DUNELM ENTERPRISES, INC.

Seismic Source Analyses

For The

SeaScan Tri-Cluster®

Seismic Sound Source System

Final Report

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Rod Cotton

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Executive Summary

The 1200 cu in SeaScan Tri-Cluster® array is a very stable and compact unit that produces an efficient broadband seismic signal.

A typical example of the signature and its power spectrum is shown in Figures. 1 and 2 on the following pages.

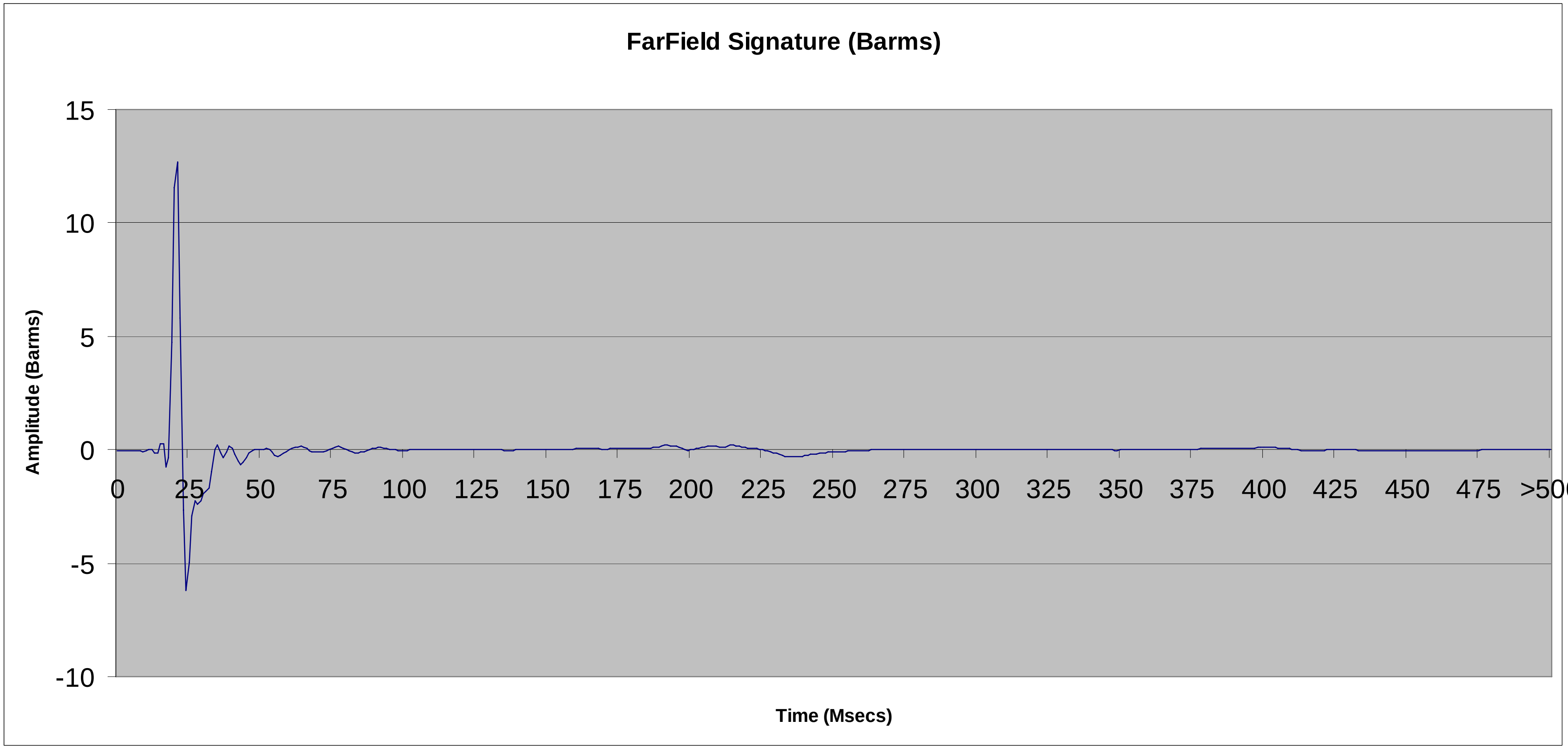
The average zero–to-peak output is 13.05 +/- 0.29 Barms; the average peak-to-peak output is 19.10 +/- 0.72 Barms. These are very stable numbers. The increase in the standard deviation of the peak-to-peak value is partly due to the effect of the changing sea surface on the ghost and thus contains a small but unpredictable component. The average power of the spectrum relative to 1 dB per Hz at 1 meter is 190.91 +/- 0.70 dB.

The primary-to-bubble ration averages 32.78 +/- 3.73 which is exceedingly good. A higher standard deviation here is expected because the ratio is so very high that small amounts of random noise in the denominator can produce magnified changes in the ratio.

The system is flexible and modular so that multiple units may be deployed if more power is required. Figures 3 and 4 show two units in operation for a total of 2400 cu in. The zero-to-peak amplitude is 25.8 Barms and the peak-to-peak 38.61 Barms with a primary-to-bubble ratio of 33.27

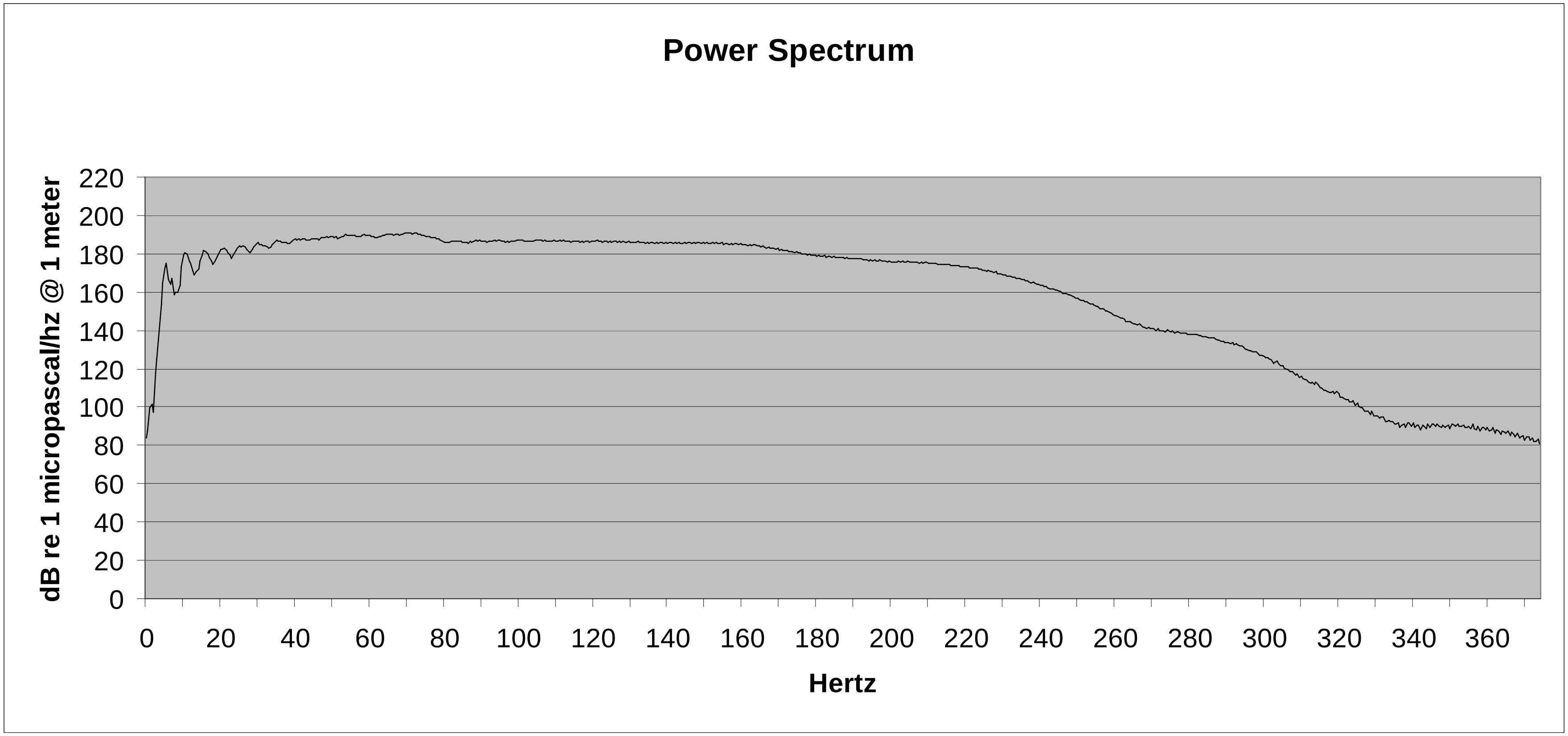
Bubble stability is shown to be exceedingly good and is detailed in the note by Dave Ridyard following the displayed signatures (see pages 8 and 9).

Figure 1: Time signature of the 1200 cu in Tri-Cluster® array at a depth of 10 Feet (from fig 2.33)



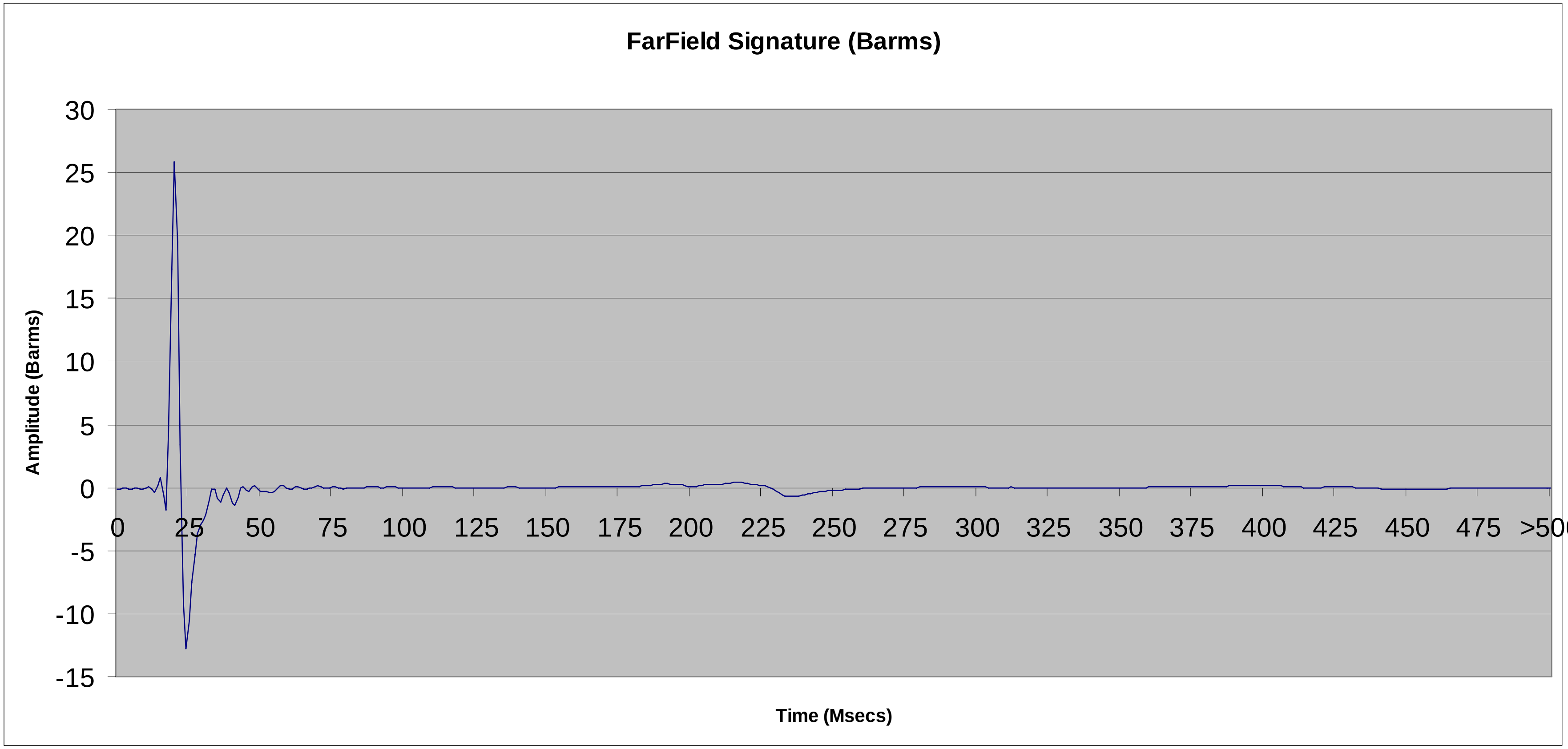
0-P Barm 13.24 P-P Barm 19.46 P/B Ratio = 36.98 Period = 193.75 Depth = 2.63 M Power = 190.87 Db

Figure 2: Power Spectrum of the Signature from the 1200 cu in Tri-Cluster® array (from fig 2.33)



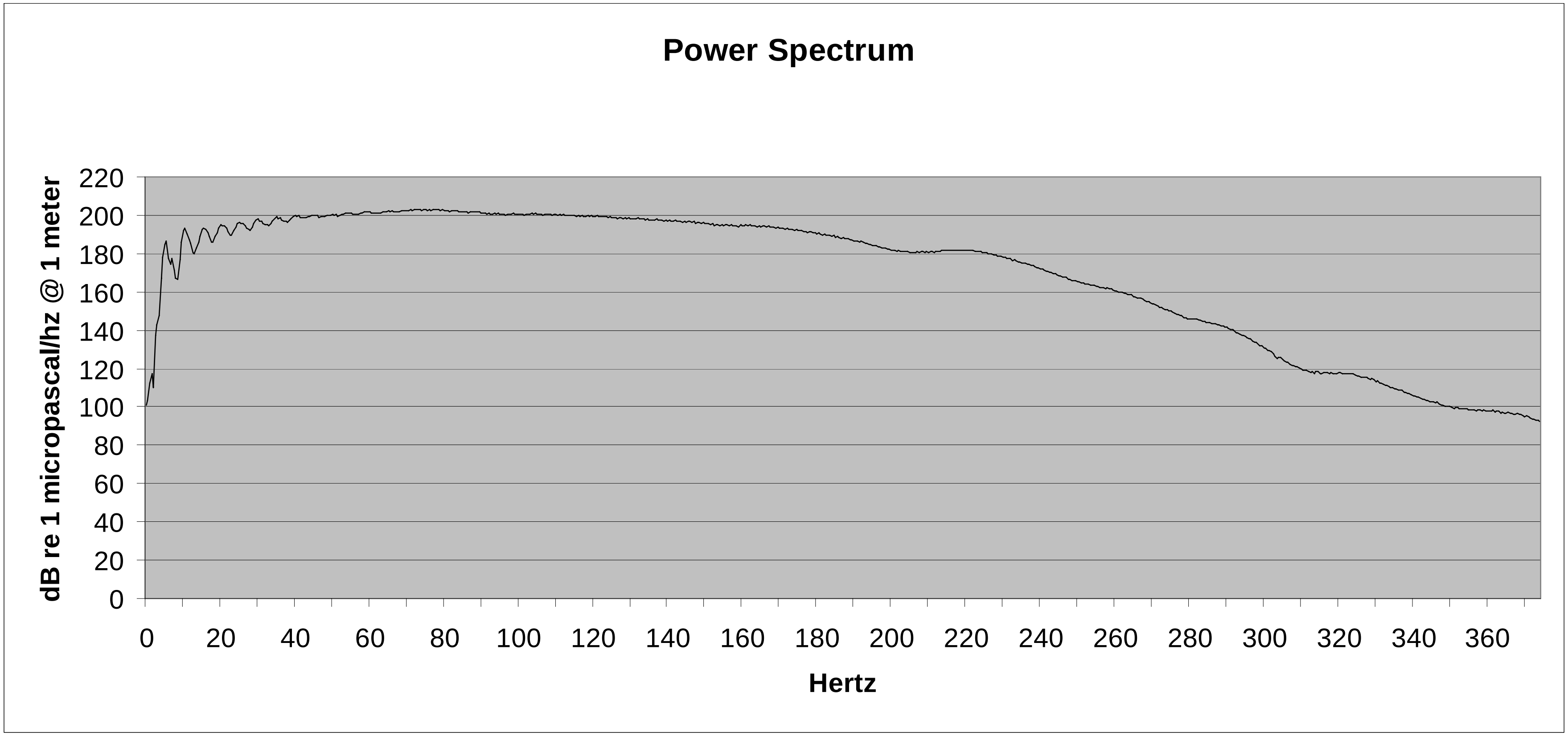
0-P Barm	13.24	P-P Barm	19.46	P/B Ratio =	36.98	Period =	193.75	Depth =	2.63	M	Power =	190.87	Db

Time signature of the 2400 cu in Tri-Cluster® array at a depth of 10 Feet (from fig 2.33)



0-P Barm	25.80	P-P Barm	38.61	P/B Ratio =	33.27	Period =	196.50	Depth =	3.00	M	Power =	203.16	Db

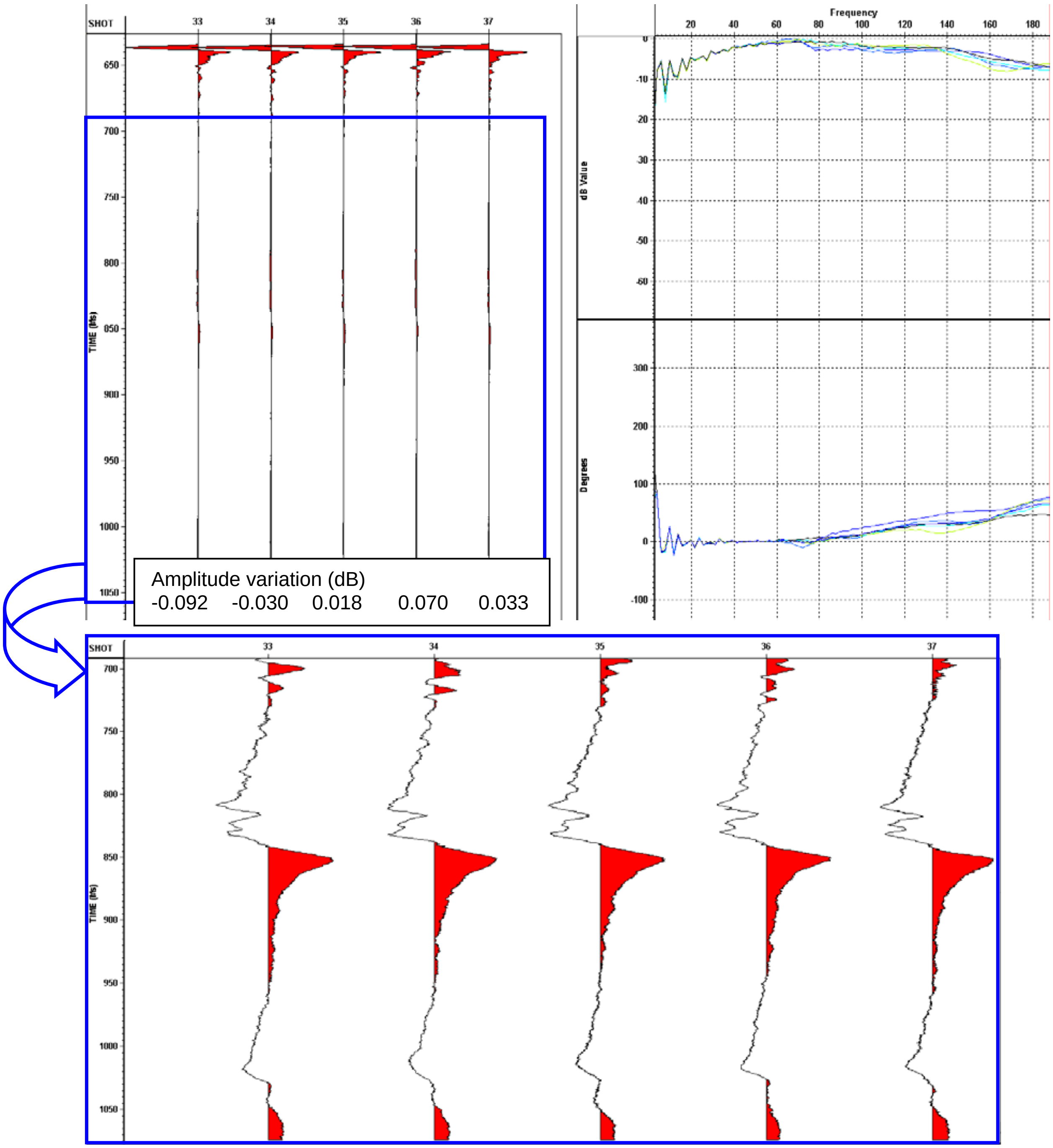
Figure 2: Power Spectrum of the Signature from the 2400 cu in Tri-Cluster® array (from fig 2.33)



0-P Barm 25.80 P-P Barm 38.61 P/B Ratio = 33.27 Period = 196.50 Depth = 3.00 M Power = 203.16 Db

A Note on Repeatability by Dave Ridyard

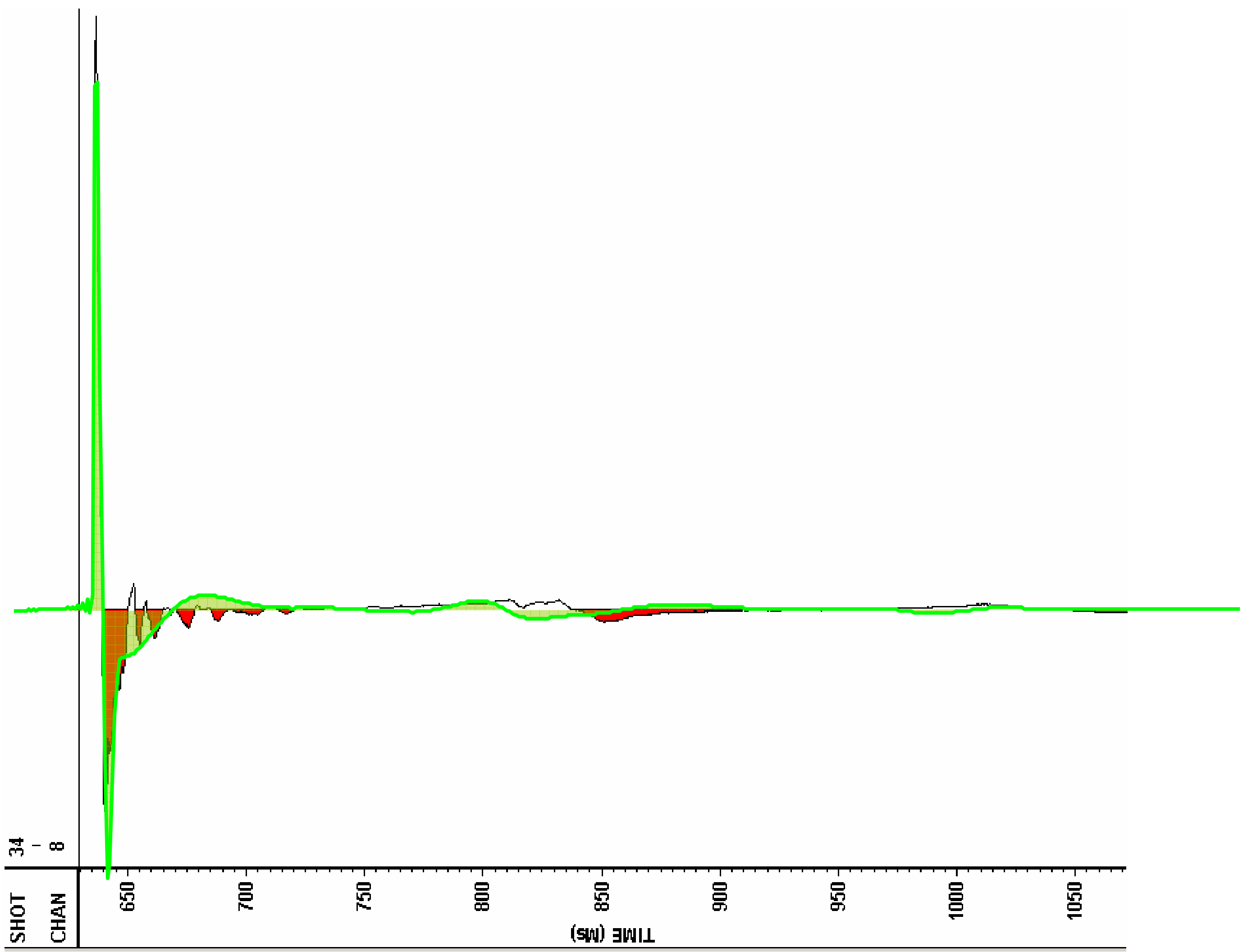
During the sea test, only 5 consecutive shots were recorded using the full 1200 cu.in. Tri-Cluster ® array. These shots are shown below. Note the repeatability of the signature, even though no correction has been made for varying geometry during the acquisition. The power output of the five shots are all within +/-0.1dB, with the spectral content being highly repeatable in both amplitude and phase. The lower figure shows a high gain zoom of the bubble oscillation, and illustrates the extreme repeatability of the signature.



