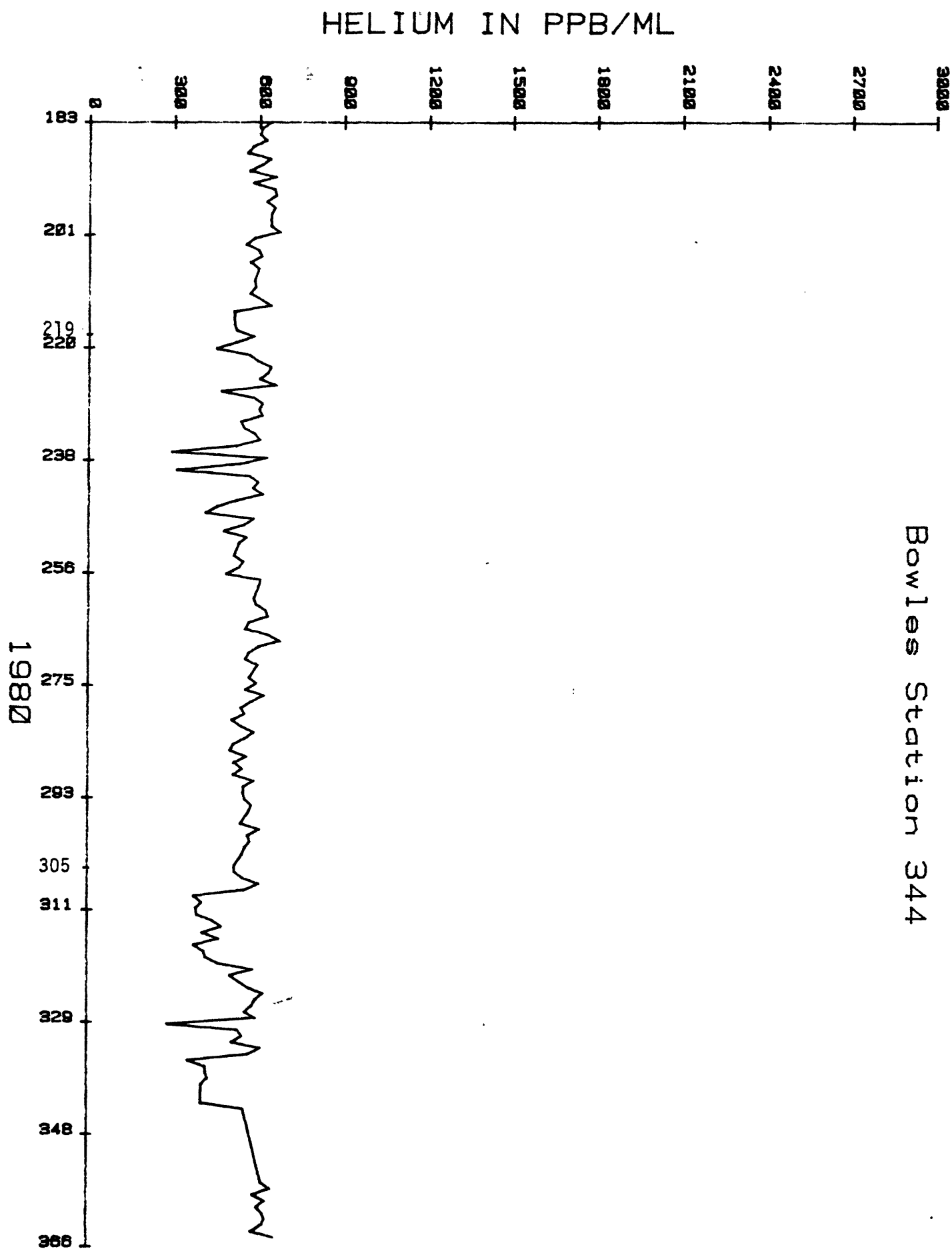

Figure 37.--Helium concentrations in water samples, Calipatria, California, July through December, 1980.