Modeling accuracy

An interesting by-product of any far field signature test is to verify the performance of prior array modeling exercises. Three modeling packages were used to model the Tri-Cluster ® array used in the test. All the packages did a reasonable job of estimating the amplitude of the first peak to within 5-10%. However, two of the packages significantly overestimated the depth of the ghost notch, the amplitude of the ghost trough, and the bubble period. It would appear that the likely cause of this is an inappropriate handling of the three different source depths within the Tri-Cluster ® array.

The best model signature was that provided by Dr. Cotton. This model slightly overestimated the amplitude of the ghost, but as shown below, agreement is very good, suggesting that Dr. Cotton's modeling algorithms are the most effective for modeling Tri-Cluster ®.



Processing Summary

The raw data was marginally contaminated with very low amplitude, very low frequency sinusoidal noise. This was removed by the application of a zero-phase filter with an 5(18) – 256(72) Hz bandpass. A program was written in Visual Basic ™ to:

- read in the data
- apply the bandpass filter to reject the noise
- scale the data according to the calibration factor for the instrument
- compute the:
  - zero-to-peak amplitude
  - peak-to-peak amplitude
  - primary-to-bubble ratio
  - dominant remaining bubble period
  - spectral power in dB/µPascal/Hz at one meter
- display
  - time signature
  - indices computed
  - amplitude spectra

The SeaScan Tri-Cluster ® array produces a powerful clean signal and a smooth spectrum. The Tri-Cluster ® has a middle cluster of a vertical square of guns. This means that one pair of guns is at a different depth, by 1 meter, to the other pair in the cluster. This smears out the ghost reflection which looks good at first sight. The ghost is clearly attenuated on all of the SeaScan Tri-Cluster® arrays. However, the two ghosts are there. Visual inspection only has a dynamic range of about 15 dB. The data and its processing support a dynamic range that is realistically between 80 dB and 120 dB. Some clients may question the wisdom of smearing out the ghost in this manner and frankly, the industry is divided on this issue. The SeaScan Tri-Cluster® array excels in its primary-to-bubble ratio, 40:1.

Recommendations:

- Keep the arrays horizontal and straight in the water
- Do not deploy the arrays too deep.
- Horizontal is more important than depth
- Ideal depths are 10 feet to 15 feet
- Use 10 feet depths in calm water
- Move to 15 feet depths in rough water
- If the depth can't be right, let it be shallow, never deeper than 15 feet
- Warm up the guns and ensure proper timing just before production starts
- Near field hydrophones should be below the array
- Near field hydrophones should be 1 meter below single guns
- Near field hydrophones should be 3 meters below a group of guns
- Do not strap the near field phone to a frame member

Field Procedure

In order to record the far-field signature of an air gun array, several spatial conditions must be satisfied.

1. The far field hydrophone must be placed sufficiently far below the array for the source to look like a point source. That is, if the hydrophone happens to be positioned directly below the front edge of the Tri-Cluster® array, then the difference in vertical travel time from a gun at the front of the array to the hydrophone and the slant path travel time from a gun at the rear of the array to the hydrophone due to the different distances traveled must be within the standard deviation of the expected firing time error, assuming no problem exists with the firing system itself As a rule of thumb, the distance from the array to the hydrophone should be 10 times larger than the largest dimension on the array itself.

   In this case, the time delay between the time-brake hydrophone mounted on the array frame and the far-field hydrophones is a consistent 80 msecs. At a water velocity of 1.5 M/msecs, this translates into a distance of 120 meters. The largest array used in terms of physical dimensions of length is the SeaScan Tri-Cluster array which has a distance of 4 meters between the first and last guns. Therefore, if the hydrophone is placed vertically under the lead gun, and 120 meters below it, the slant path, by Pythagoras, will be 120.06664 meters. This translates into a delay of 0.09996 msecs, which is the order of magnitude of the resolution of the air gun timing controllers and about a third of the standard deviation of the firing time error that is due to mechanical delays in individual guns.

   From this standpoint, the setup is more than satisfactory and the condition improves with the smaller dimensioned arrays.

2. The hydrophone ideally should be positioned vertically beneath the center of the array. This is difficult to achieve because the crew has no control over sub-sea currents and tides other than the choice of geographic location. If there is good separation from the array to the hydrophone, then there is an areal zone in which signal attenuation at the hydrophone is minimized due minimal differences in travel paths from individual guns and the size of this zone increases as the distance from the array to the hydrophone increases. However, the deeper the hydrophone is placed the likelihood of drift increases because of the increased likelihood of encountering significant water currents. A test set-up is always a compromise.

   The setup chosen here of a depth to the far field hydrophones of 120 meters is correct for the dimensions of the array and the conditions observed at the time of the test.

3. The recorded signature should be clean, that is, containing no other reflections within the time frame of the signal analyses, which is at least one second of recorded time. This translates into having at least 750 meters of water beneath the hydrophone, and since the depth of the hydrophone is around 120 meters, a total water depth of around 900 meters is the minimum requirement. It follows from this that the test set up must be at least 900 meters from any shoreline or sea-floor in any direction about the set up.

   There is a clear water bottom reflection at 1850 msecs and another fainter reversed polarity event at 2035 msecs. The first is interpreted as the water bottom and the second as perhaps denser bed rock below the sea floor. This puts the sea floor 978.75 meters below the time break hydrophone, that is, approximately 982 meters below sea surface. This clearly exceeds the requirement outlined above by nearly 80 meters and provides 1.305 msecs of clean, uninterrupted listening time after the onset of the signal from the array. A listening time of 1 second is normally considered adequate and less is acceptable when the condition cannot be met (local water depth not deep enough).

In this test, the record length was 4 seconds and the sample rate 0.25 msecs, both of which exceed minimum requirements which typically are 1 second record length with a sample rate of 1 msecs.

Some signature tests are recorded in dynamic mode. This is especially important when the arrays being tested are mounted in a flexible manner and rely on the towing speed to stretch them out. In this case, all the arrays were frame mounted and the test was conducted in static mode. This has the advantage of making the positioning of the hydrophone vertically below the center of the array a much simpler task. In dynamic mode, there is a strong tendency for the hydrophone to stream back behind the array. This unwanted effect can be minimized by deploying a heavy streamlined weight on the (armored) cable that supports the hydrophone. A simple way to build such a weight is to fill an old oxy-acetylene cylinder with lead (if affordable) or scrap iron and concrete (if not), weld tail fins for stability at the rear and a strong lifting ring on the back of the device. It will look frighteningly like a dumb bomb from World War II! In the static test, as this one, a simple weight on the end of the hydrophone cable is sufficient to maintain good tension in the cable.

In this test, three hydrophones were deployed. The first was mounted on the array frame as a near-field phone. This is important as a time-break phone and the time delay between the onset of signal at this phone and the onset of signal at the far-field phone gives confirmation of the distance between the array and the far-field phone. This distance should also be known from the deployment depth of the array and the length of hydrophone cable paid out after compensation for the slant angle of the cable. The quality of the signal on the time-break hydrophone is often compromised, especially when multiple guns are fired simultaneously. This is because the separation distances between the guns are of the same order of magnitude as the distance of the hydrophone to the nearest gun; therefore the energy from the individual guns arrives out of phase giving rise to a much distorted signal. Sometimes however, the dominant period of the oscillating bubble of the nearest gun is discernable, especially when the signal is transformed into the frequency domain and the spectrum analyzed for a peak frequency. When this occurs, the signal is a good test of the performance of the gun. The peak frequency should match that expected for a gun of a given type, volume, depth and operating pressure. If the peak frequency does not match, then the gun is of the wrong type (unlikely), wrong volume, depth or pressure. If all of these are known to be correct, then it is likely that the gun is partially filled with water thus reducing its' effective volume. Continued rapid firing of a gun in this condition usually ejects the water.

There were two far-field phones deployed. One was a low sensitivity phone, calibrated at .088 volts/bar and the other was a high sensitivity phone calibrated at 1.0 volts/bar. The results from both phones was inspected but only the high sensitivity phone was used in the analyses because the signals were mostly of low amplitude and it was important to maintain as high a signal to noise ratio as possible.

Two air gun controllers were employed. One was a WALShot, a Baker Atlas in-house developed system and the other was a DigiSHOT device manufactured by Input/Output. The near field hydrophone was not used when recording with the DigiSHOT controller. All the SeaScan Tri-Cluster ® data was recorded vie the WALShot system.

The signals were all recorded on CD in SEG Y format and converted to ASCII text files for general processing.

Calibration

A calibration analysis was conducted by inserting voltages of 10 volts and 5 volts into the recorder as oscillating signals of 30 Hz, 60 Hz and 90Hz each.

The 5 and 10 volt signals produced a calibration of 1 volt = 7297337.

Display

Summary

The following table summarizes the results of one of each of the scenarios recorded. The test column T2 is Arraytest2, the run that contains all the SeaScan Tri-Cluster ® data. The column 0-P is the maximum zero to peak value in Barms. The column P/B is the Peak to Bubble ratio. The column POWER is the peak amplitude in dB relative to 1 µPascal/Hertz at 1 Meter and is derived from the Power spectrum. The Column COMMENTS usually indicates the recording system used, in this case the WALShot.

TABLE 1

DESCRIPTION	TEST	FILE	VOLUME	O-P	P/B	POWER	COMMENTS
Tri-Cluster ® ARRAY 10 FT	T2	2.25	2400	25.08	33.50	204.88	WALShot
Tri-Cluster ® ARRAY 10 FT	T2	2.35	1200	12.92	34.36	191.44	WALShot
Tri-Cluster ® ARRAY 10 FT	T2	2.41	600	6.41	25.64	182.42	WALShot
Tri-Cluster ® ARRAY 10 FT	T2	2.46	300	3.73	10.86	175.34	WALShot
Tri-Cluster ® ARRAY 10 FT	T2	2.57	150	1.99	4.44	171.22	WALShot
Tri-Cluster ® ARRAY 10 FT	T2	2.61	150	2.13	4.31	188.06	WALShot
Tri-Cluster ® ARRAY 10 FT	T2	2.67	300	3.45	16.41	173.52	WALShot
Tri-Cluster ® ARRAY 10 FT	T2	2.72	150	2.41	3.53	175.04	WALShot
Tri-Cluster ® ARRAY 10 FT	T2	2.76	300	3.85	10.07	176.81	WALShot
Tri-Cluster ® ARRAY 10 FT	T2	2.80	600	6.78	10.22	181.11	WALShot
Tri-Cluster ® ARRAY 10 FT	T2	2.85	900	9.85	20.42	188.26	WALShot
Tri-Cluster ® ARRAY 10 FT	T2	2.90	1200	13.04	30.32	190.12	WALShot
Tri-Cluster ® ARRAY 10 FT	T2	2.94	900	10.96	18.18	188.94	WALShot

The following Tables 2, 3 and 4 give the channel allocation numbers per record. The high gain hydrophone is on channel 8 and is used for all air gun array displays. Table 5 gives the record/file/source correspondence.

TABLE 2

REC										TRACE
1	1	2	3	4	5	6	7	8	9	10
2	11	12	13	14	15	16	17	18	19	20
3	21	22	23	24	25	26	27	28	29	30
4	31	32	33	34	35	36	37	38	39	40
5	41	42	43	44	45	46	47	48	49	50
6	51	52	53	54	55	56	57	58	59	60
7	61	62	63	64	65	66	67	68	69	70
8	71	72	73	74	75	76	77	78	79	80
9	81	82	83	84	85	86	87	88	89	90
10	91	92	93	94	95	96	97	98	99	100
11	101	102	103	104	105	106	107	108	109	110
12	111	112	113	114	115	116	117	118	119	120
13	121	122	123	124	125	126	127	128	129	130
14	131	132	133	134	135	136	137	138	139	140
15	141	142	143	144	145	146	147	148	149	150
16	151	152	153	154	155	156	157	158	159	160
17	161	162	163	164	165	166	167	168	169	170
18	171	172	173	174	175	176	177	178	179	180
19	181	182	183	184	185	186	187	188	189	190
20	191	192	193	194	195	196	197	198	199	200
21	201	202	203	204	205	206	207	208	209	210
22	211	212	213	214	215	216	217	218	219	220
23	221	222	223	224	225	226	227	228	229	230
24	231	232	233	234	235	236	237	238	239	240
25	241	242	243	244	245	246	247	248	249	250
26	251	252	253	254	255	256	257	258	259	260
27	261	262	263	264	265	266	267	268	269	270
28	271	272	273	274	275	276	277	278	279	280
29	281	282	283	284	285	286	287	288	289	290
30	291	292	293	294	295	296	297	298	299	300
31	301	302	303	304	305	306	307	308	309	310
32	311	312	313	314	315	316	317	318	319	320
33	321	322	323	324	325	326	327	328	329	330
34	331	332	333	334	335	336	337	338	339	340
35	341	342	343	344	345	346	347	348	349	350
36	351	352	353	354	355	356	357	358	359	360
37	361	362	363	364	365	366	367	368	369	370
38	371	372	373	374	375	376	377	378	379	380
39	381	382	383	384	385	386	387	388	389	390
40	391	392	393	394	395	396	397	398	399	400

TABLE 3

41	401	402	403	404	405	406	407	408	409	410
42	411	412	413	414	415	416	417	418	419	420
43	421	422	423	424	425	426	427	428	429	430
44	431	432	433	434	435	436	437	438	439	440
45	441	442	443	444	445	446	447	448	449	450
46	451	452	453	454	455	456	457	458	459	460
47	461	462	463	464	465	466	467	468	469	470
48	471	472	473	474	475	476	477	478	479	480
49	481	482	483	484	485	486	487	488	489	490
50	491	492	493	494	495	496	497	498	499	500
51	501	502	503	504	505	506	507	508	509	510
52	511	512	513	514	515	516	517	518	519	520
53	521	522	523	524	525	526	527	528	529	530
54	531	532	533	534	535	536	537	538	539	540
55	541	542	543	544	545	546	547	548	549	550
56	551	552	553	554	555	556	557	558	559	560
57	561	562	563	564	565	566	567	568	569	570
58	571	572	573	574	575	576	577	578	579	580
59	581	582	583	584	585	586	587	588	589	590
60	591	592	593	594	595	596	597	598	599	600
61	601	602	603	604	605	606	607	608	609	610
62	611	612	613	614	615	616	617	618	619	620
63	621	622	623	624	625	626	627	628	629	630
64	631	632	633	634	635	636	637	638	639	640
65	641	642	643	644	645	646	647	648	649	650
66	651	652	653	654	655	656	657	658	659	660
67	661	662	663	664	665	666	667	668	669	670
68	671	672	673	674	675	676	677	678	679	680
69	681	682	683	684	685	686	687	688	689	690
70	691	692	693	694	695	696	697	698	699	700
71	701	702	703	704	705	706	707	708	709	710
72	711	712	713	714	715	716	717	718	719	720
73	721	722	723	724	725	726	727	728	729	730
74	731	732	733	734	735	736	737	738	739	740
75	741	742	743	744	745	746	747	748	749	750
76	751	752	753	754	755	756	757	758	759	760
77	761	762	763	764	765	766	767	768	769	770
78	771	772	773	774	775	776	777	778	779	780
79	781	782	783	784	785	786	787	788	789	790
80	791	792	793	794	795	796	797	798	799	800

TABLE 4

81	801	802	803	804	805	806	807	808	809	810
82	811	812	813	814	815	816	817	818	819	820
83	821	822	823	824	825	826	827	828	829	830
84	831	832	833	834	835	836	837	838	839	840
85	841	842	843	844	845	846	847	848	849	850
86	851	852	853	854	855	856	857	858	859	860
87	861	862	863	864	865	866	867	868	869	870
88	871	872	873	874	875	876	877	878	879	880
89	881	882	883	884	885	886	887	888	889	890
90	891	892	893	894	895	896	897	898	899	900
91	901	902	903	904	905	906	907	908	909	910
92	911	912	913	914	915	916	917	918	919	920
93	921	922	923	924	925	926	927	928	929	930
94	931	932	933	934	935	936	937	938	939	940
95	941	942	943	944	945	946	947	948	949	950
96	951	952	953	954	955	956	957	958	959	960
97	961	962	963	964	965	966	967	968	969	970
98	971	972	973	974	975	976	977	978	979	980
99	981	982	983	984	985	986	987	988	989	990
100	991	992	993	994	995	996	997	998	999	1000
101	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
102	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020
103	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030
104	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040
105	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050
106	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060
107	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070
108	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080
109	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090
110	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100
111	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110
112	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120
113	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130
114	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140
115	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150
116	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160
117	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170
118	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180
119	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190
120	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200
121	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210
122	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220

Table 5: **Record/File/Source Correspondence**

Record #	File #	Volume	Comment
23	228	2400	Both arrays
24	238	2400	Both arrays
25	248	2400	Both arrays
26	258	2400	Both arrays
27	268	2400	Both arrays
28	278	2400	Both arrays
29	288	2400	Both arrays
30	298	2400	Both arrays
31	308	2400	Both arrays
32	318	2400	Both arrays
33	328	1200	Starboard array
34	338	1200	Starboard array
35	348	1200	Starboard array
36	358	1200	Starboard array
37	368	1200	Starboard array
38	378	600	#3,4,5,6, only
39	388	600	#3,4,5,6, only
40	398	600	#3,4,5,6, only
41	408	600	#3,4,5,6, only
42	418	600	#3,4,5,6, only
43	428	600	#3,4,5,6, only
44	438	300	# 1,2, only
45	448	300	# 1,2, only
46	458	300	# 1,2, only
47	468	300	# 1,2, only
48	478	300	# 7, 8 only
49	488	300	Bad data
50	498	300	Bad data
51	508	300	# 7, 8 only
52	518	300	# 7, 8 only
53	528	300	# 7, 8 only
54	538	300	# 7, 8 only
55	548	150	# 8 only
56	558	150	# 8 only
57	568	150	# 8 only
58	578	150	# 8 only
59	588	150	# 8 only
60	598	150	# 3 only
61	608	150	# 3 only
62	618	150	# 3 only
63	628	150	# 3 only
64	638	150	# 3 only
65	648	300	# 3, 4 only
66	658	300	# 3, 4 only
67	668	300	# 3, 4 only
68	678	300	# 3, 4 only
69	688	150	# 5 only

Record #	File #	Volume	Comment
70	698	150	# 5 only
71	708	150	# 5 only
72	718	150	# 5 only
73	728	150	# 5 only
74	738	300	# 5, 6, only
75	748	300	# 5, 6, only
76	758	300	# 5, 6, only
77	768	300	# 5, 6, only
78	778	600	# 3, 4, 5, 6, only
79	788	600	# 3, 4, 5, 6, only
80	798	600	# 3, 4, 5, 6, only
81	808	600	# 3, 4, 5, 6, only
82	818	600	# 3, 4, 5, 6, only
83	828	900	# 1, 2, 3, 4, 5, 6, only
84	838	900	# 1, 2, 3, 4, 5, 6, only
85	848	900	# 1, 2, 3, 4, 5, 6, only
86	858	900	# 1, 2, 3, 4, 5, 6, only
87	868	900	# 1, 2, 3, 4, 5, 6, only
88	878	1200	All guns
89	888	1200	All guns
90	898	1200	All guns
91	908	1200	All guns
92	918	1200	All guns
93	928	900	# 1, 2, 5, 6, 7, 8, only
94	938	900	# 1, 2, 5, 6, 7, 8, only
95	948	900	# 1, 2, 5, 6, 7, 8, only
96	958	900	# 1, 2, 5, 6, 7, 8, only

Field Recording Logs

Gun Array Testing

File: Arraytest2.segy
Records : 1 – 96
Synchronizer : WALShot
Air Pressure : 2000 psi
Trace (original) : 6 – Time Break Hydrophone – center of array
7 – Lo Sensitivity far field phone 1 V / bar
8 – Hi Sensitivity far field phone 0.88 V/bar (See Calibration sheet)
Array : SeaScan Tri-Cluster Array

Notes : Side elevation of Sea Scan Array. All guns 150ci.

(4)
(3)
Bow (2) (8) Stern
(1) (7)
(6)
(7)

Depth is given as 10 feet, based on array floatation.

Record	Volume	Depth	Comment
1 – 9	2400	10	Tuning Depth per SeaScan Tri-Cluster
9 – 20	2400	10	Both Arrays
21 – 22	2400	10	BAD
23 – 32	2400	10	Both Arrays
33 – 37	1200	10	Stbd Array only all guns
38 – 43	600	10	#3, 4, 5, 6, only
44 – 47	300	10	#1, 2, only
48	300	10	#7, 8, only
49 – 50			BAD

Record	Volume	Depth	Comment
51 – 54	300	10	#7, 8, only
55 – 59	150	10	#8 only
60 – 64	150	10	#3 only
65 – 68	300	10	#3, 4, only
69 – 73	150	10	#5 only
74 – 77	300	10	#5, 6, only
78 – 82	600	10	#3, 4, 5, 6, only
83 – 87	900	10	#1, 2, 3, 4, 5, 6, only
88 – 92	1200	10	All guns
93 – 96	900	10	#1, 2, 5, 6, 7, 8, only

Displays

The following pages contain all the displays of the recorded data annotated with appropriate comments where necessary.

Each title block describes the array in use, its record number from the field recording log and any other pertinent information such as depth of deployment.

Below each title block is script from the processing software giving the zero-to-peak (0-P) amplitude in Barms, the peak-to-peak (P-P) Barms, the primary-to-bubble ratio (P/B), the period (t) in msecs of the dominant peak to bubble component, the depth in meters as determined by the software from the time delay of the peak and trough in the recorded signature, and the power (dB) in decibels relative to one micro-Pascal per hertz at one meter.

It was discovered on inspection of the field data that a very low frequency sinusoid noise component was present on many of the records. It is also a low power effect because it is hardly evident on the SeaScan Tri-Cluster data which reported the greatest power, and presumably swamped this noise train. In the cases of the low power of many of the smaller arrays, clusters and single guns tested, this sinusoid was quite evident and distorted the spectrum at the low frequency end. For this reason, an 5(18) – 256(72) Hz zero phase bandpass filter was designed and applied to all field data. The low cut diminished from 5 Hz at18 dB/octave and the high cut diminished from 256 Hz at72 dB/octave. The frequency range of interest normally spans an 8 – 200 Hz range. The processing including the filtering was completed at 0.25 msecs and the data were resampled to 1 msec.

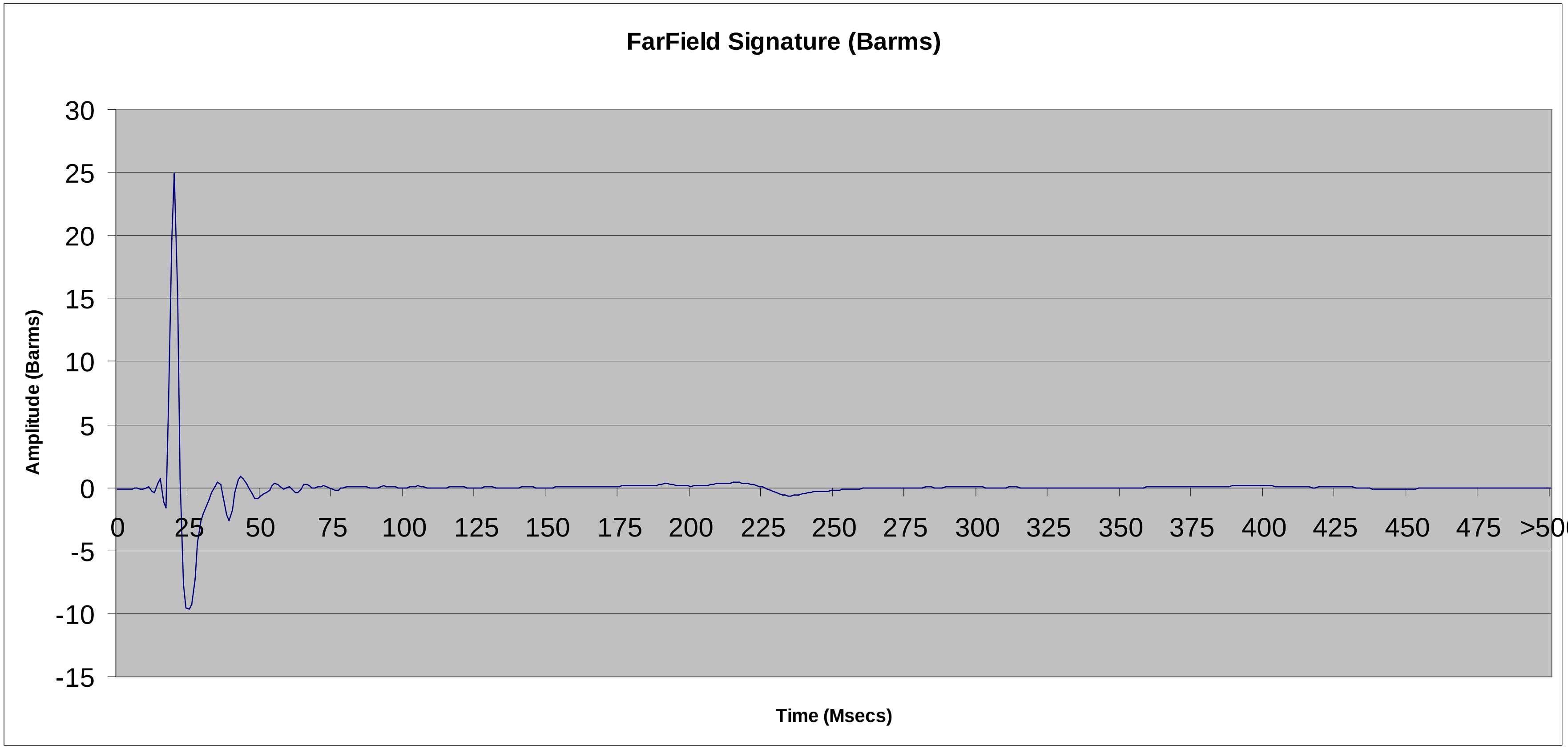
Displays of All Recorded Data

The following displays in landscape format are derived from the processed data. The first display is the filtered and scaled time signature, followed by the power spectrum of the same series. The data were transferred from the output of the custom processing software via a text file into Excel for display. A line of Excel cells also picked up several statistics including the zero-to-peak output, peak-to-peak output, primary to bubble ratio, period of the most significant bubble oscillation and peak output on the power spectrum is dB re 1 micropascal/hertz at 1 meter.

Arraytest 2 – SeaScan Tri-Cluster ® Array

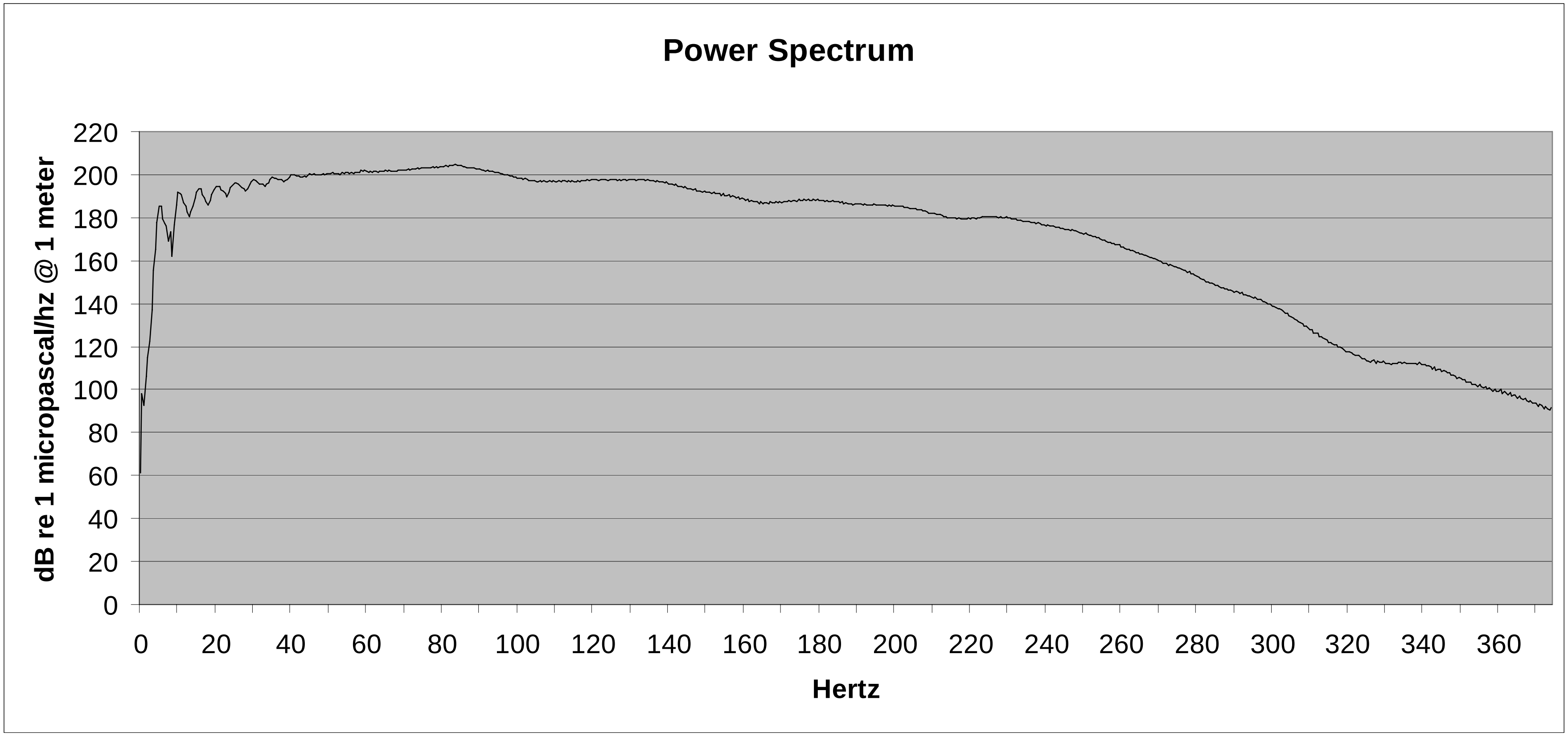
The SeaScan Tri-Cluster ® array comprised two identical 1200 cu in arrays of clustered 150 cu in sleeve guns. It is a compact and efficient design that produces a strong signature (2400 cu in) and a smooth spectrum. The ghost is never well developed on Tri-Cluster ® arrays and this is thought to be due to the fact that the center cluster of four 150 cu in guns is built as a square so that there is a meter difference in the depth between the upper and lower pair.

File 2.23: 2400 cu in Twin SeaScan Tri-Cluster ® array @ 10 ft



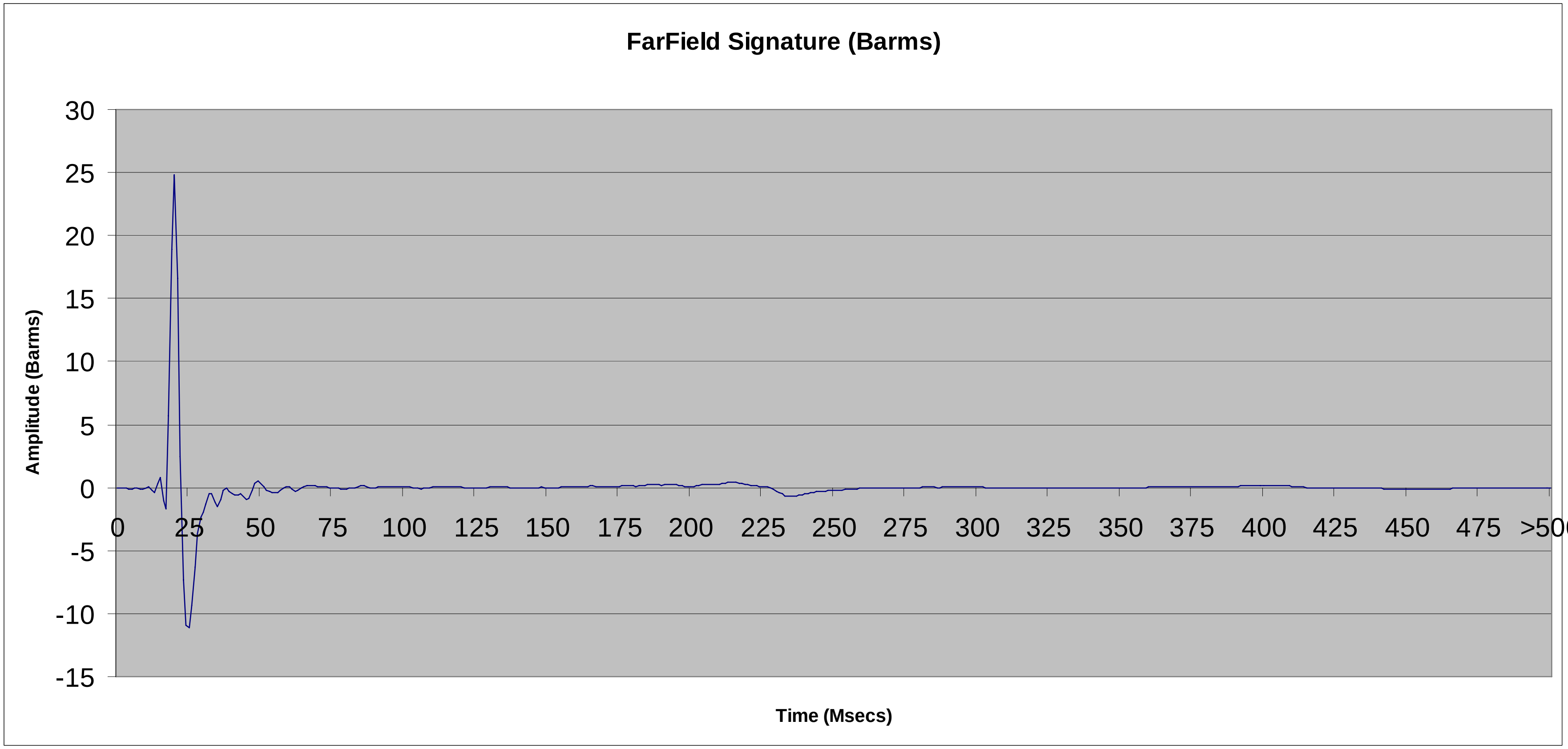
0-P Barm	25.03	P-P Barm	36.55	P/B Ratio =	31.95	Period =	196.00	Depth =	3.00	M	Power =	203.41	Db

File 2.23: 2400 cu in Twin SeaScan Tri-Cluster® array @ 10 ft



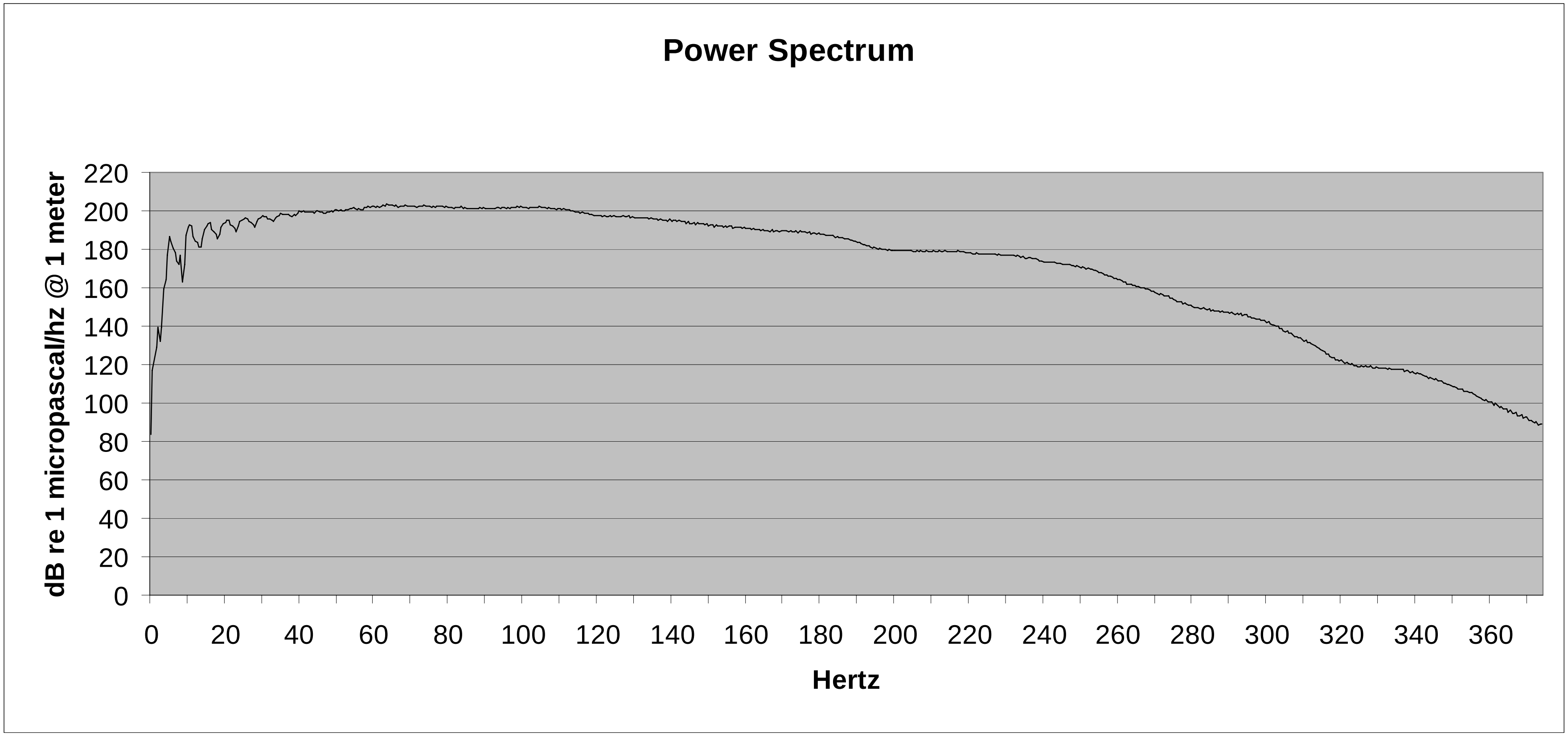
0-P Barm	25.03	P-P Barm	36.55	P/B Ratio =	31.95	Period =	196.00	Depth =	3.00	M	Power =	203.41 Db

File 2.24: 2400 cu in Twin SeaScan Tri-Cluster ® array @ 10 ft



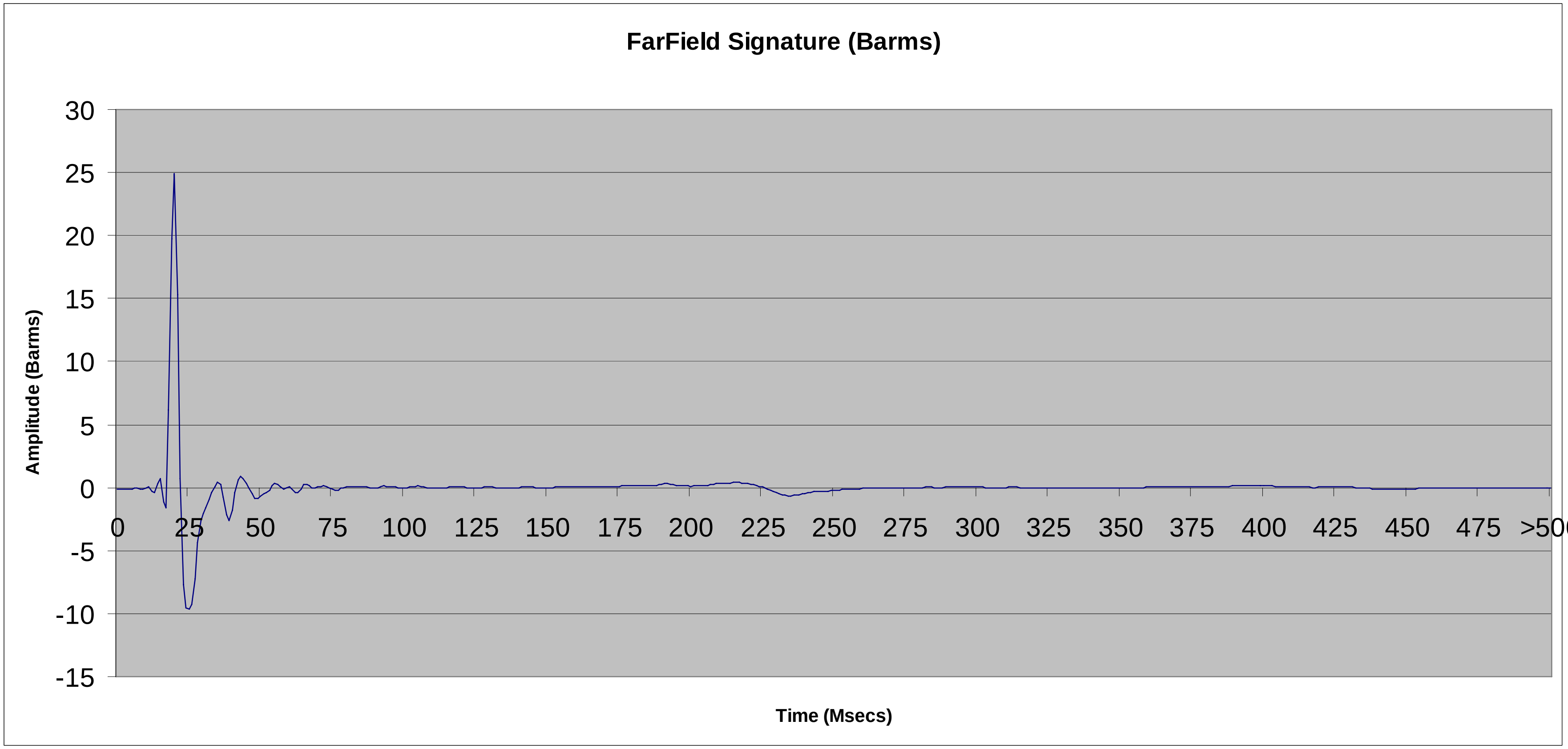
0-P Barm	24.85	P-P Barm	36.15	P/B Ratio =	30.67	Period =	194.00	Depth =	3.38	M	Power =	203.34	Db