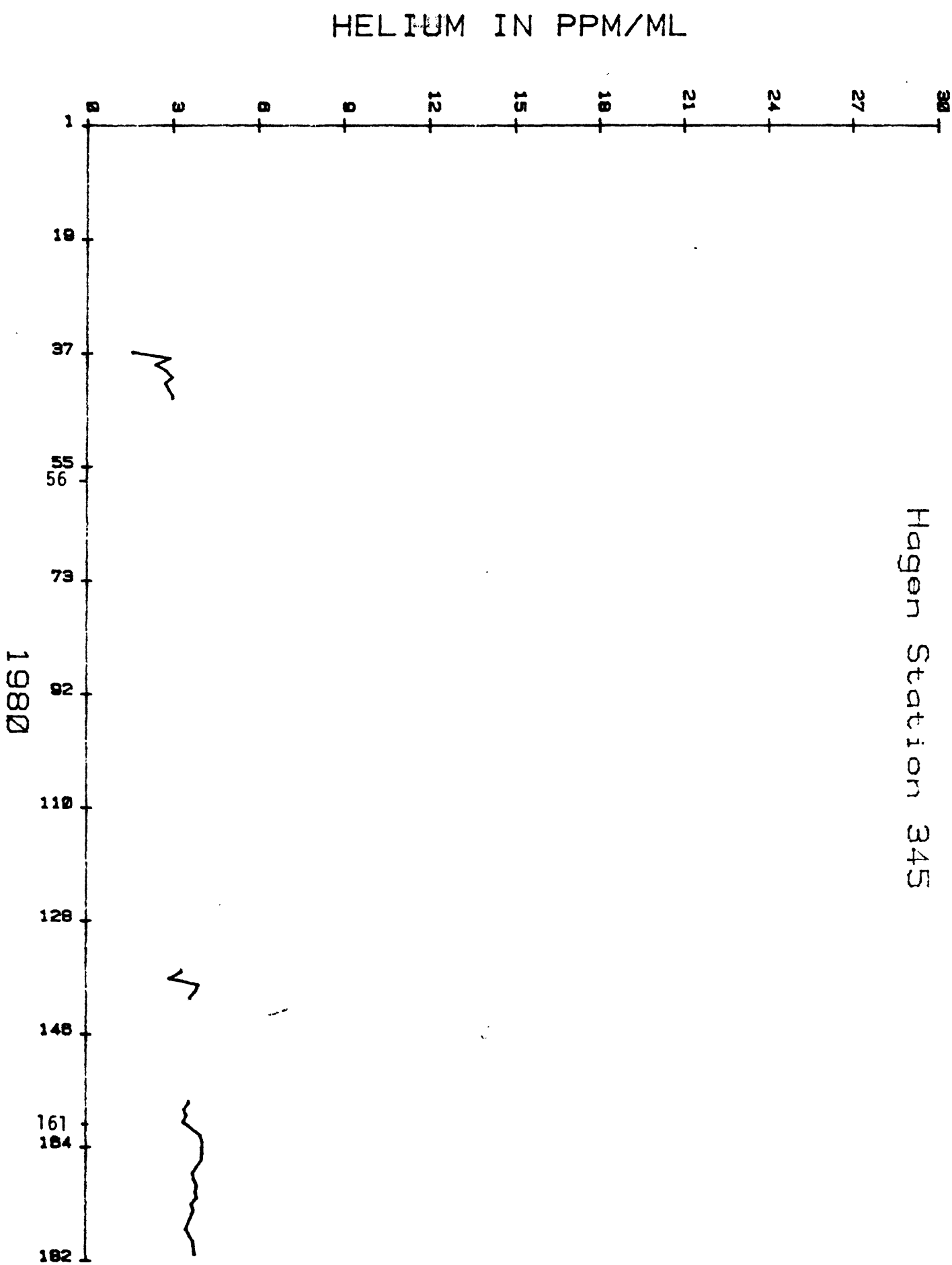

Figure 38.--Helium concentrations in water samples, Brawley, California, January through June, 1980.