File 2.24: 2400 cu in Twin SeaScan Tri-Cluster ® array @ 10 ft



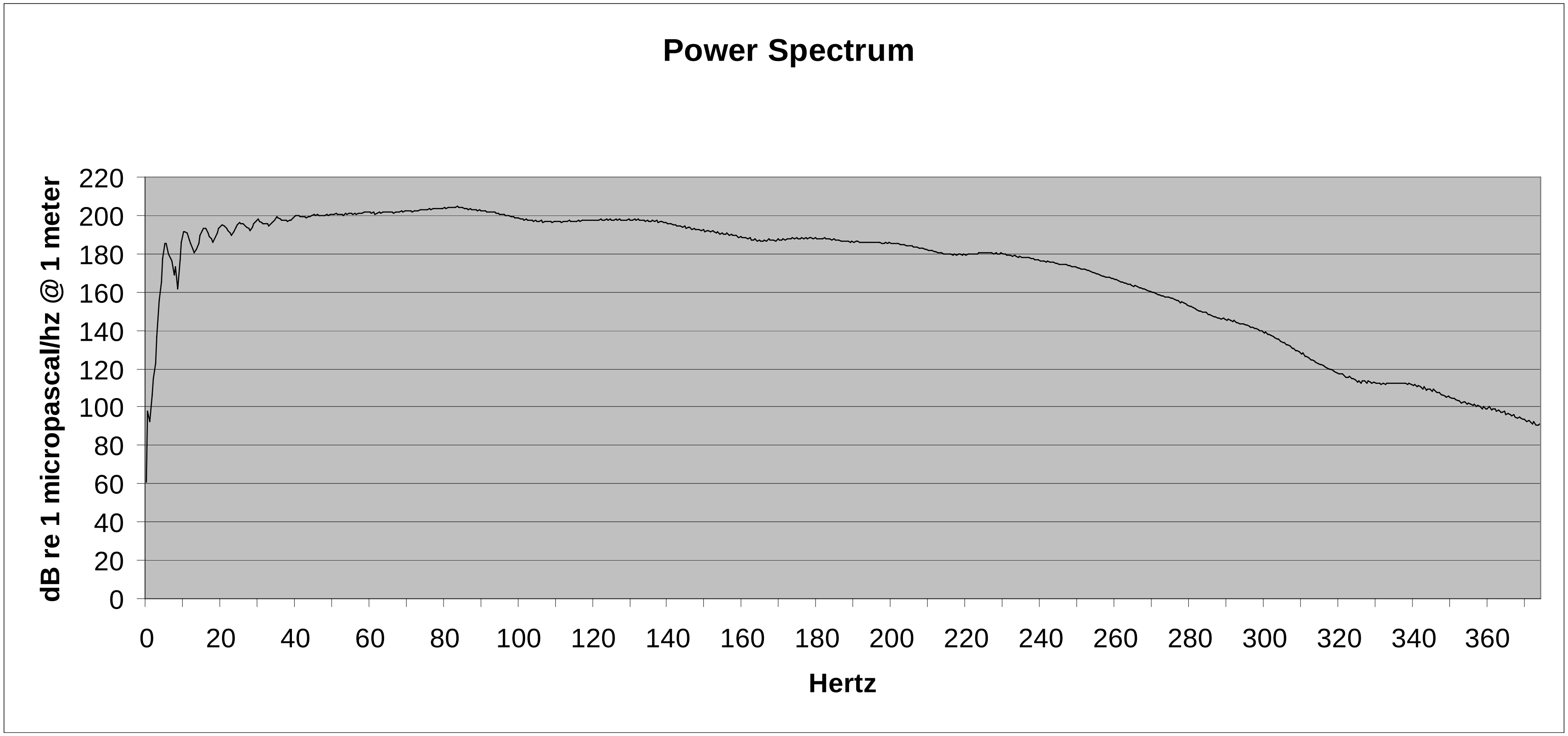
0-P Barm	24.85	P-P Barm	36.15	P/B Ratio =	30.67	Period =	194.00	Depth =	3.38	M	Power =	203.34	Db

File 2.25: 2400 cu in Twin SeaScan Tri-Cluster ® array @ 10 ft



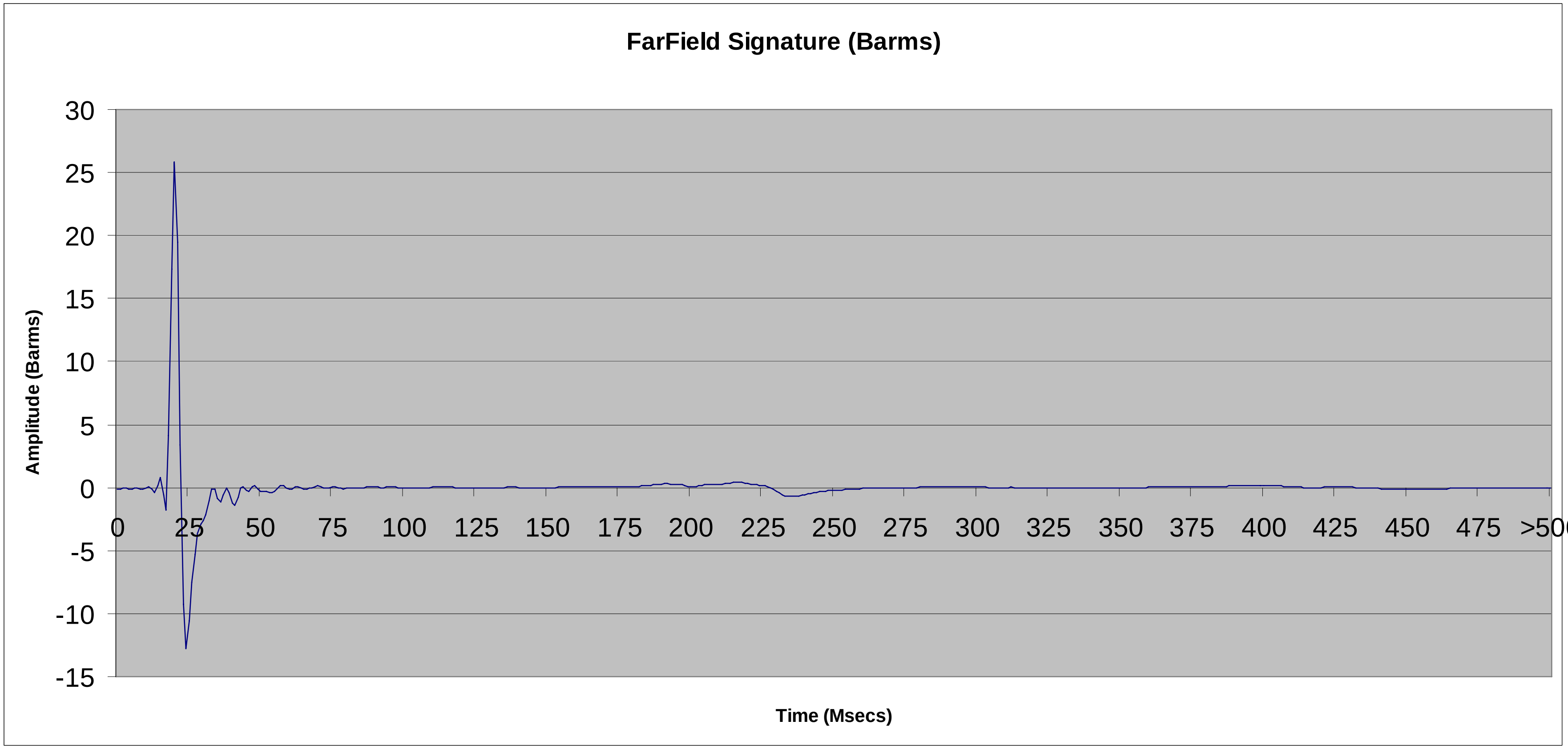
0-P Barm	25.08	P-P Barm	34.74	P/B Ratio =	33.50	Period =	196.50	Depth =	4.13	M	Power =	204.88	Db

File 2.25: 2400 cu in Twin SeaScan Tri-Cluster ® array @ 10 ft



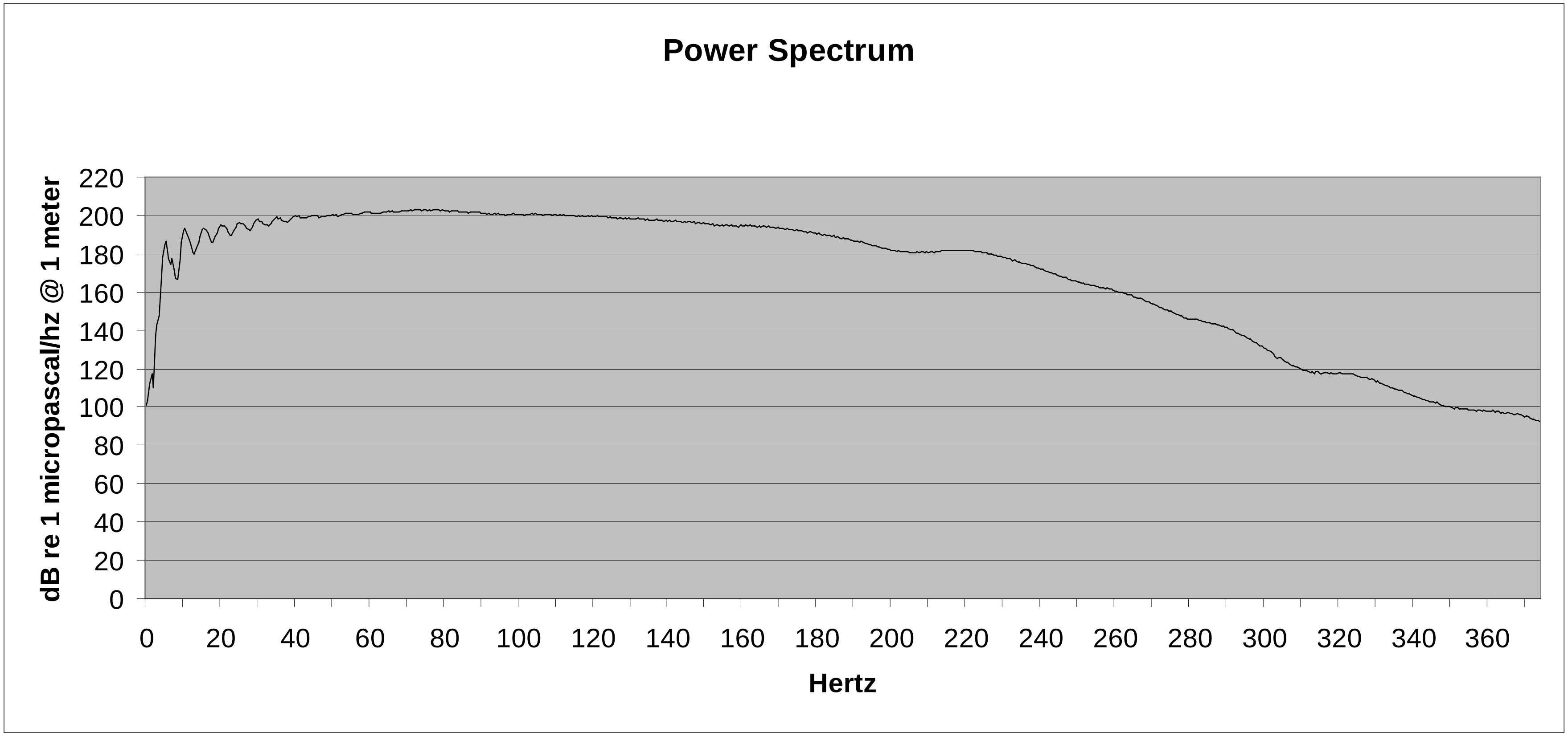
0-P Barm	25.08	P-P Barm	34.74	P/B Ratio =	33.50	Period =	196.50	Depth =	4.13	M	Power =	204.88	Db

File 2.26: 2400 cu in Twin SeaScan Tri-Cluster ® array @ 10 ft



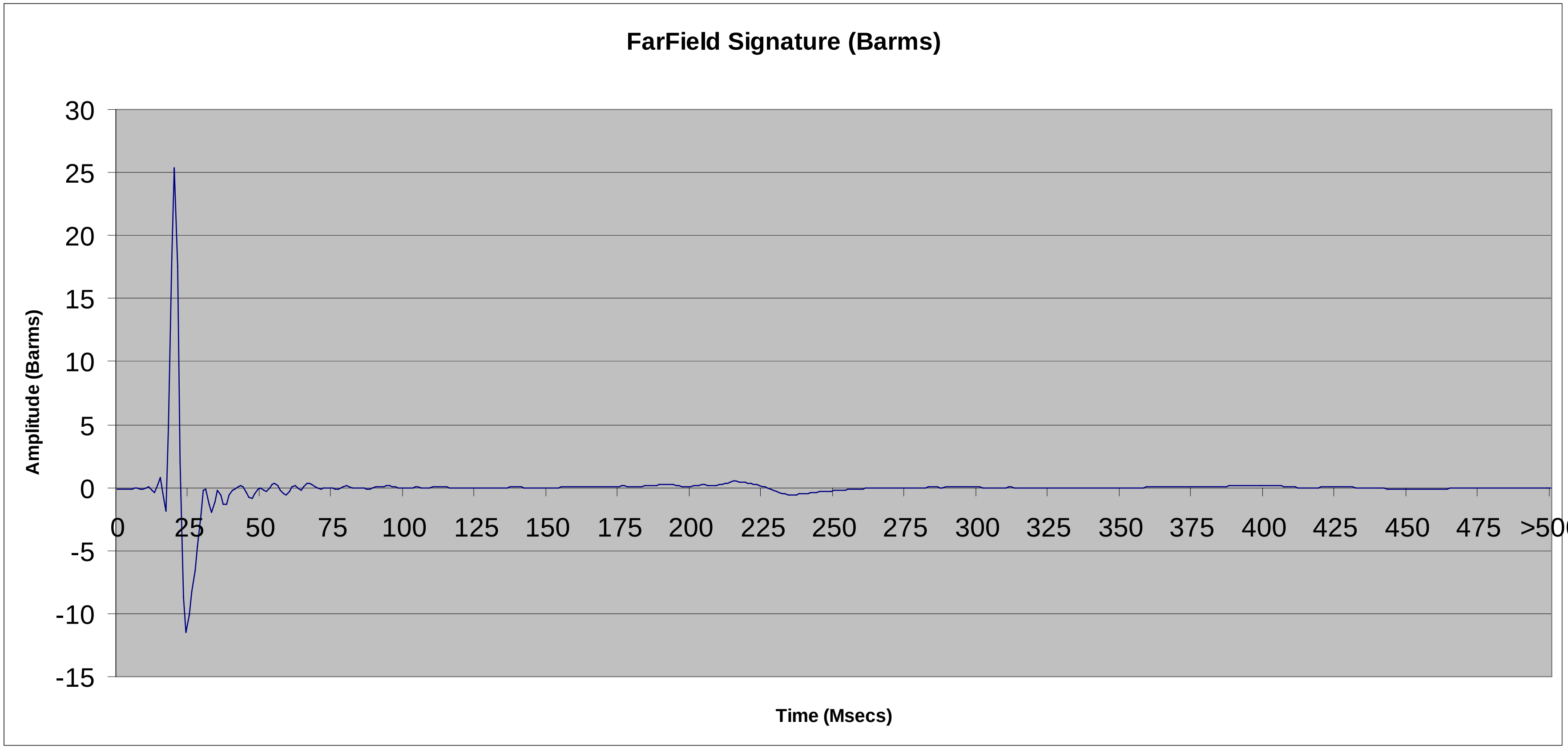
0-P Barm	25.80	P-P Barm	38.61	P/B Ratio =	33.27	Period =	196.50	Depth =	3.00	M	Power =	203.16	Db

File 2.26: 2400 cu in Twin SeaScan Tri-Cluster ® array @ 10 ft



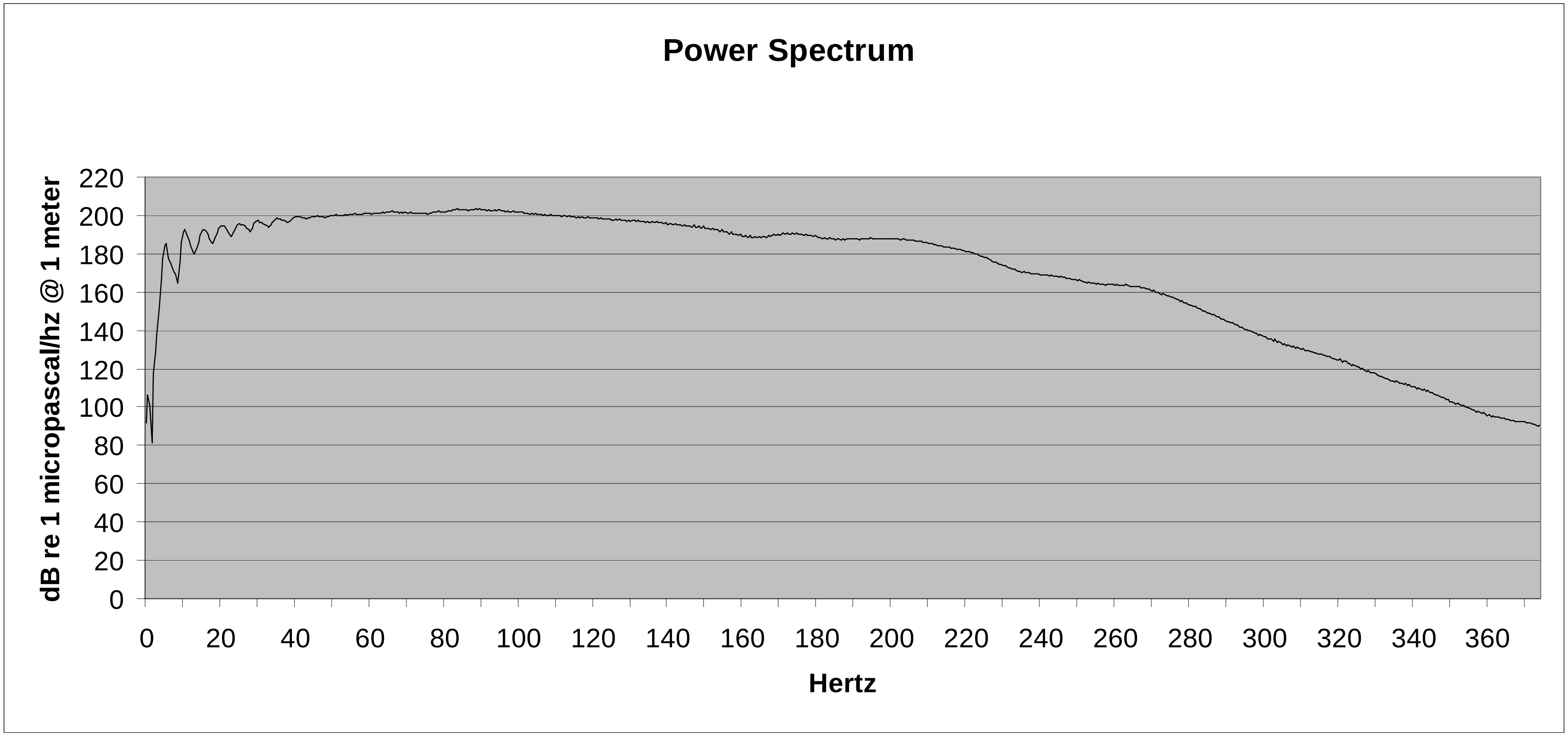
0-P Barm 25.80 P-P Barm 38.61 P/B Ratio = 33.27 Period = 196.50 Depth = 3.00 M Power = 203.16 Db

File 2.27: 2400 cu in Twin SeaScan Tri-Cluster ® array @ 10 ft



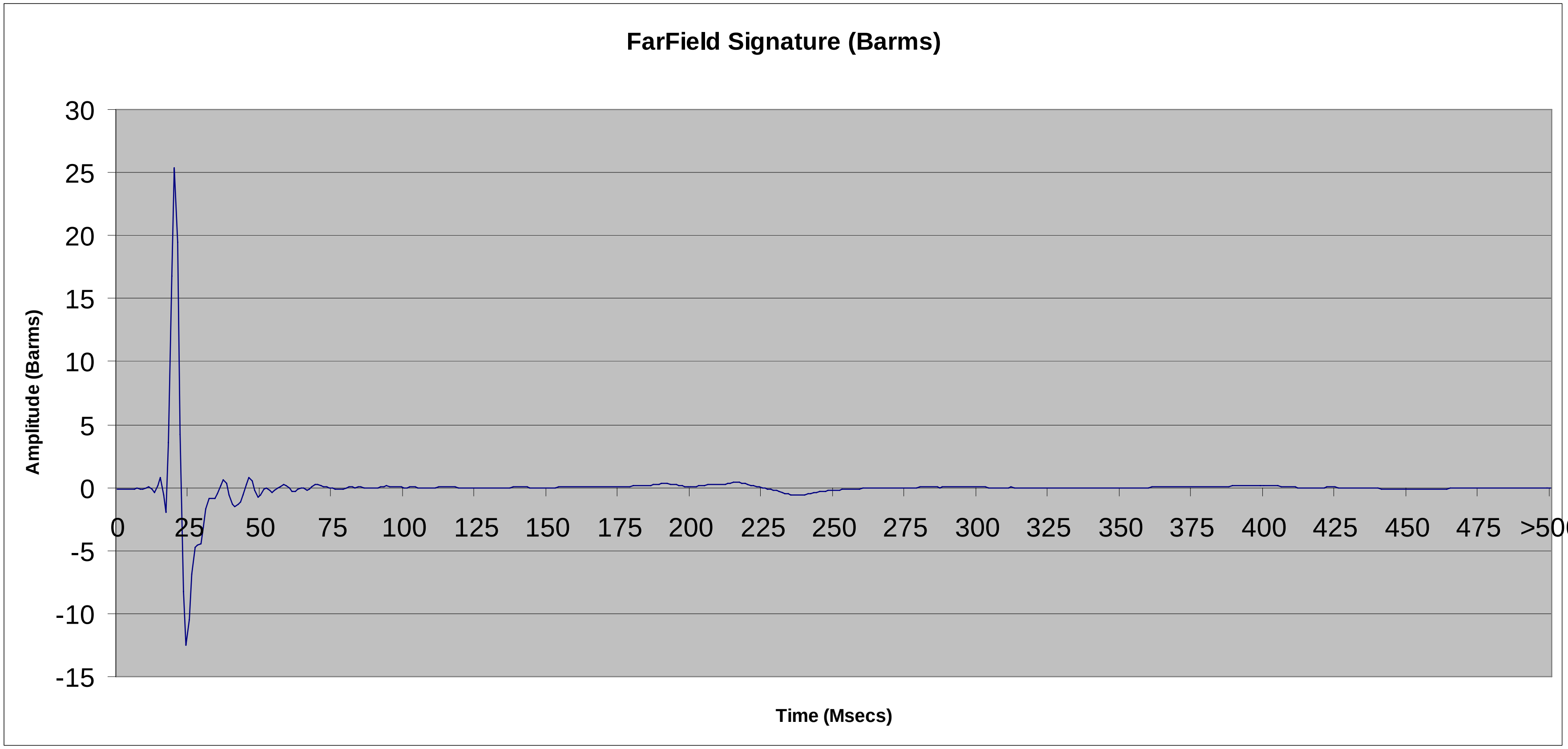
0-P Barm	25.41	P-P Barm	36.88	P/B Ratio =	34.51	Period =	195.50	Depth =	3.00	M	Power =	203.44	Db

File 2.27: 2400 cu in Twin SeaScan Tri-Cluster ® array @ 10 ft



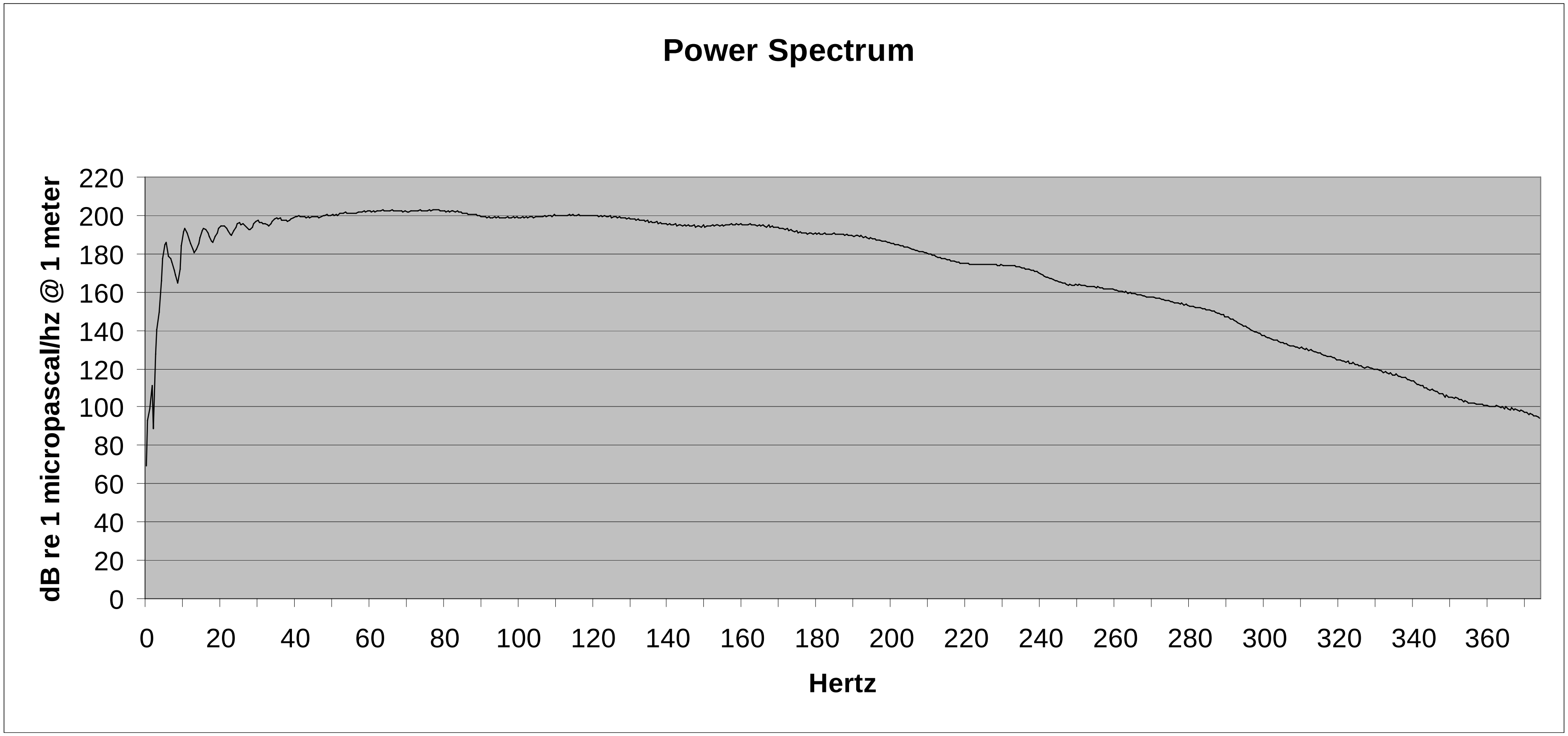
0-P Barm 25.41 P-P Barm 36.88 P/B Ratio = 34.51 Period = 195.50 Depth = 3.00 M Power = 203.44 Db

File 2.28: 2400 cu in Twin SeaScan Tri-Cluster ® array @ 10 ft



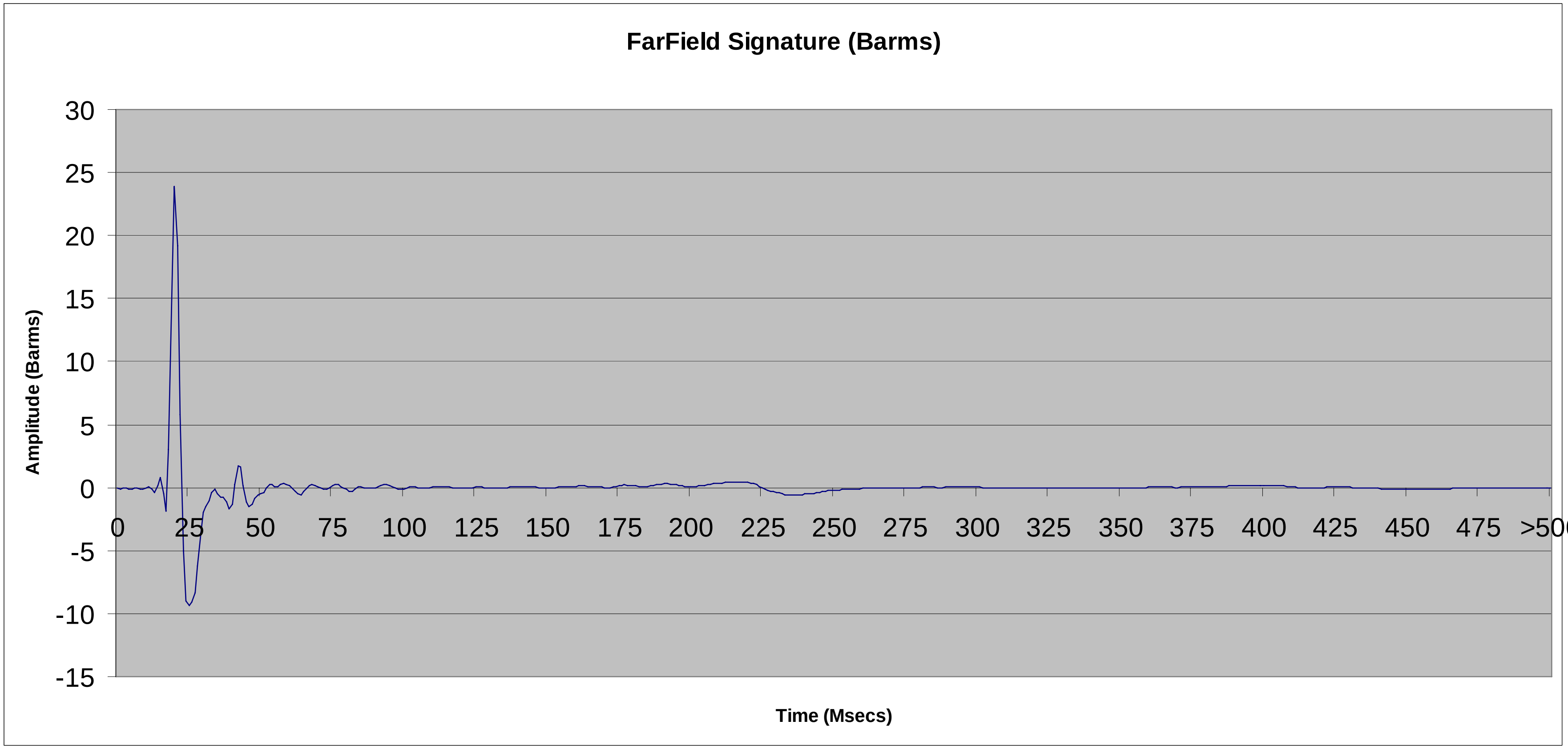
0-P Barm	25.37	P-P Barm	37.85	P/B Ratio =	31.48	Period =	196.25	Depth =	3.00	M	Power =	202.89	Db

File 2.28: 2400 cu in Twin SeaScan Tri-Cluster® array @ 10 ft



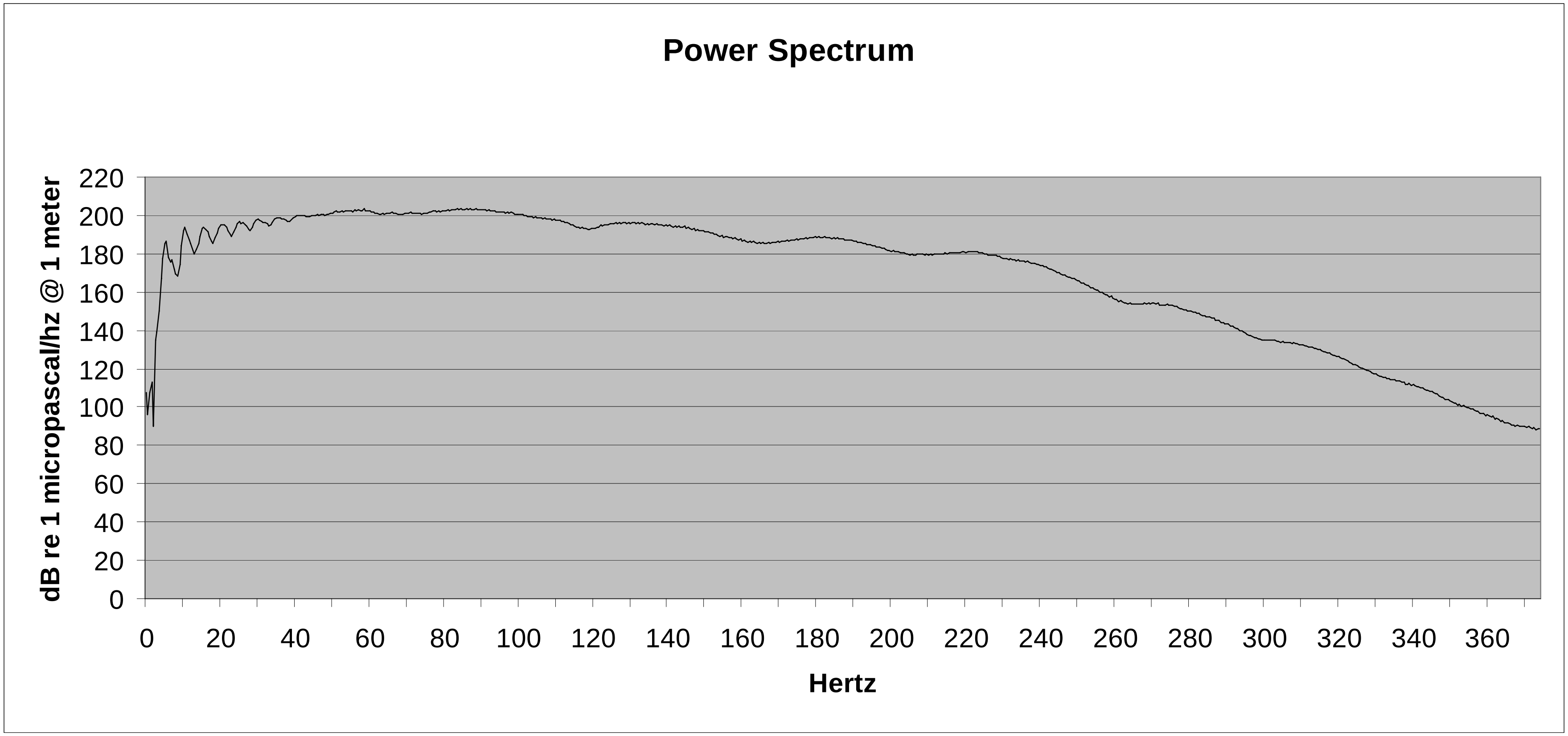
0-P Barm 25.37 P-P Barm 37.85 P/B Ratio = 31.48 Period = 196.25 Depth = 3.00 M Power = 202.89 Db

File 2.29: 2400 cu in Twin SeaScan Tri-Cluster ® array @ 10 ft



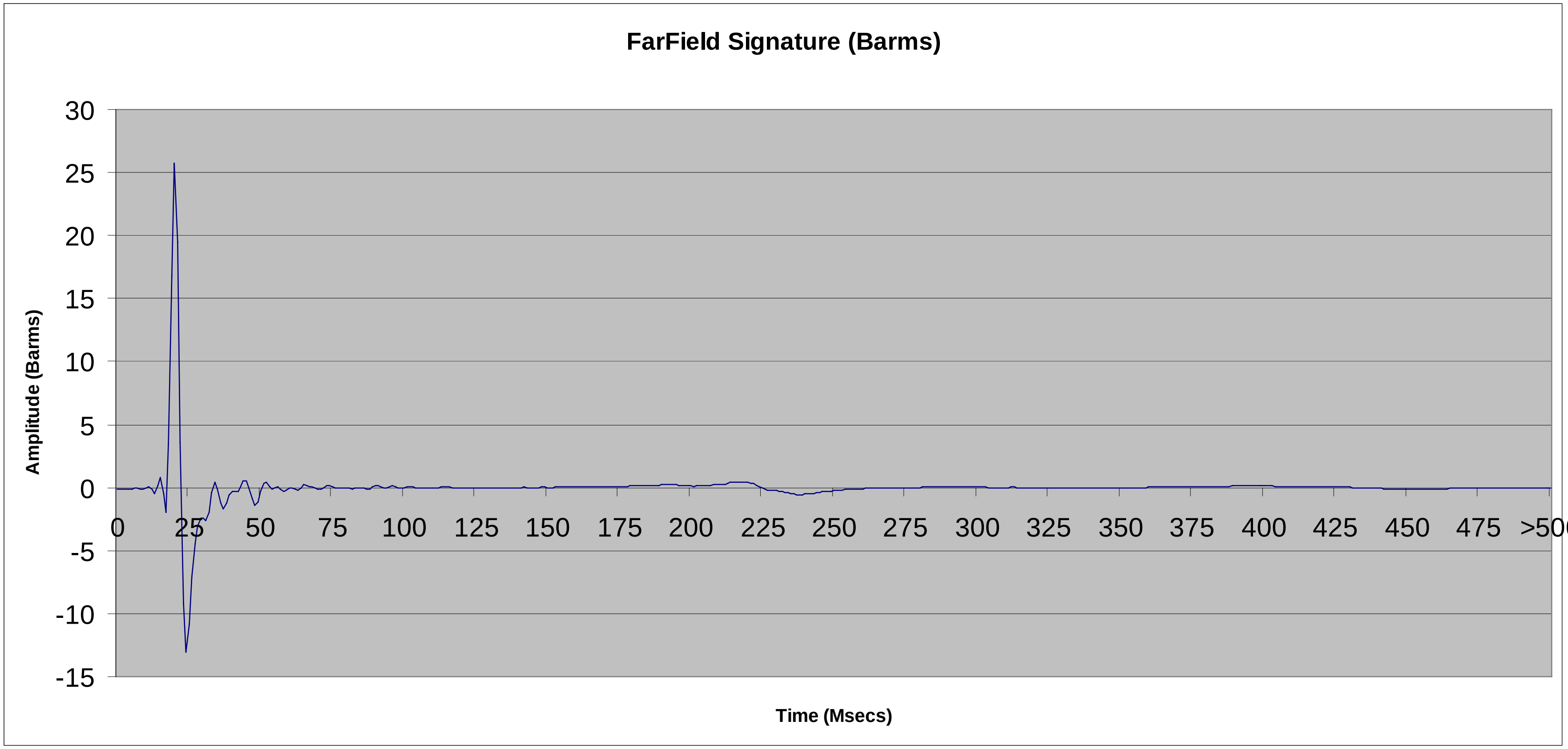
0-P Barm	24.07	P-P Barm	33.46	P/B Ratio =	31.33	Period =	197.50	Depth =	3.38	M	Power =	203.52	Db

File 2.29: 2400 cu in Twin SeaScan Tri-Cluster ® array @ 10 ft



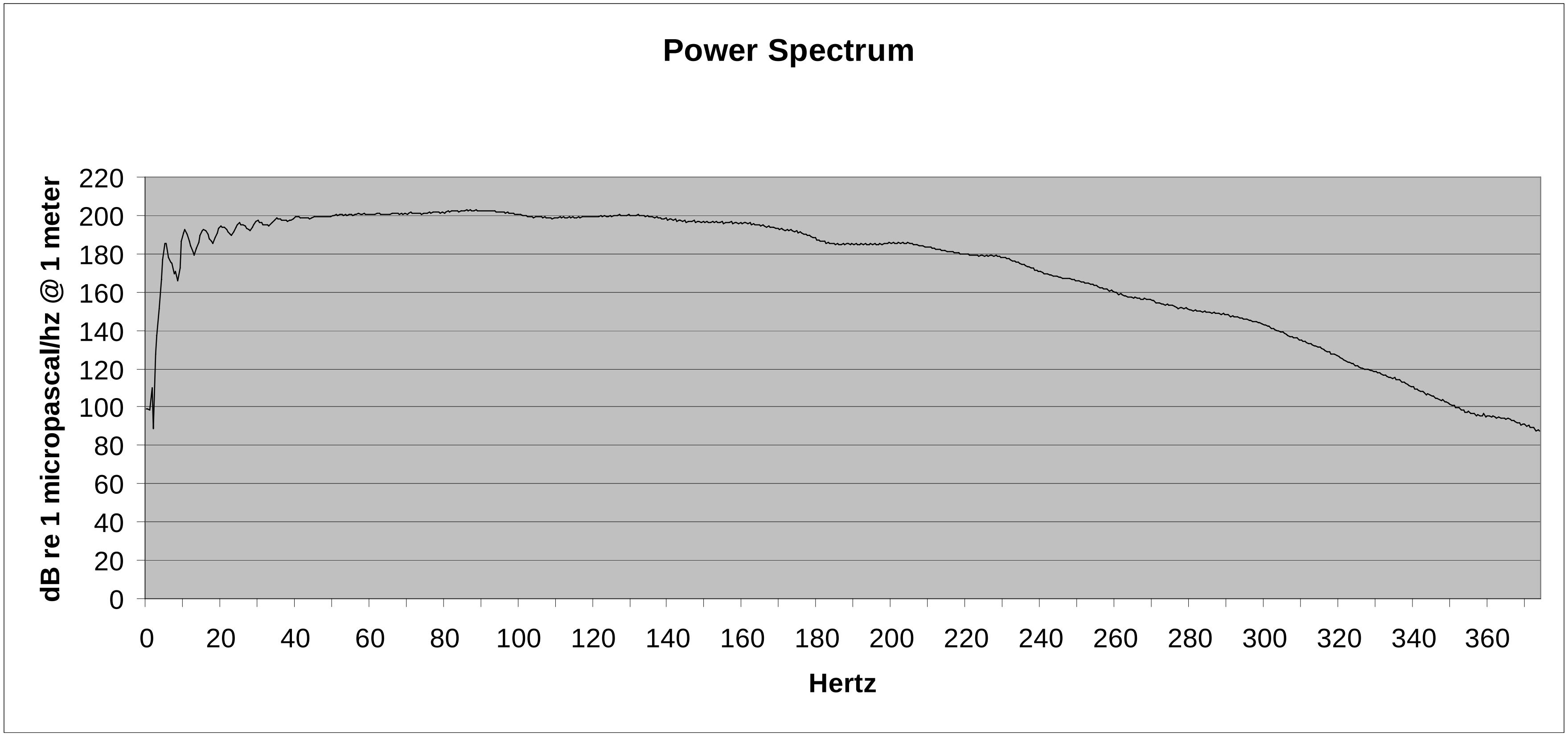
0-P Barm	24.07	P-P Barm	33.46	P/B Ratio =	31.33	Period =	197.50	Depth =	3.38	M	Power =	203.52	Db