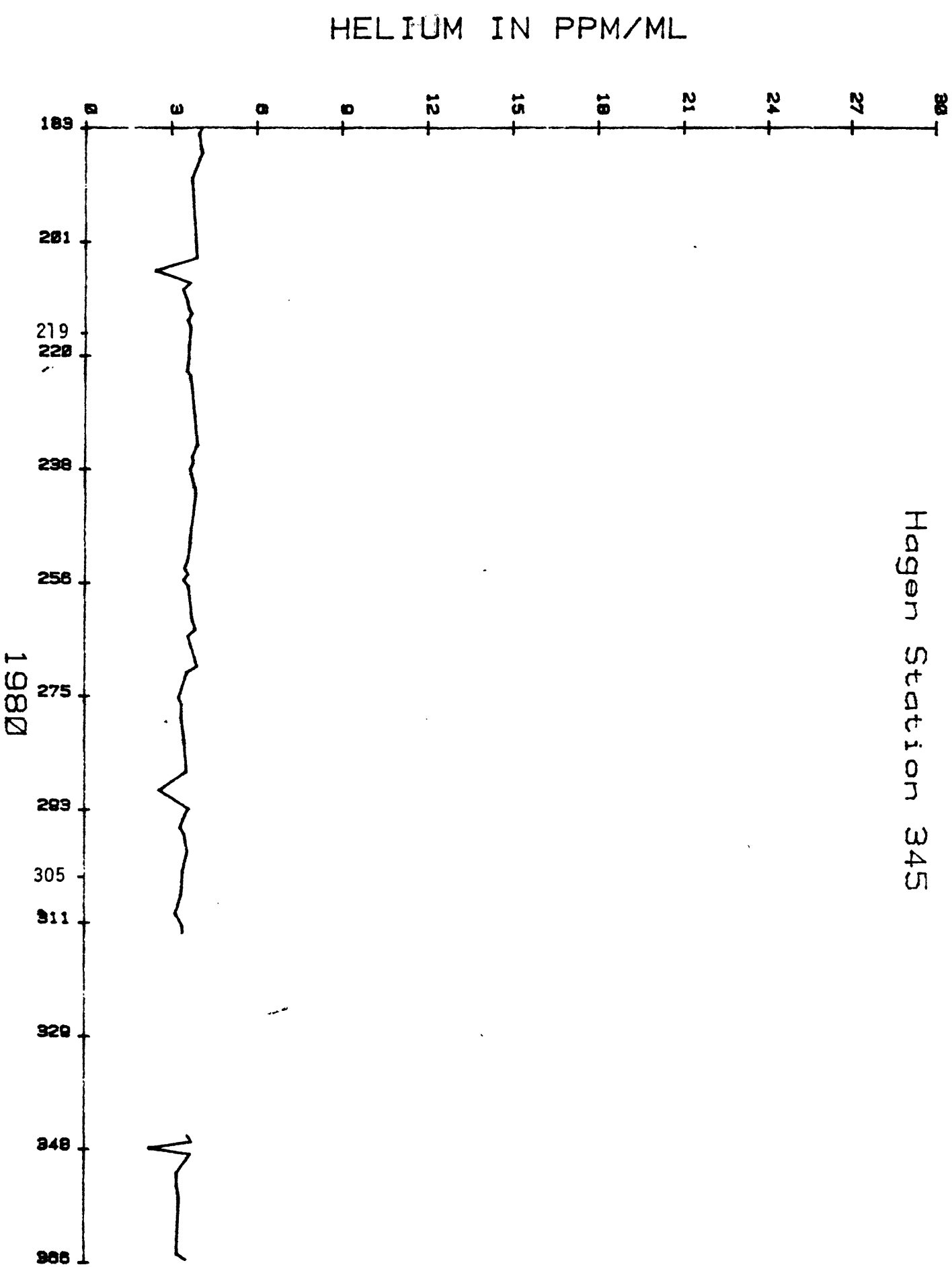

Figure 39.--Helium concentrations in water samples, Brawley, California, July through December, 1980.

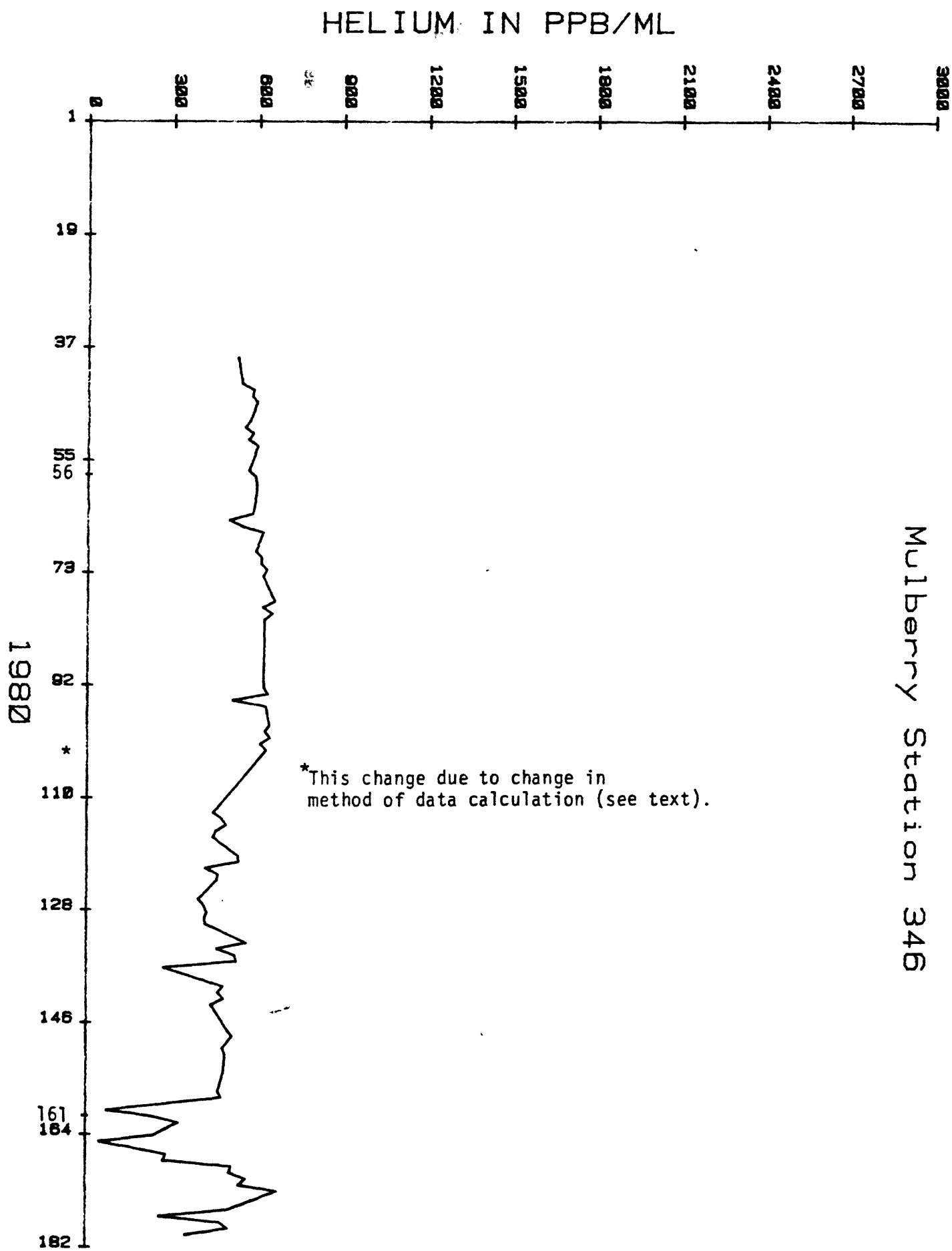

Figure 40.--Helium concentrations in water samples, Brawley, California. January through June, 1980.