File 2.30: 2400 cu in Twin SeaScan Tri-Cluster ® array @ 10 ft



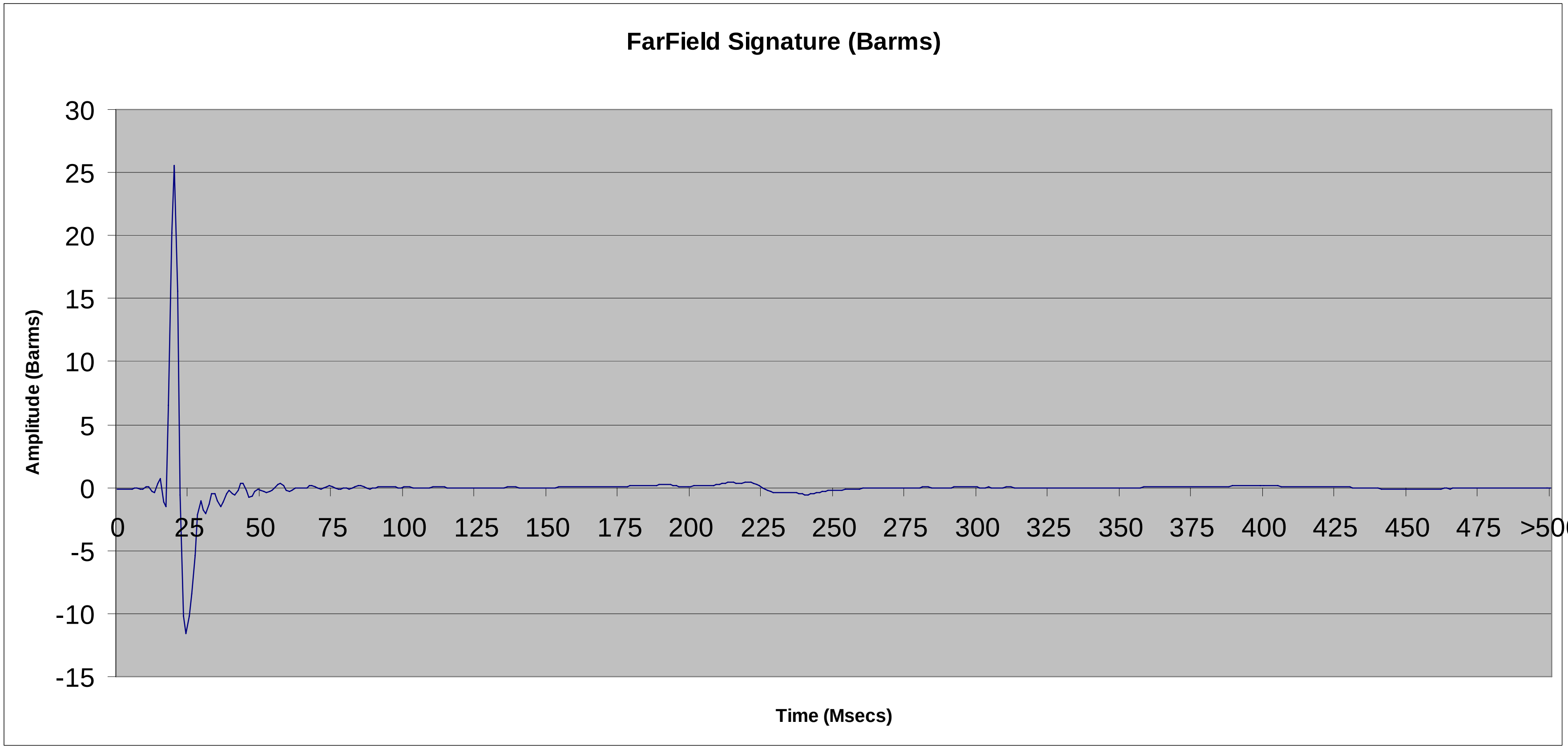
0-P Barm25.71 P-P Barm 38.75 P/B Ratio =26.30 Period =31.50 Depth =3.00 M Power =202.92 Db

File 2.30: 2400 cu in Twin SeaScan Tri-Cluster ® array @ 10 ft



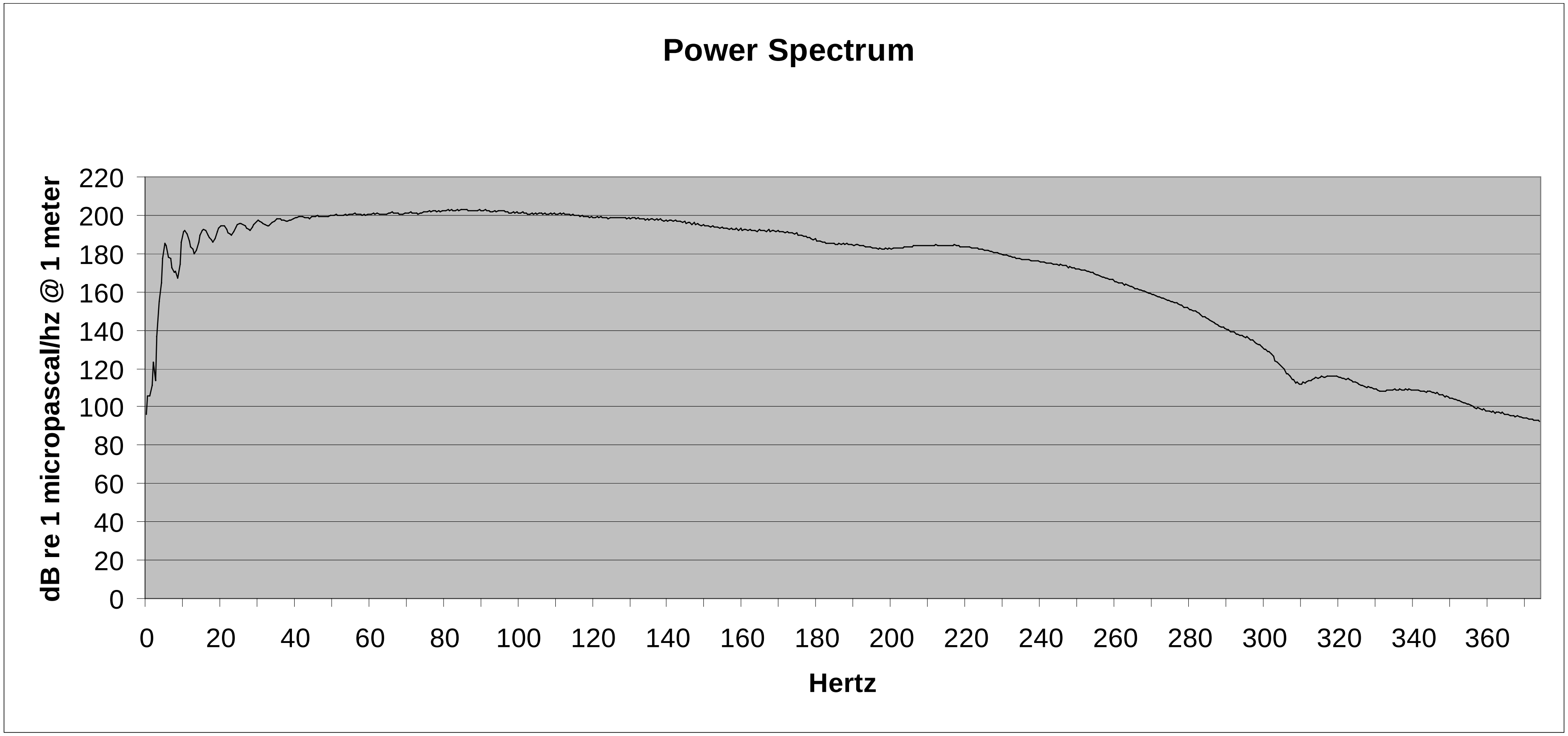
0-P Barm25.71 P-P Barm 38.75 P/B Ratio =26.30 Period =31.50 Depth =3.00 M Power =202.92 Db

File 2.31: 2400 cu in Twin SeaScan Tri-Cluster ® array @ 10 ft



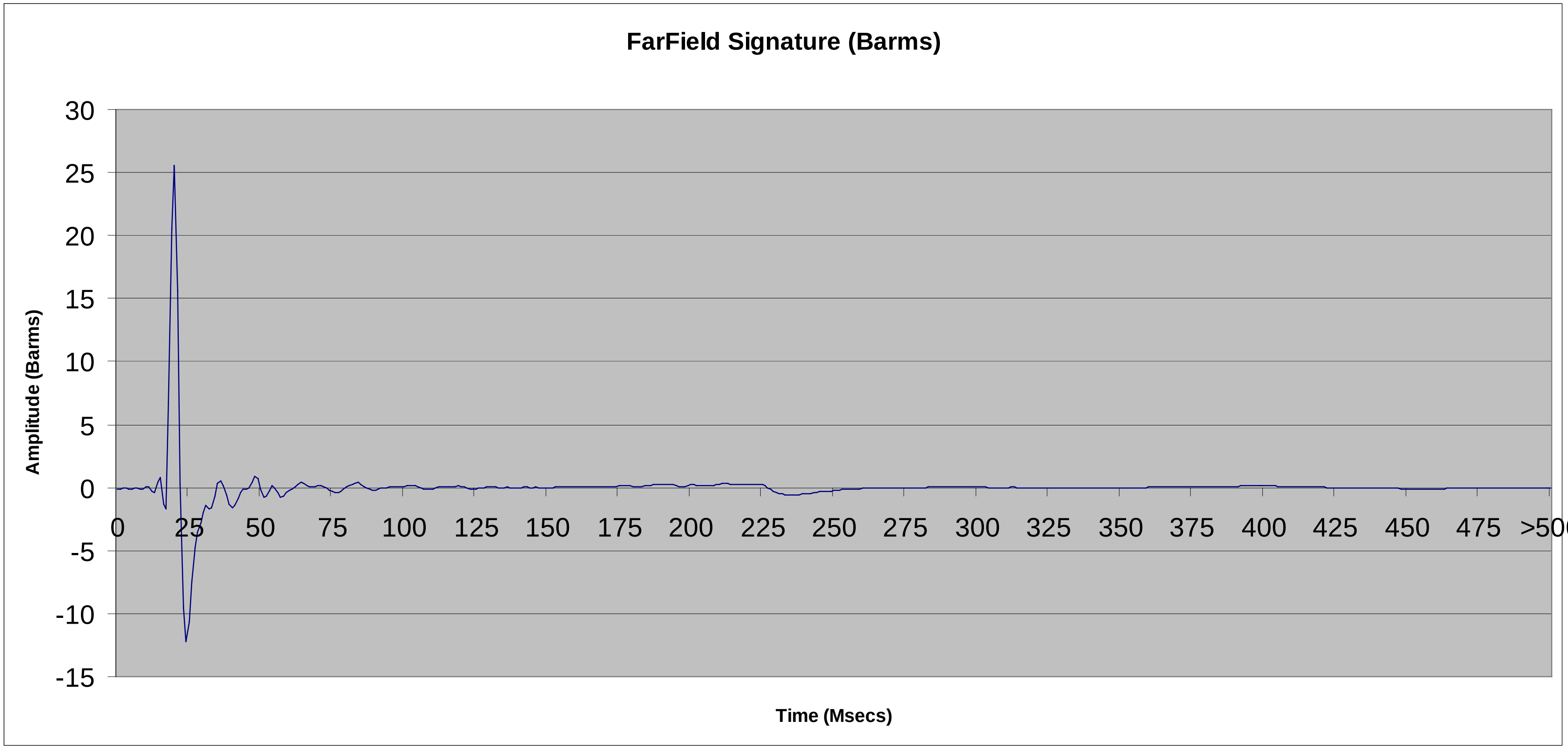
0-P Barm	25.70	P-P Barm	37.44	P/B Ratio =	37.34	Period =	194.00	Depth =	3.00	M	Power =	202.94	Db

File 2.31: 2400 cu in Twin SeaScan Tri-Cluster ® array @ 10 ft



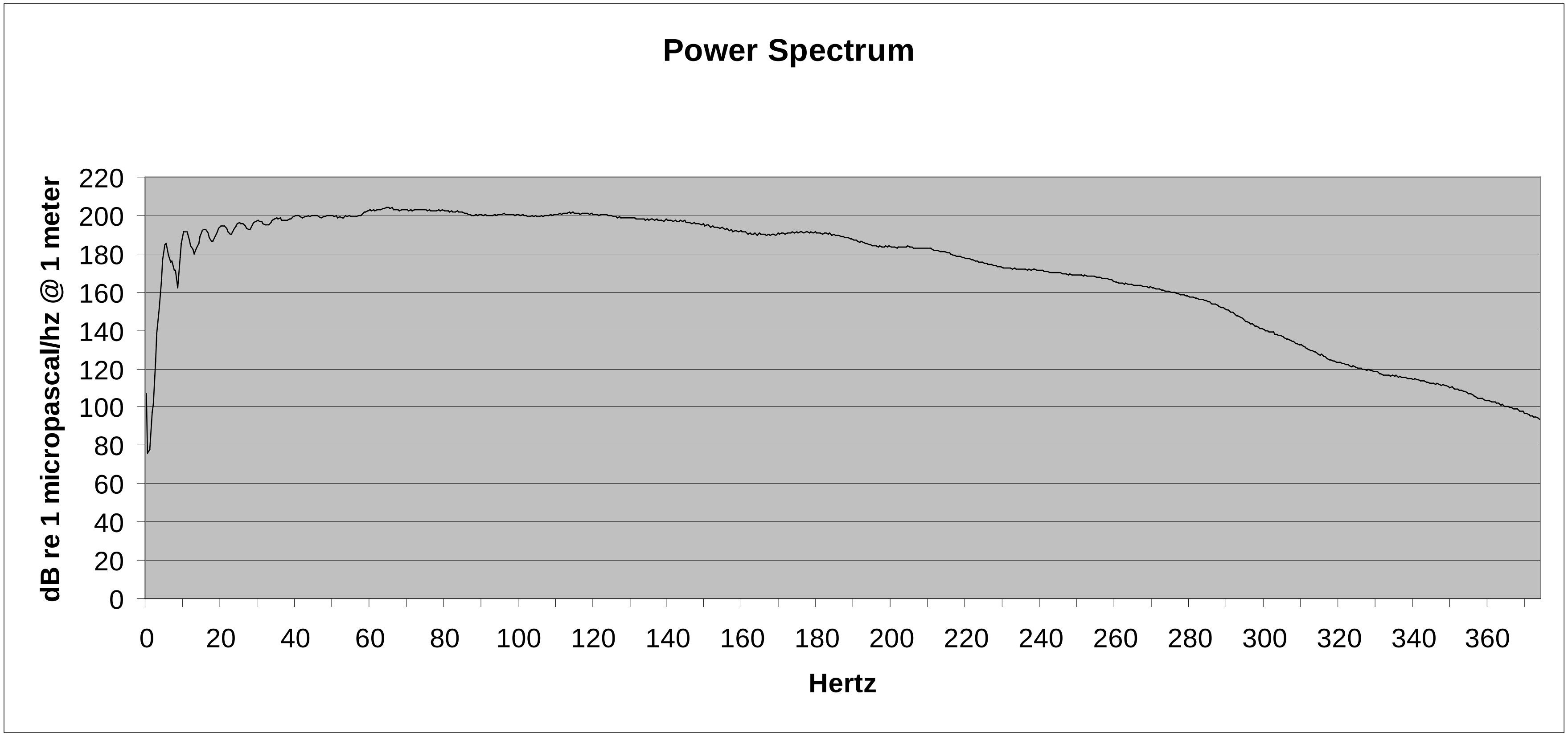
0-P Barm 25.70 P-P Barm 37.44 P/B Ratio = 37.34 Period = 194.00 Depth = 3.00 M Power = 202.94 Db

File 2.32: 2400 cu in Twin SeaScan Tri-Cluster ® array @ 10 ft



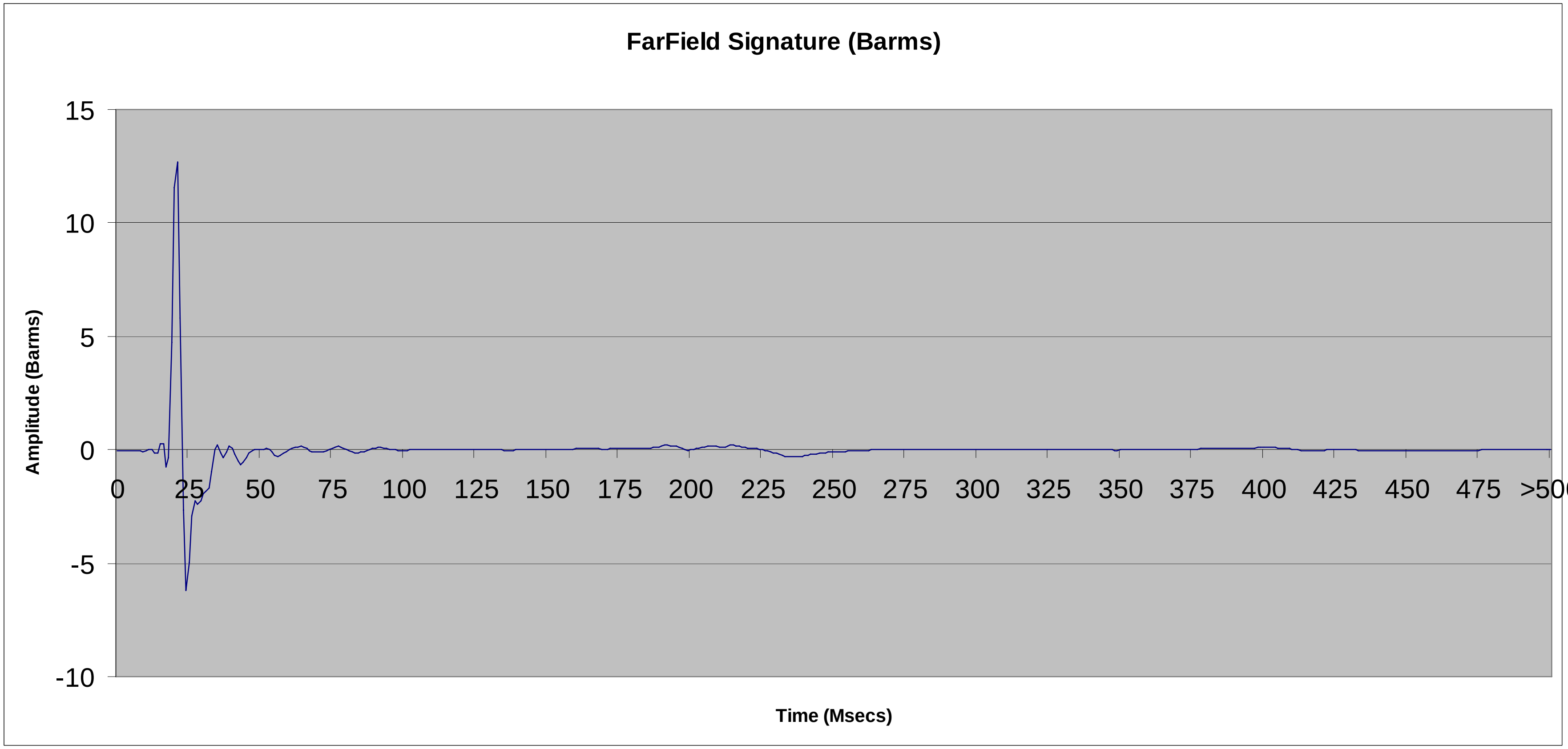
0-P Barm	25.81	P-P Barm	38.00	P/B Ratio =	27.55	Period =	29.50	Depth =	3.19	M	Power =	204.13	Db

File 2.32: 2400 cu in Twin SeaScan Tri-Cluster ® array @ 10 ft



0-P Barm 25.81 P-P Barm 38.00 P/B Ratio = 27.55 Period = 29.50 Depth = 3.19 M Power = 204.13 Db

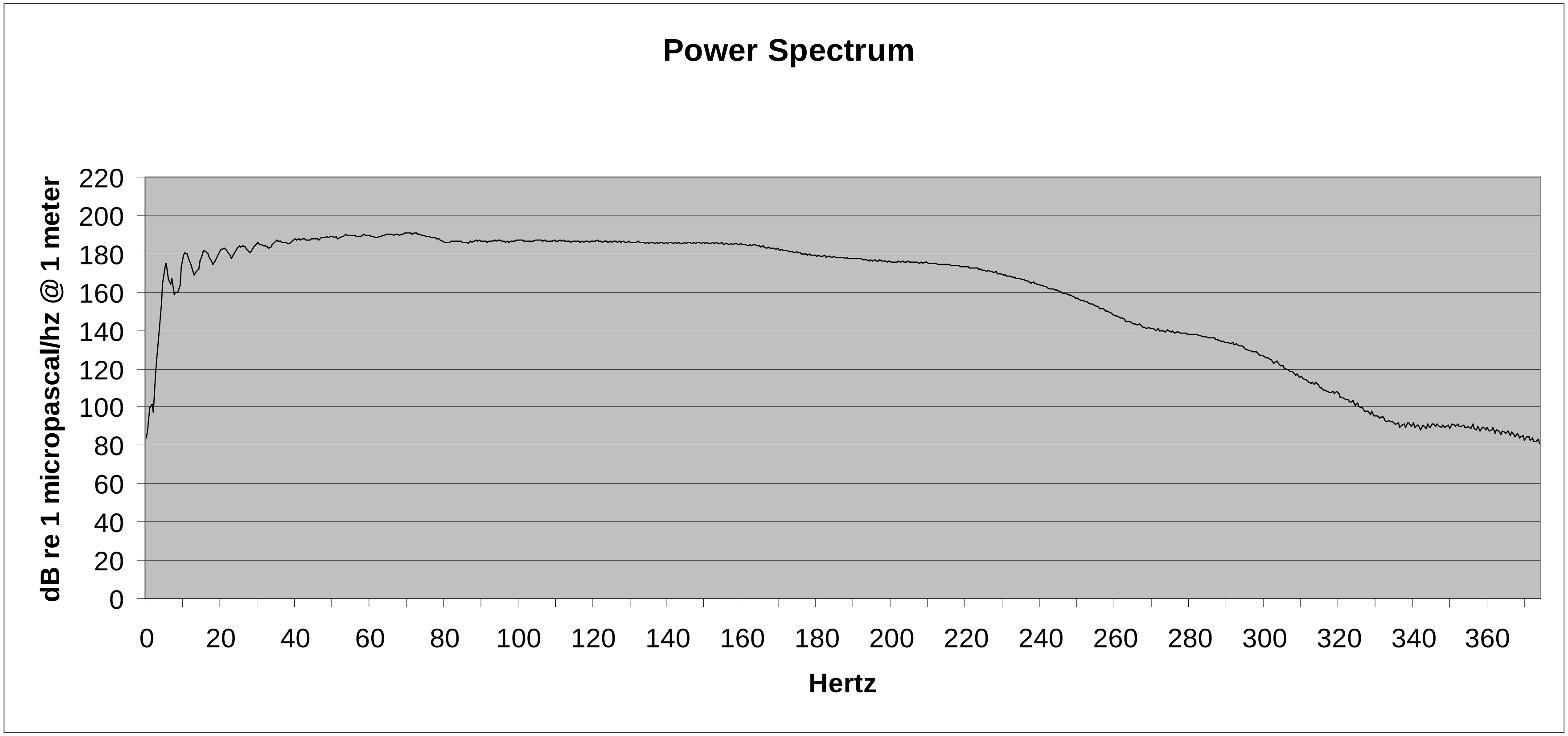
File 2.33: 1200 cu in Single SeaScan Tri-Cluster ® array @ 10 ft



0-P Barm	13.24	P-P Barm	19.46	P/B Ratio =	36.98	Period =	193.75	Depth =	2.63	M	Power =	190.87	Db

This is a single pontoon of 1200 cu ins.