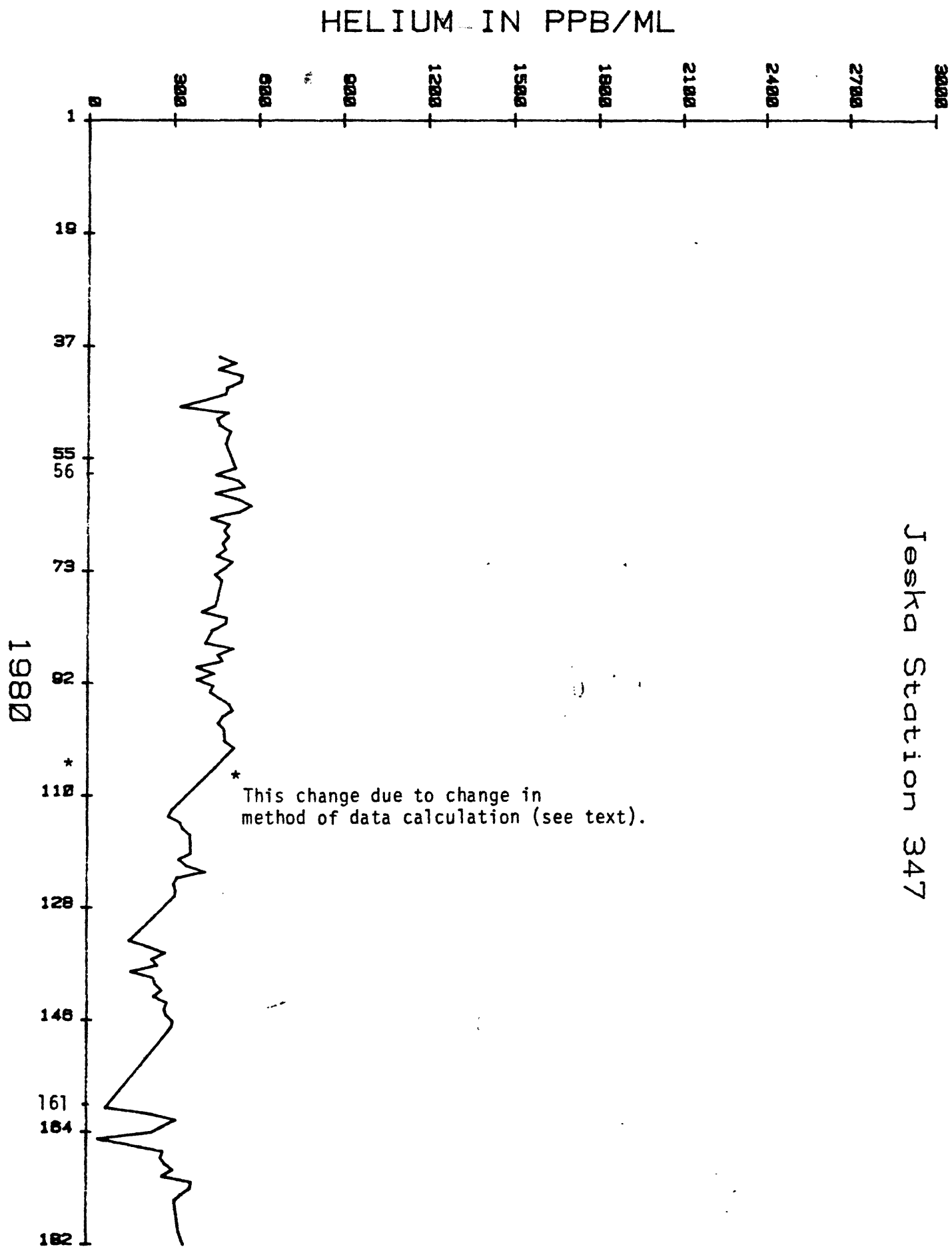

Figure 41.--Helium concentrations in water samples, Brawley, California, January through June, 1980.

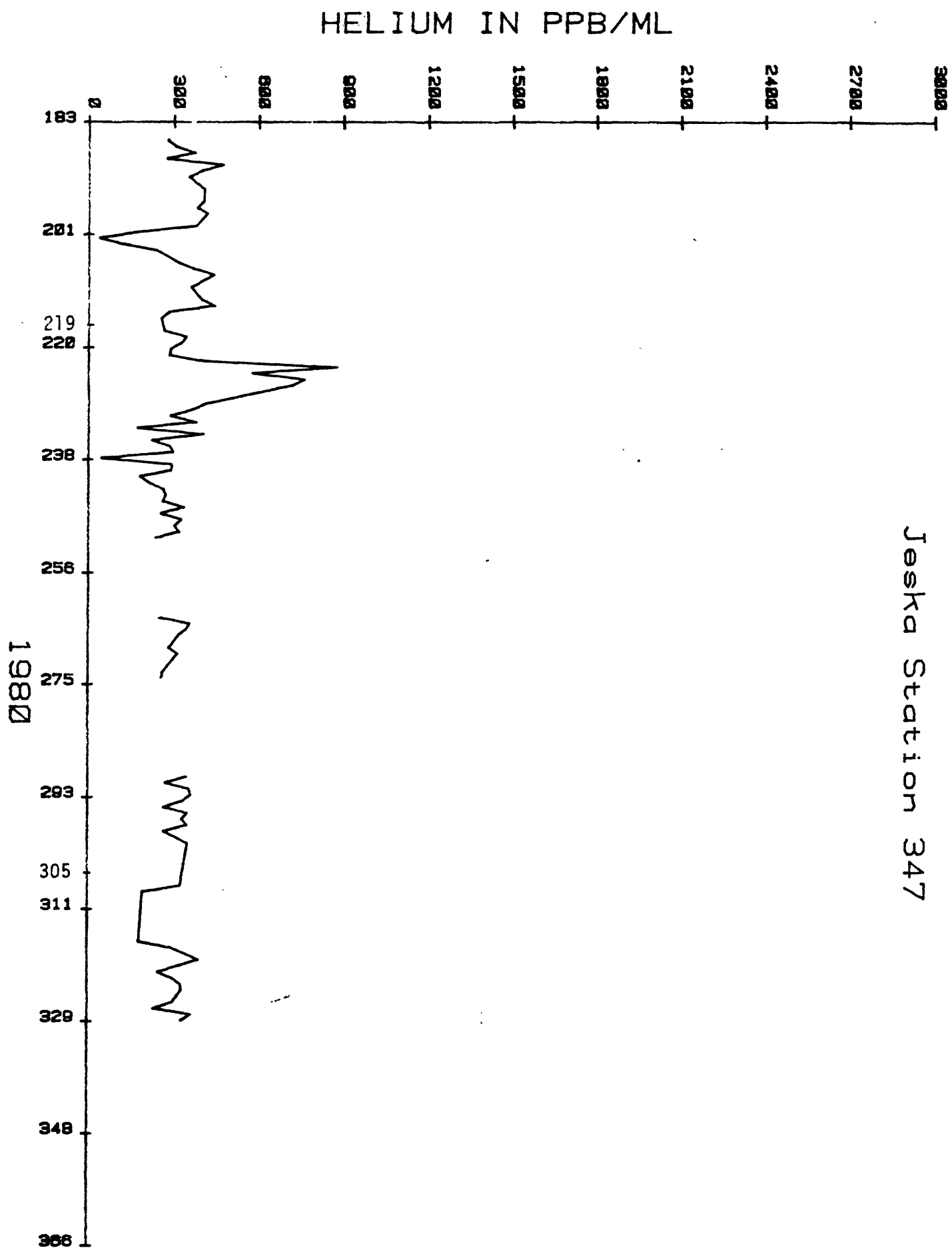

Figure 42.--Helium concentrations in water samples, Brawley, California, July through December, 1980.