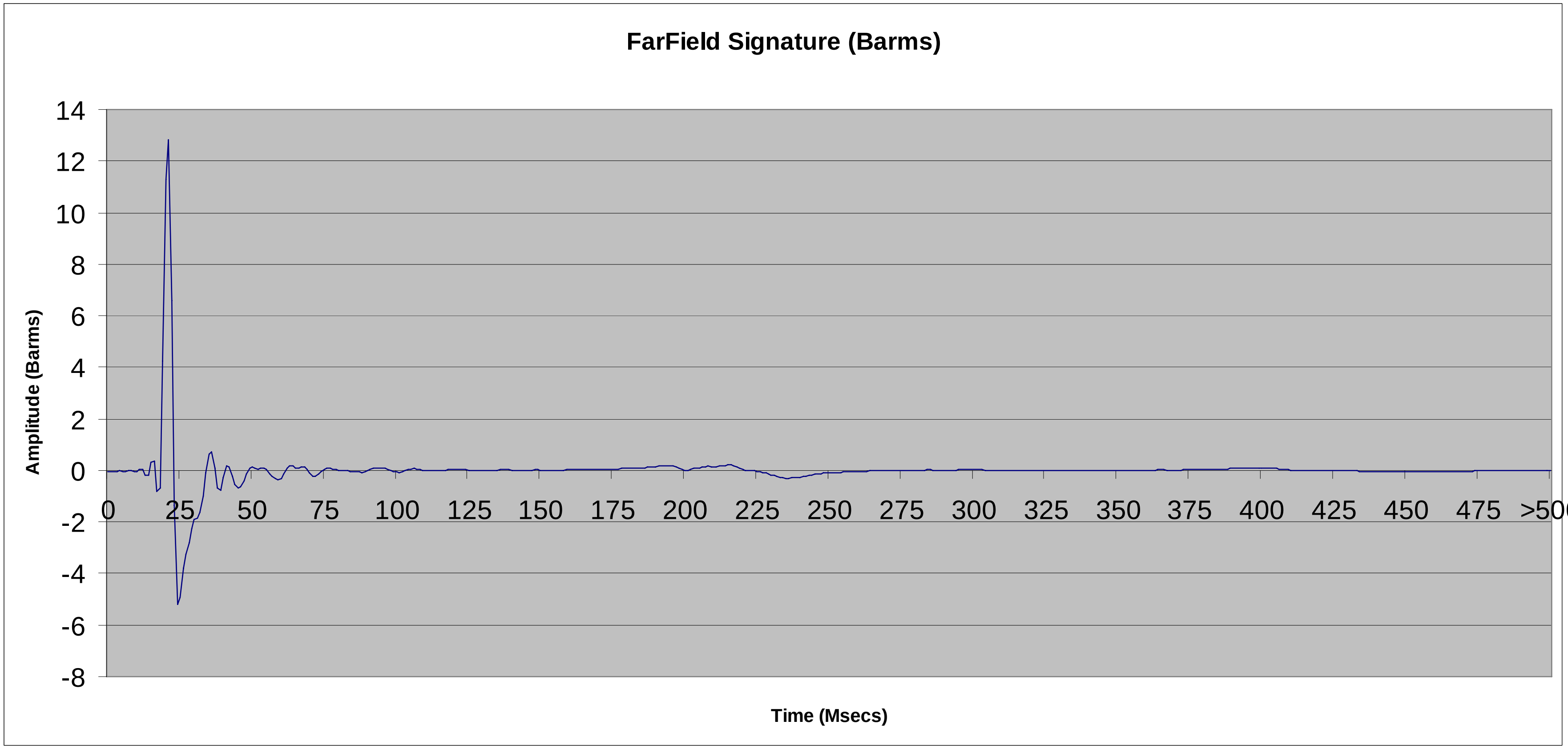
File 2.33: 1200 cu in Single SeaScan Tri-Cluster ® array @ 10 ft



0-P Barm 13.24 P-P Barm 19.46 P/B Ratio = 36.98 Period = 193.75 Depth = 2.63 M Power = 190.87 Db

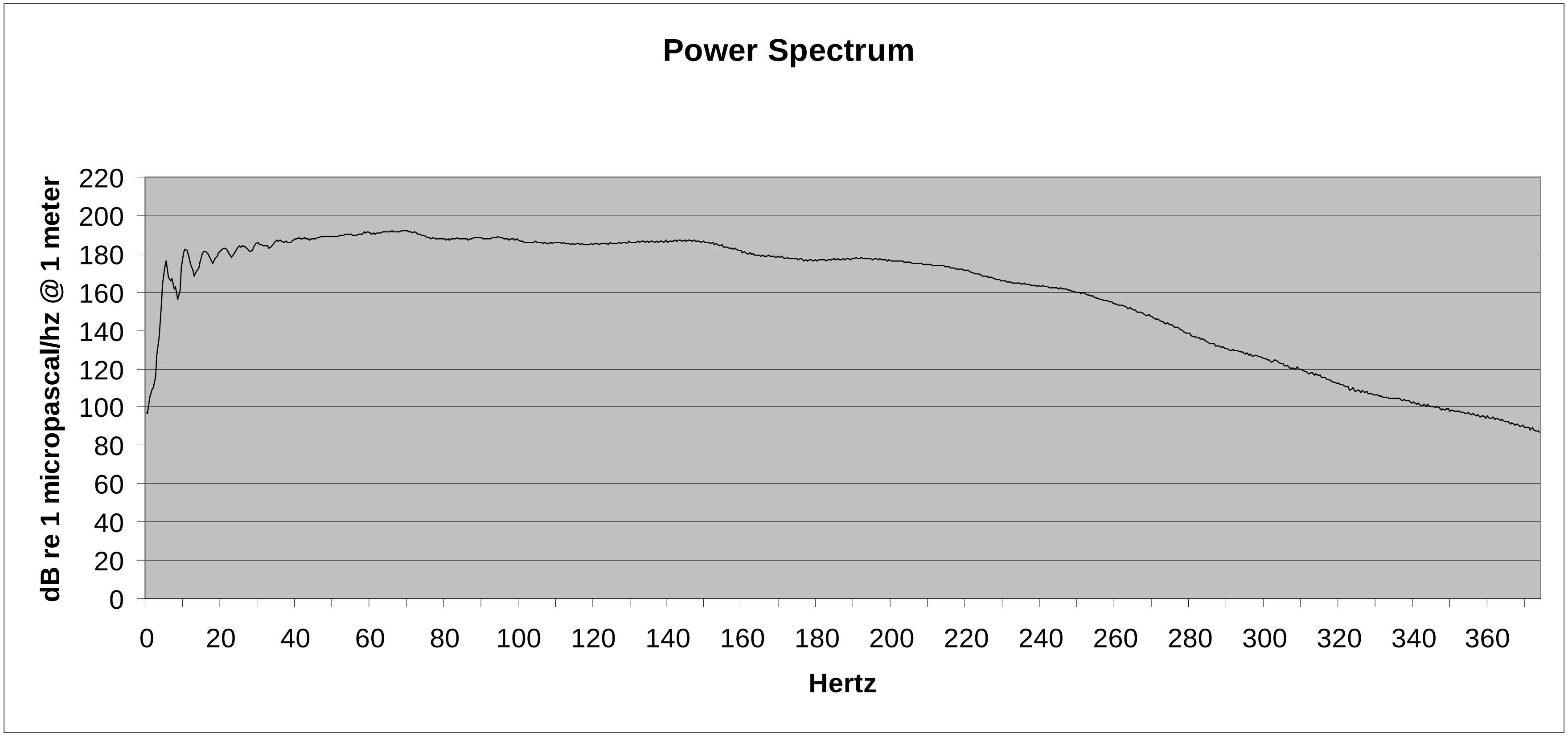
This is a single pontoon of 1200 cu ins.

File 2.34: 1200 cu in Single SeaScan Tri-Cluster ® array @ 10 ft



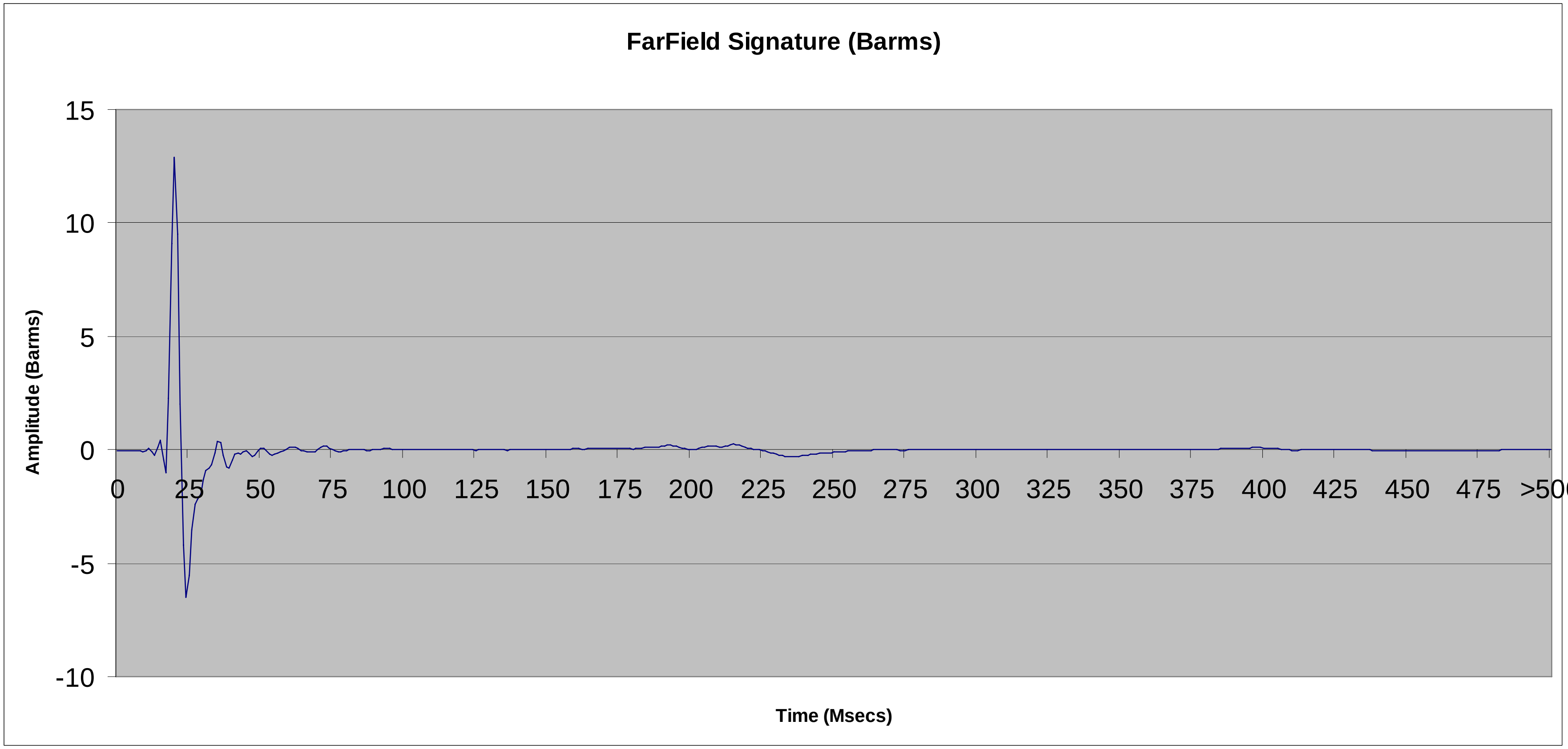
0-P Barm 13.25 P-P Barm 18.64 P/B Ratio = 30.78 Period = 194.75 Depth = 2.63 M Power = 192.07 Db

File 2.34: 1200 cu in Single SeaScan Tri-Cluster® array @ 10 ft



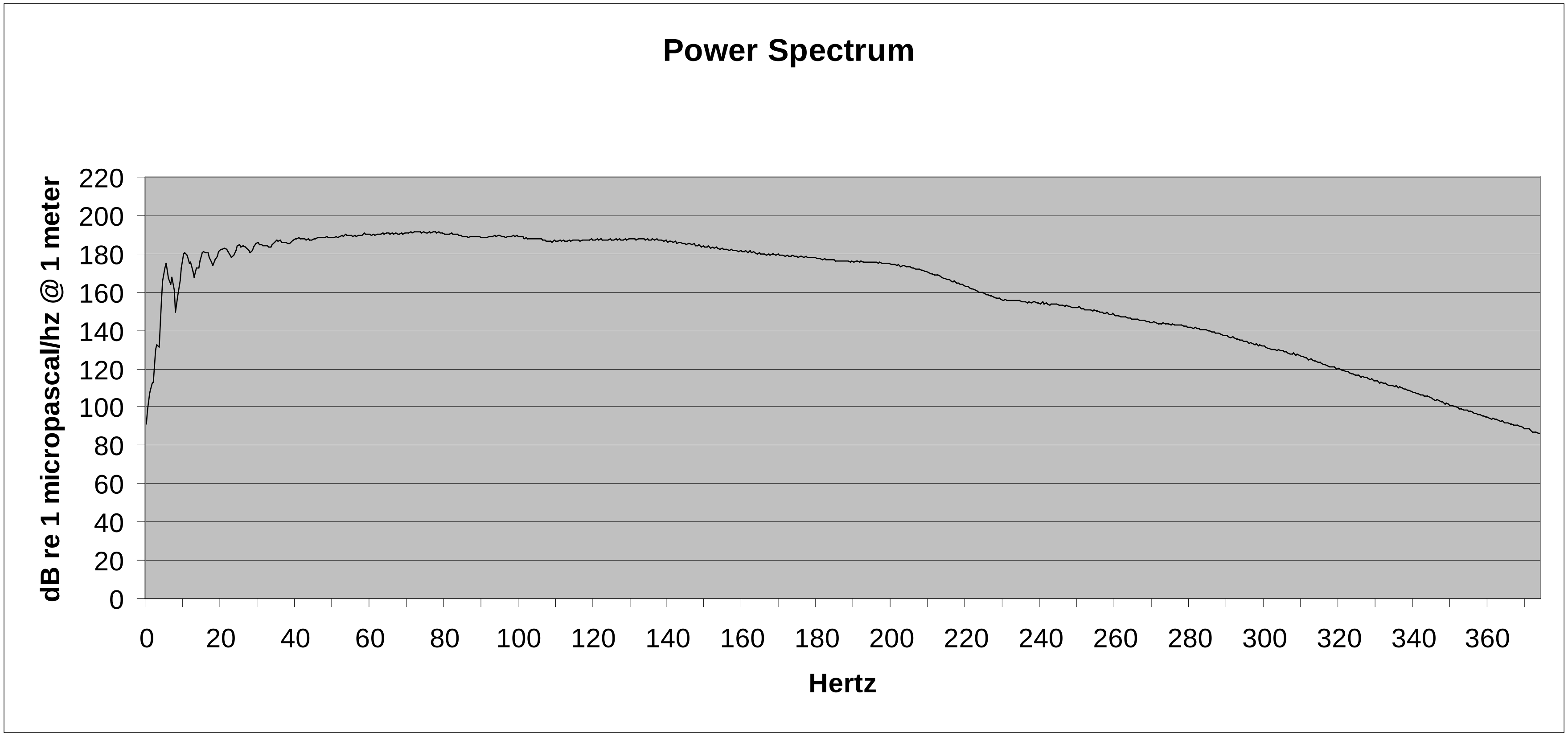
0-P Barm 13.25 P-P Barm 18.64 P/B Ratio = 30.78 Period = 194.75 Depth = 2.63 M Power = 192.07 Db

File 2.35: 1200 cu in Single SeaScan Tri-Cluster ® array @ 10 ft



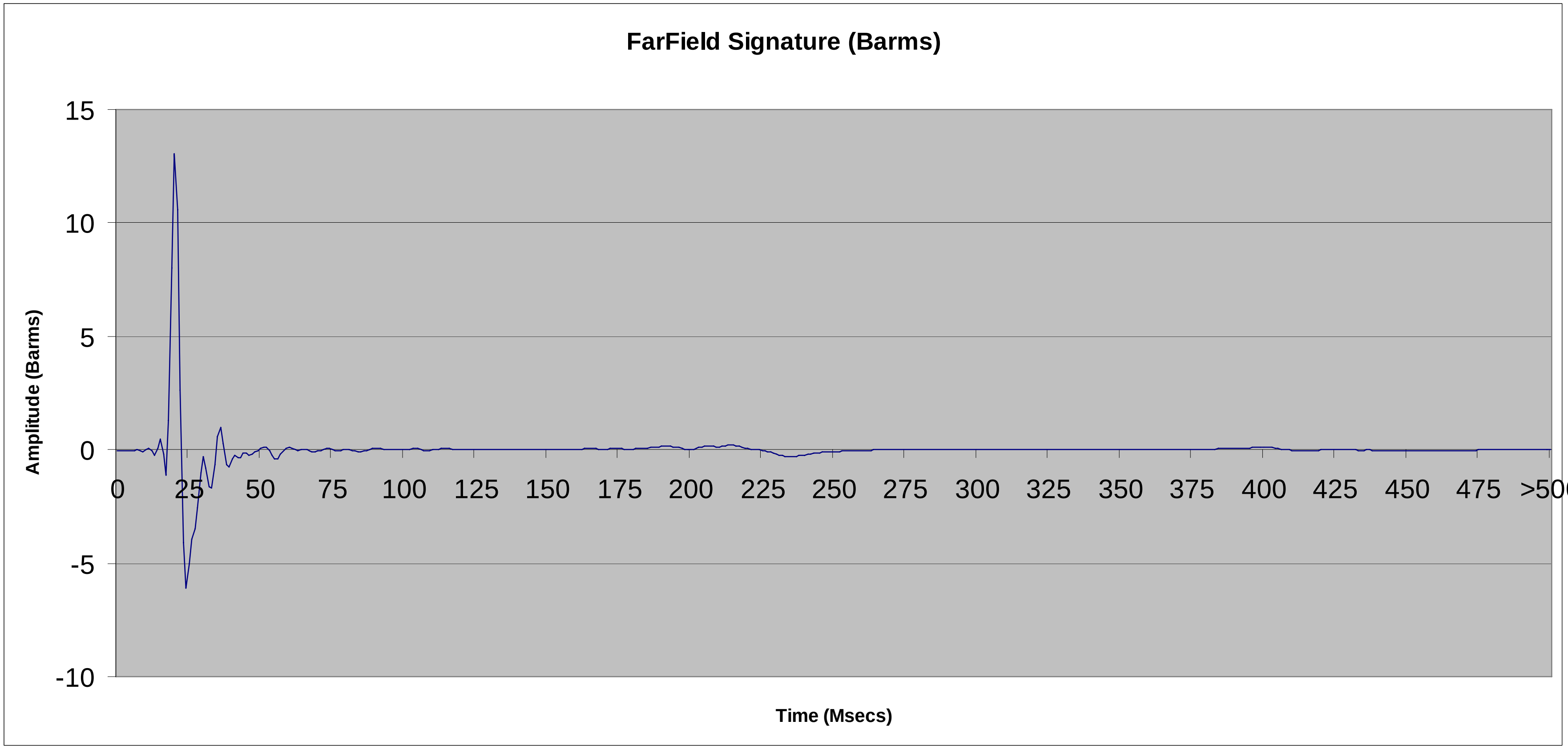
0-P Barm	12.92	P-P Barm	19.44	P/B Ratio =	34.36	Period =	195.25	Depth =	3.00	M	Power =	191.44	Db