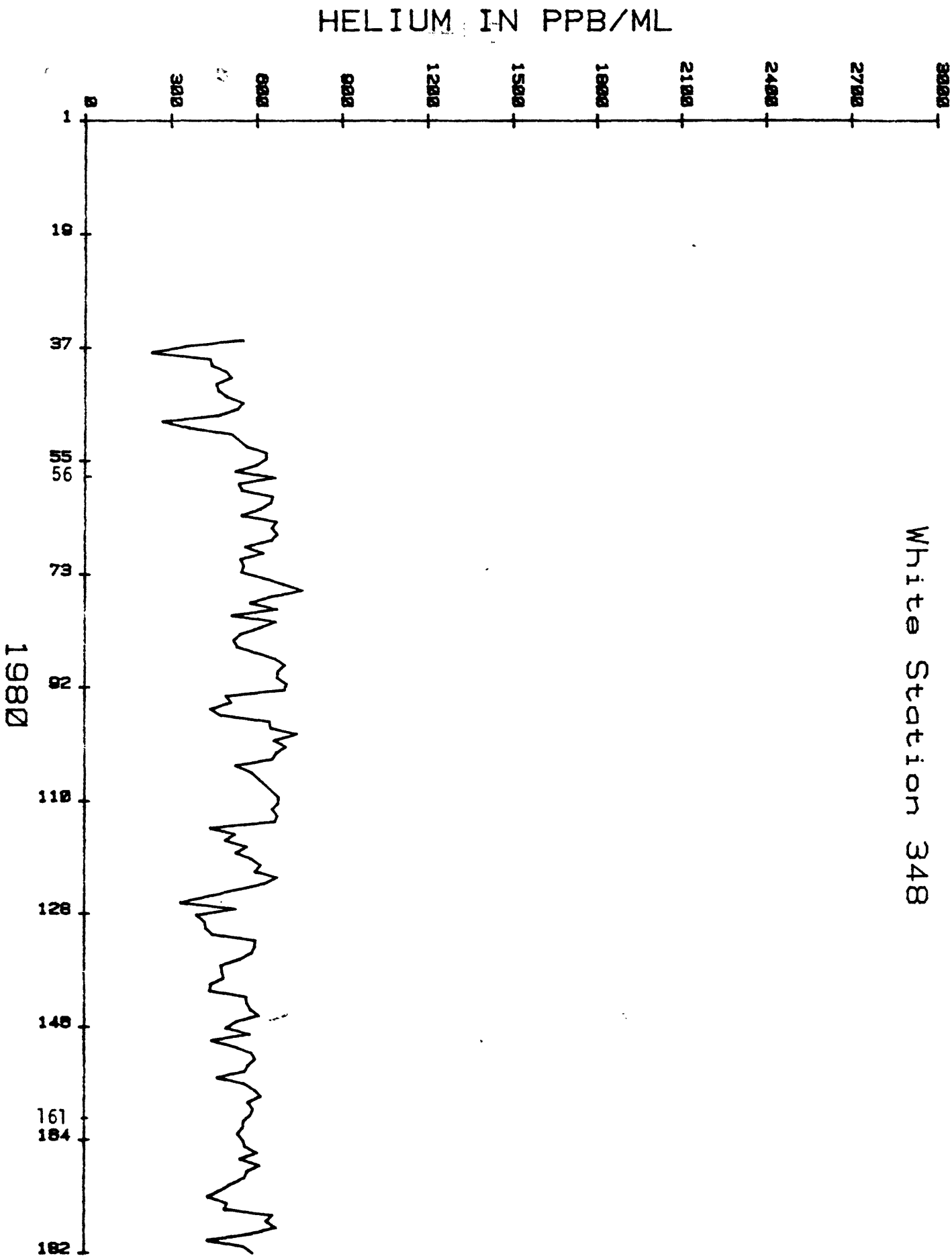

Figure 43.--Helium concentrations in water samples, Ocotillo, California, January through June, 1980.

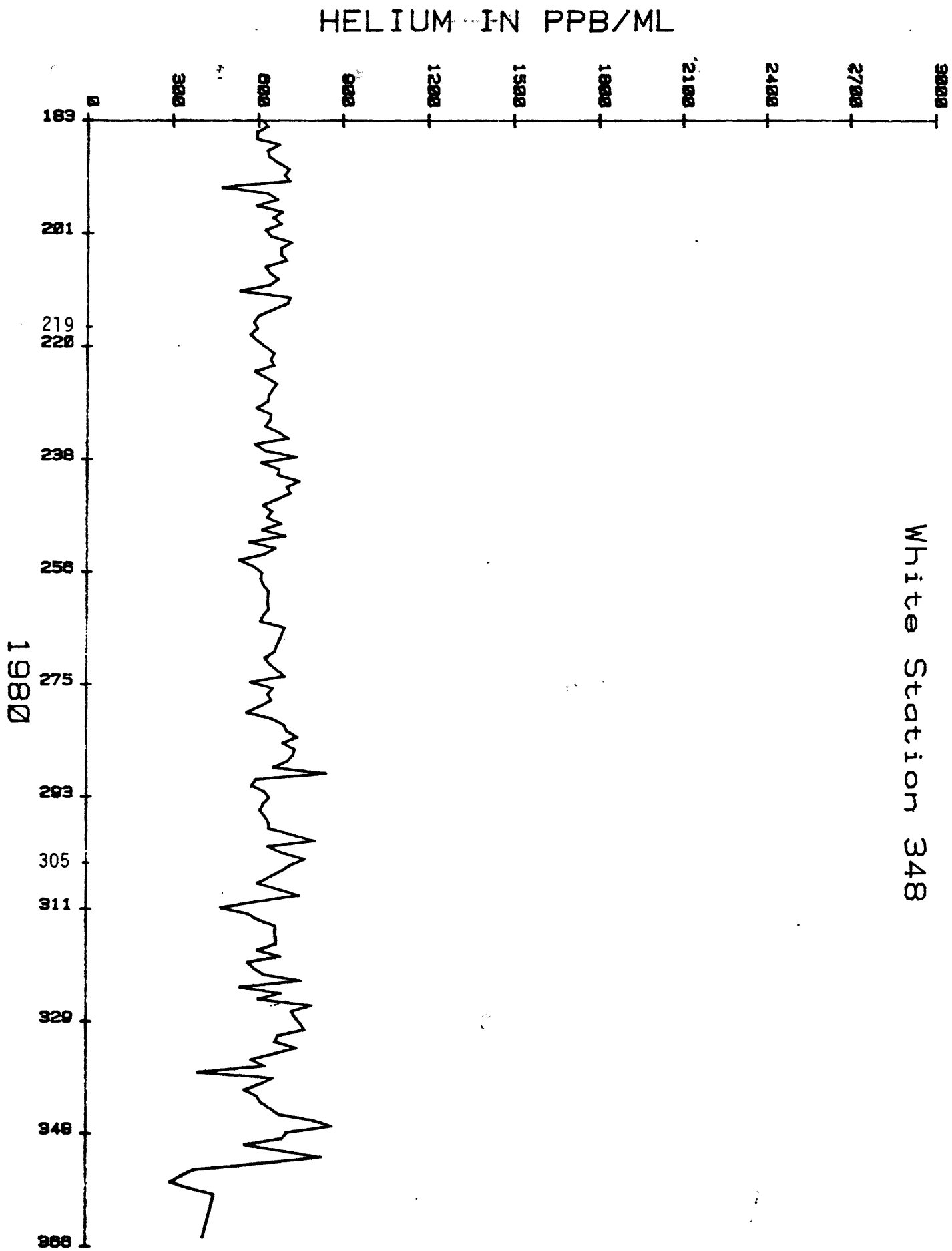

Figure 44.--Helium concentrations in water samples, Ocotillo, California, July through December, 1980.

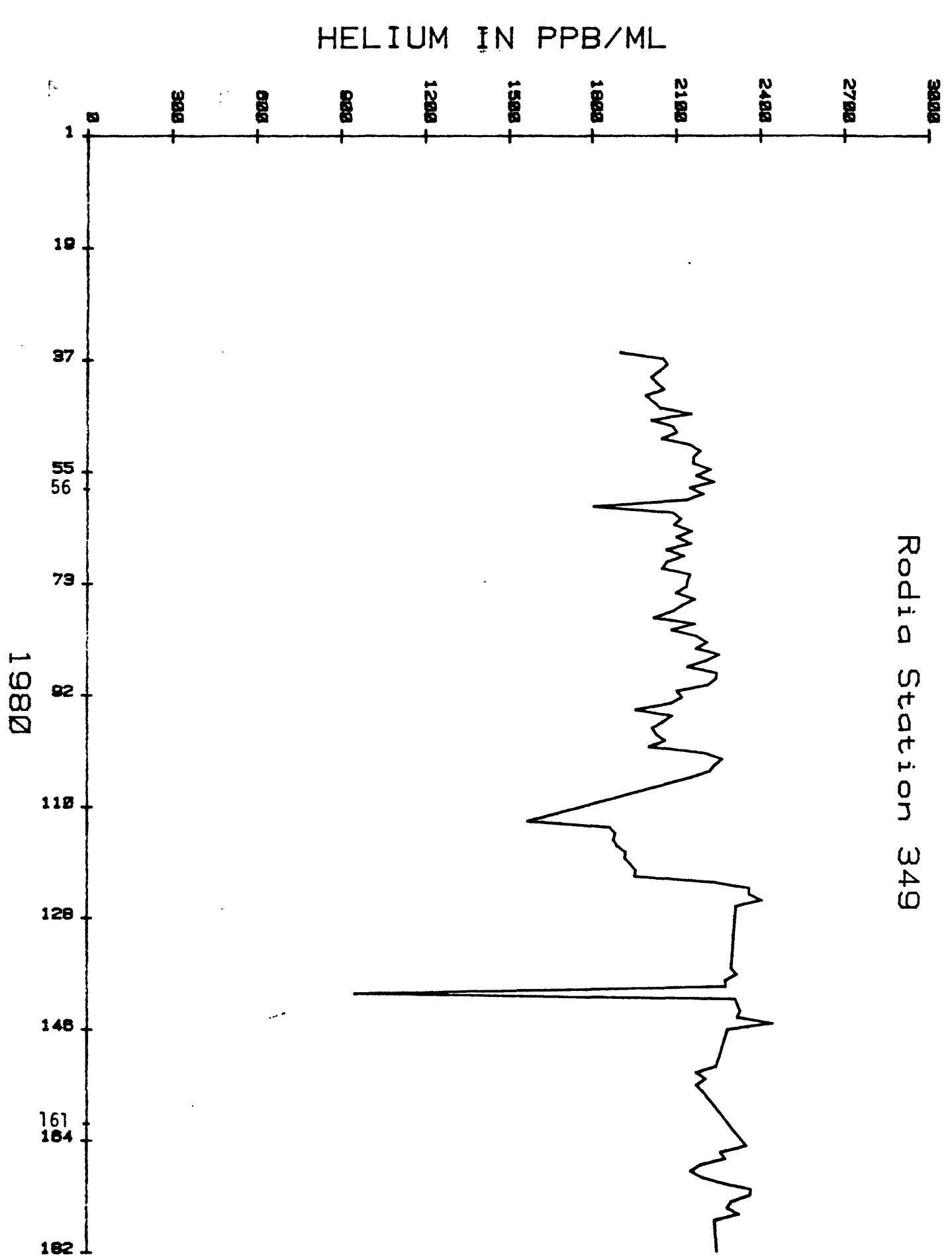

Figure 45.--Helium concentrations in water samles, Ocotillo, California, January through June, 1980.

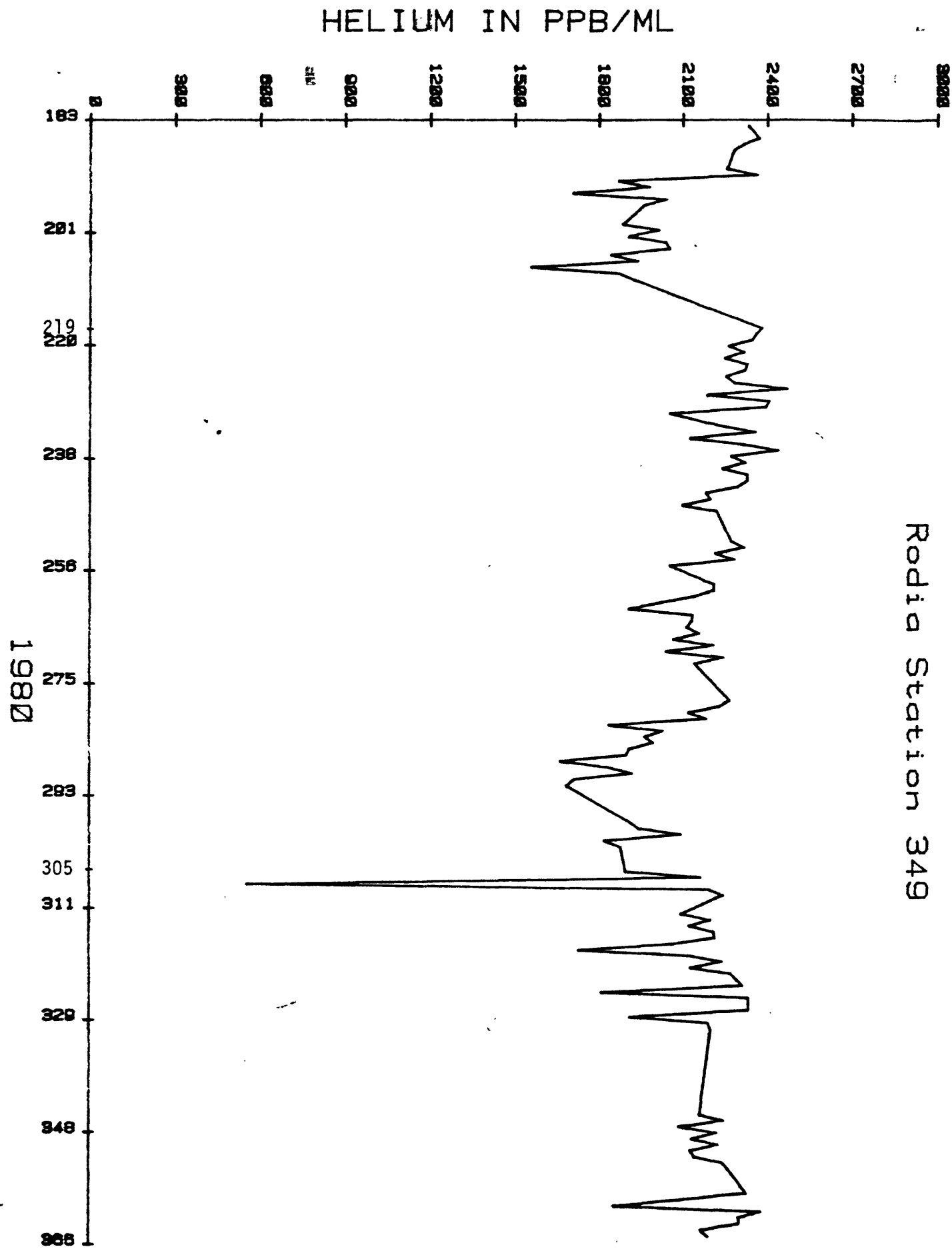

Figure 46.--Helium concentrations in water samples, Ocotillo, California, July through December, 1980.

JULIAN DATE CALENDAR

FOR LEAP YEARS ONLY

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Day
1	001	032	061	092	122	153	183	214	245	275	306	336	1
2	002	033	062	093	123	154	184	215	246	276	307	337	2
3	003	034	063	094	124	155	185	216	247	277	308	338	3
4	004	035	064	095	125	156	186	217	248	278	309	339	4
5	005	036	065	096	126	157	187	218	249	279	310	340	5
6	006	037	066	097	127	158	188	219	250	280	311	341	6
7	007	038	067	098	128	159	189	220	251	281	312	342	7
8	008	039	068	099	129	160	190	221	252	282	313	343	8
9	009	040	069	100	130	161	191	222	253	283	314	344	9
10	010	041	070	101	131	162	192	223	254	284	315	345	10
11	011	042	071	102	132	163	193	224	255	285	316	346	11
12	012	043	072	103	133	164	194	225	256	286	317	347	12
13	013	044	073	104	134	165	195	226	257	287	318	348	13
14	014	045	074	105	135	166	196	227	258	288	319	349	14
15	015	046	075	106	136	167	197	228	259	289	320	350	15
16	016	047	076	107	137	168	198	229	260	290	321	351	16
17	017	048	077	108	138	169	199	230	261	291	322	352	17
18	018	049	078	109	139	170	200	231	262	292	323	353	18
19	019	050	079	110	140	171	201	232	263	293	324	354	19
20	020	051	080	111	141	172	202	233	264	294	325	355	20
21	021	052	081	112	142	173	203	234	265	295	326	356	21
22	022	053	082	113	143	174	204	235	266	296	327	357	22
23	023	054	083	114	144	175	205	236	267	297	328	358	23
24	024	055	084	115	145	176	206	237	268	298	329	359	24
25	025	056	085	116	146	177	207	238	269	299	330	360	25
26	026	057	086	117	147	178	208	239	270	300	331	361	26
27	027	058	087	118	148	179	209	240	271	301	332	362	27
28	028	059	088	119	149	180	210	241	272	302	333	363	28
29	029	060	089	120	150	181	211	242	273	303	334	364	29
30	030		090	121	151	182	212	243	274	304	335	365	30
31	031		091		152		213	244		305		366	31

(USE IN 1964, 1968, 1972, etc.)

GPO: 1964 O—722-005

Figure 47.--Chart showing correlation of Julian and Gregorian calendar.