File 2.35: 1200 cu in Single SeaScan Tri-Cluster ® array @ 10 ft



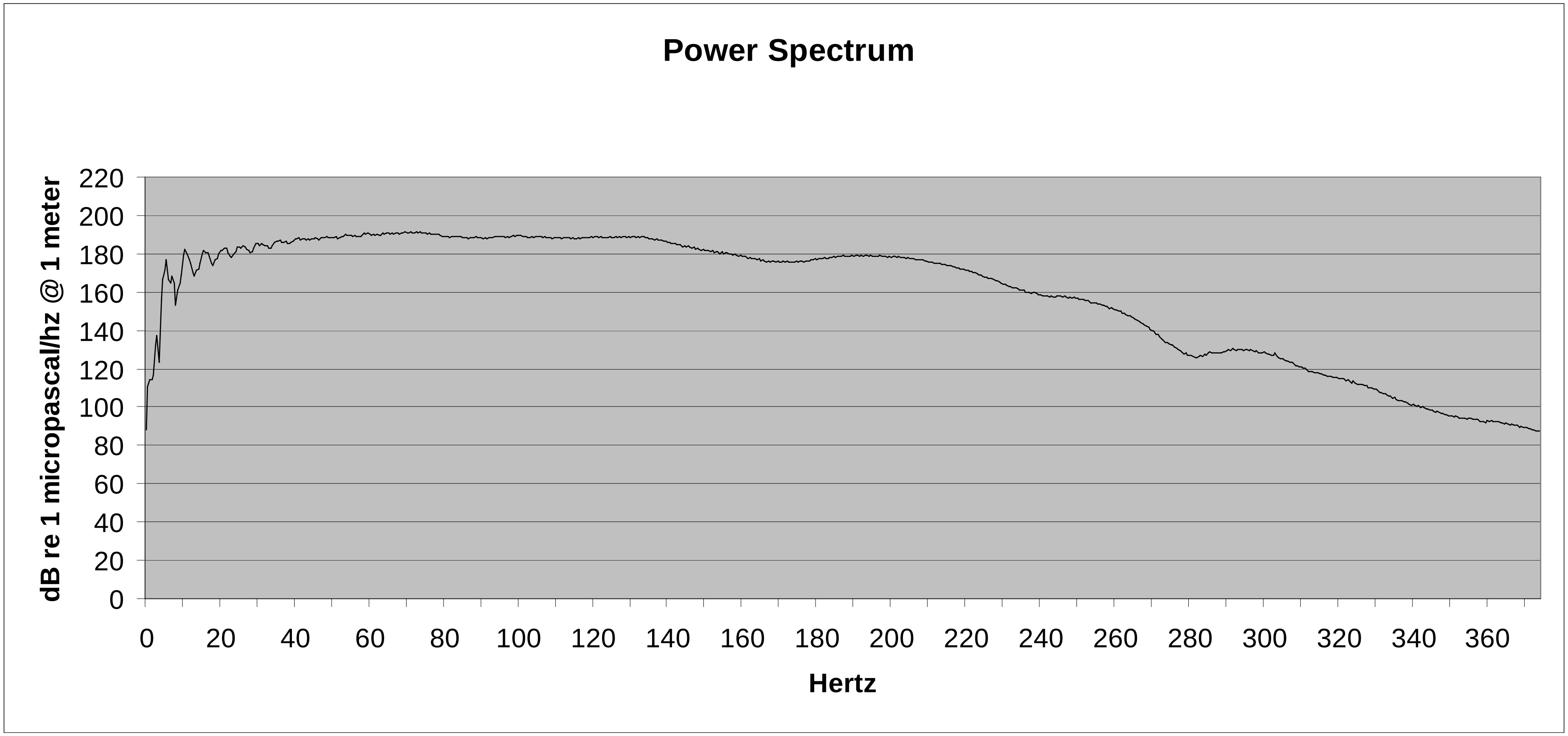
0-P Barm 12.92 P-P Barm 19.44 P/B Ratio = 34.36 Period = 195.25 Depth = 3.00 M Power = 191.44 Db

File 2.36: 1200 cu in Single SeaScan Tri-Cluster® array @ 10 ft



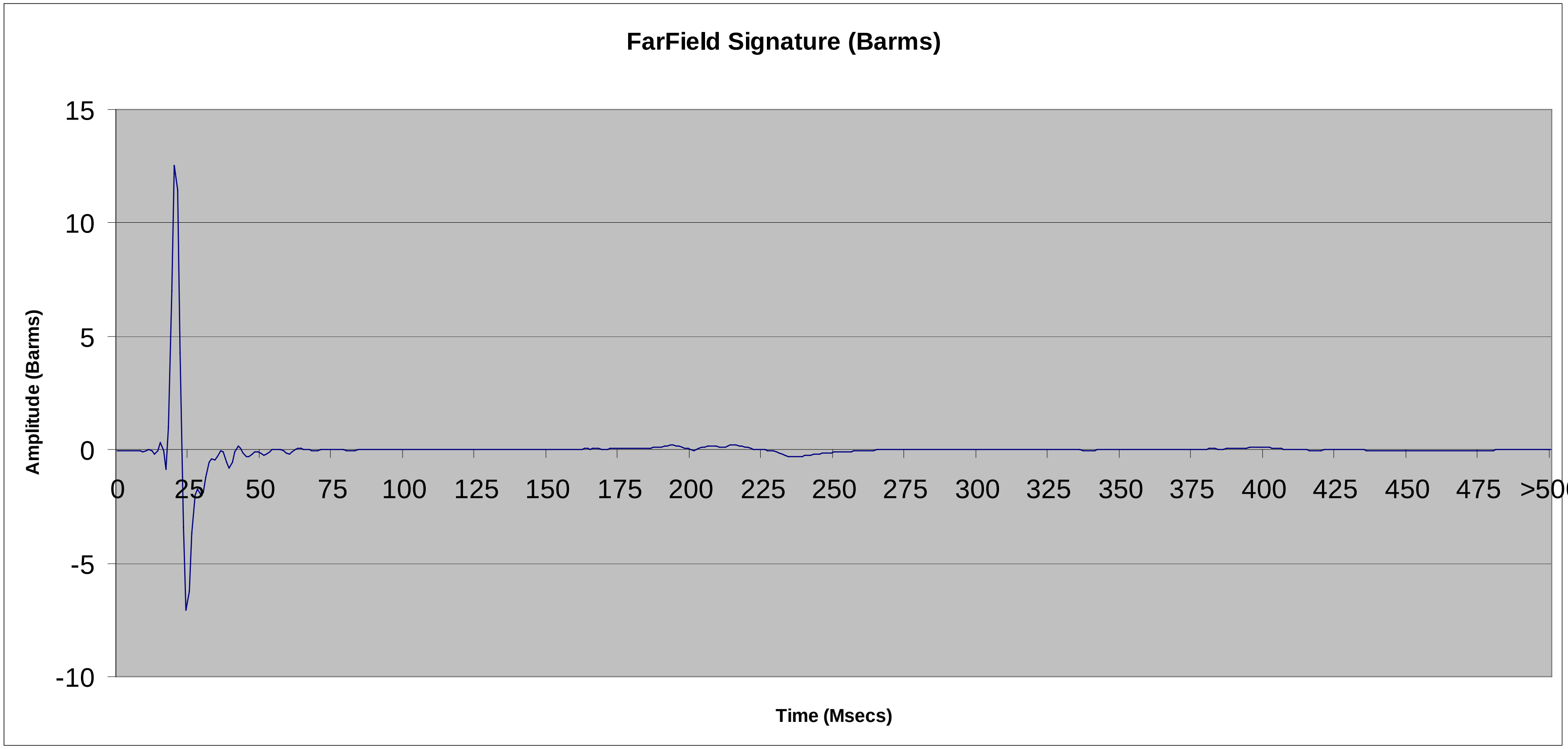
0-P Barm 13.23 P-P Barm 19.31 P/B Ratio = 29.69 Period = 193.50 Depth = 2.81 M Power = 191.32 Db

File 2.36: 1200 cu in Single SeaScan Tri-Cluster ® array @ 10 ft



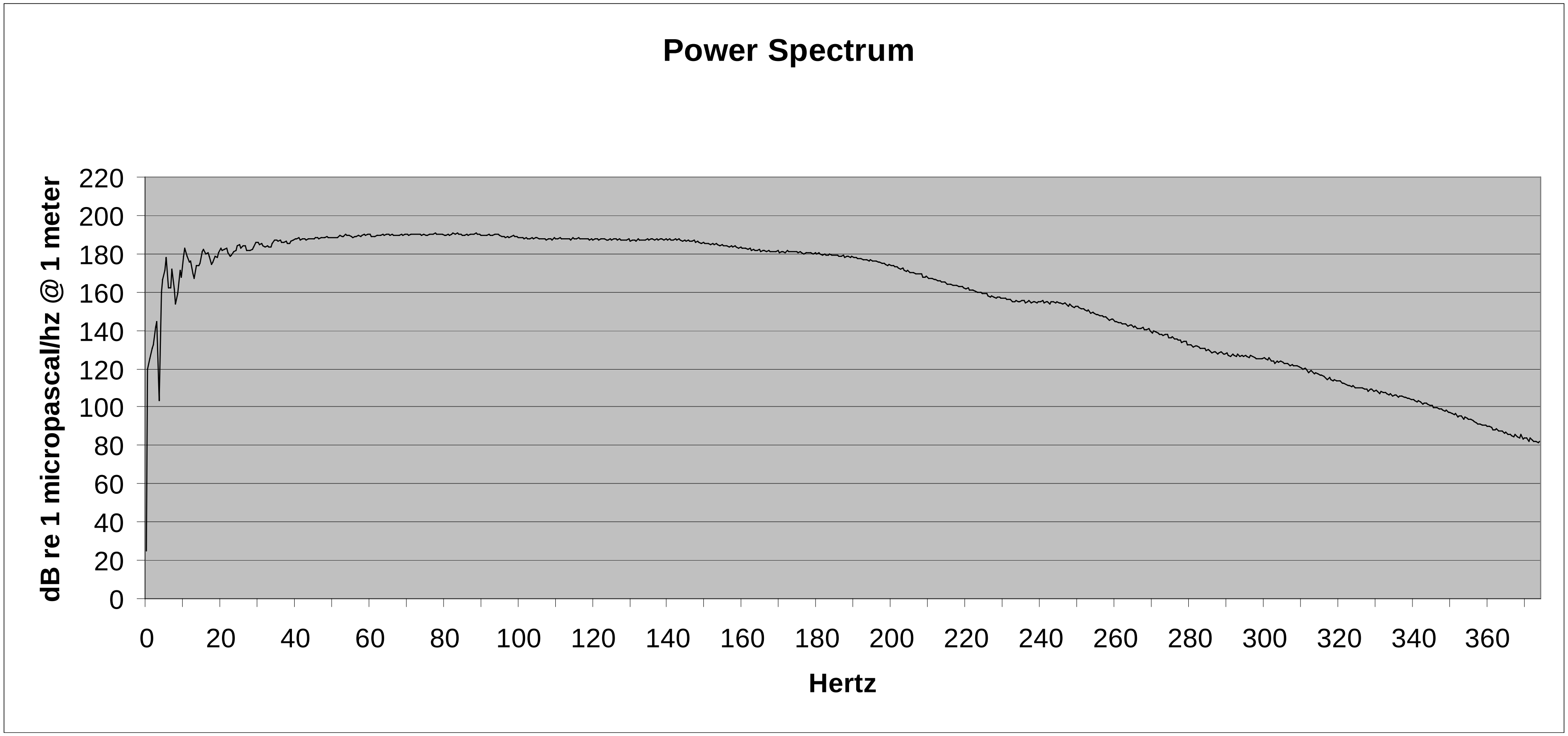
0-P Barm	13.23	P-P Barm	19.31	P/B Ratio =	29.69	Period =	193.50	Depth =	2.81	M	Power =	191.32	Db

File 2.37: 1200 cu in Single SeaScan Tri-Cluster ® array @ 10 ft



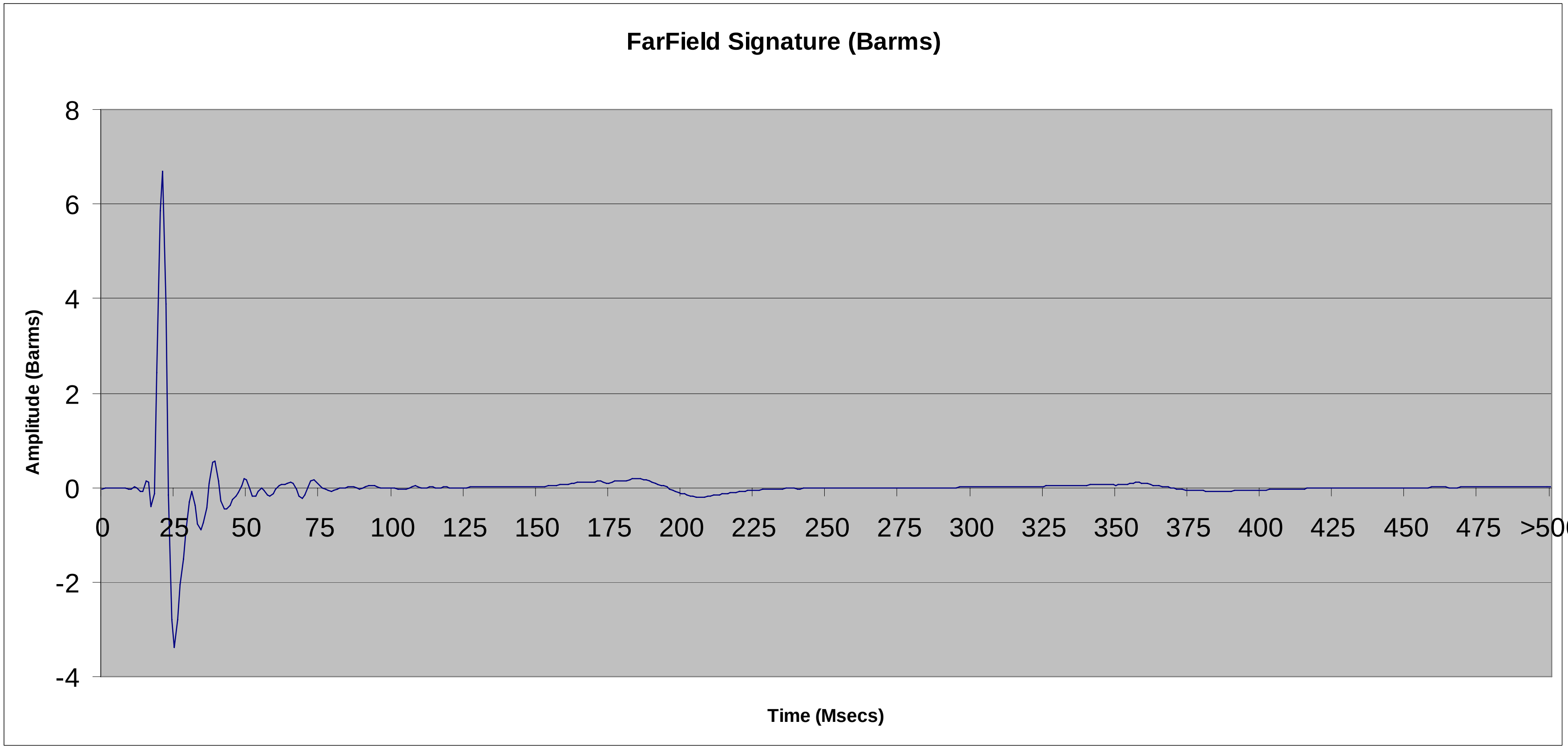
0-P Barm	12.99	P-P Barm	20.19	P/B Ratio =	37.98	Period =	195.00	Depth =	3.00	M	Power =	190.73	Db

File 2.37: 1200 cu in Single SeaScan Tri-Cluster ® array @ 10 ft



0-P Barm 12.99 P-P Barm 20.19 P/B Ratio = 37.98 Period = 195.00 Depth = 3.00 M Power = 190.73 Db

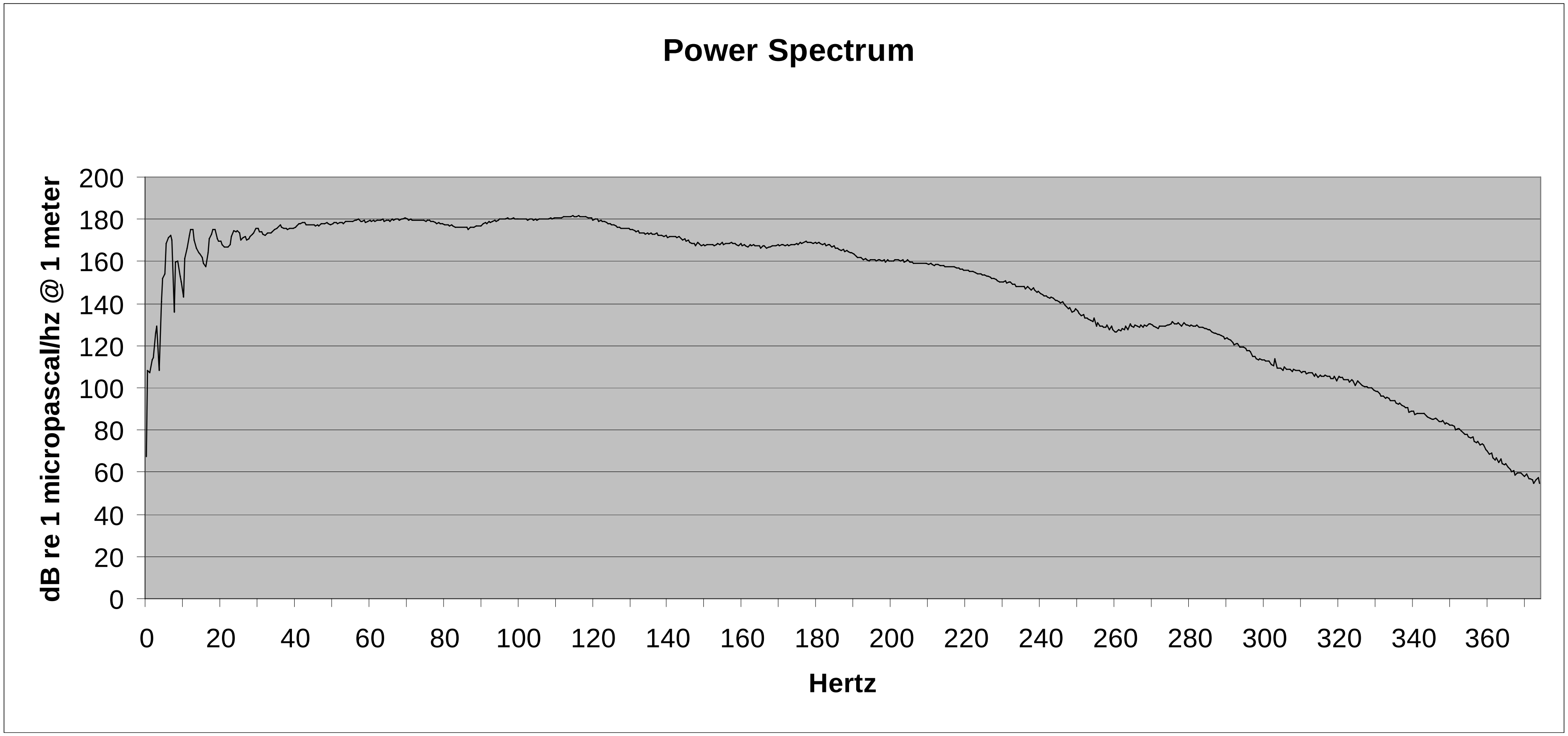
File 2.38: 600 cu in SeaScan Tri-Cluster ® array @ 10 ft



0-P Barm	6.85	P-P Barm	10.25	P/B Ratio =	23.38	Period =	163.25	Depth =	3.00	M	Power =	181.72	Db

These next series of displays illustrate single guns and clusters from the SeaScan Tri-Cluster set up.

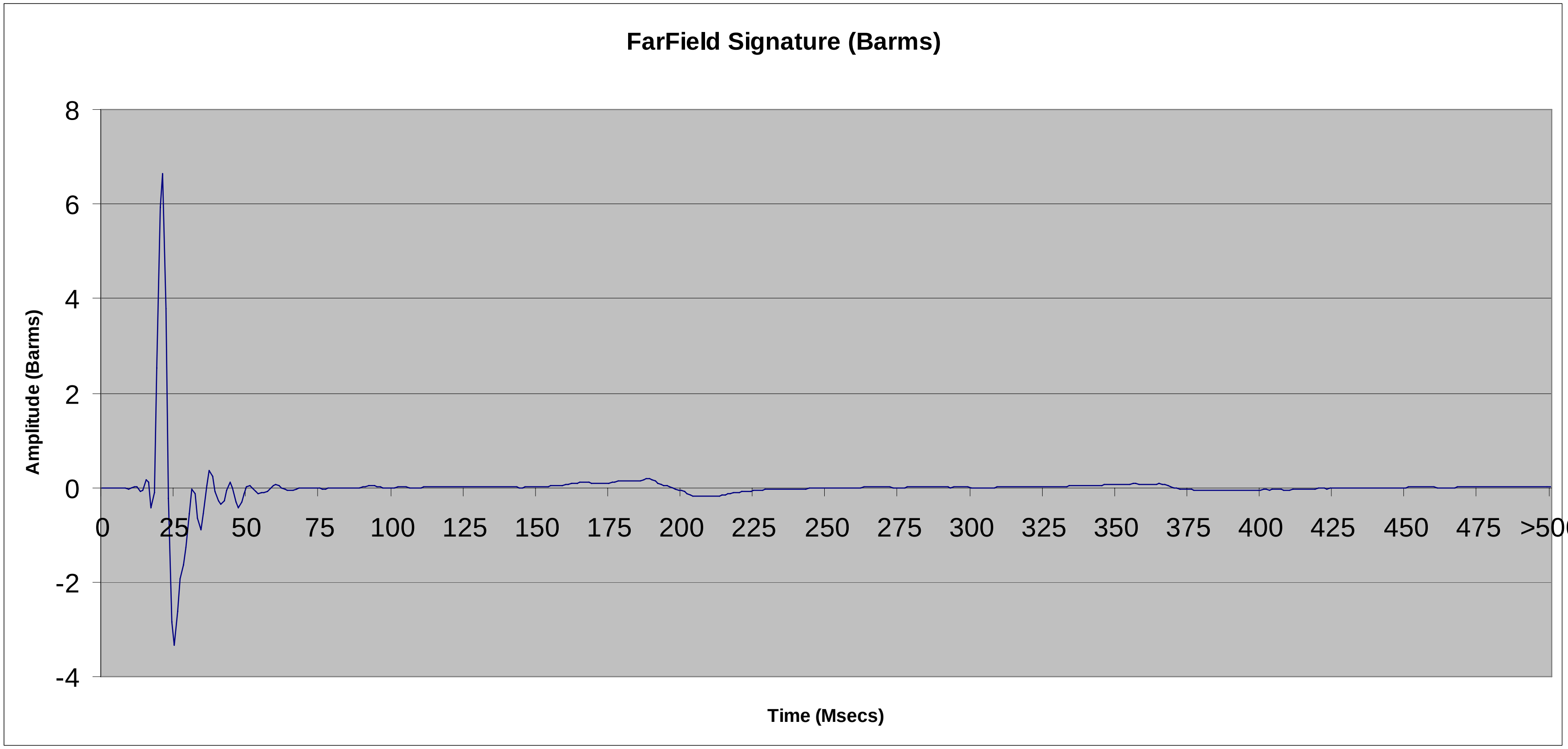
File 2.38: 600 cu in SeaScan Tri-Cluster ® array @ 10 ft



0-P Barm	6.85	P-P Barm	10.25	P/B Ratio =	23.38	Period =	163.25	Depth =	3.00	M	Power =	181.72	Db

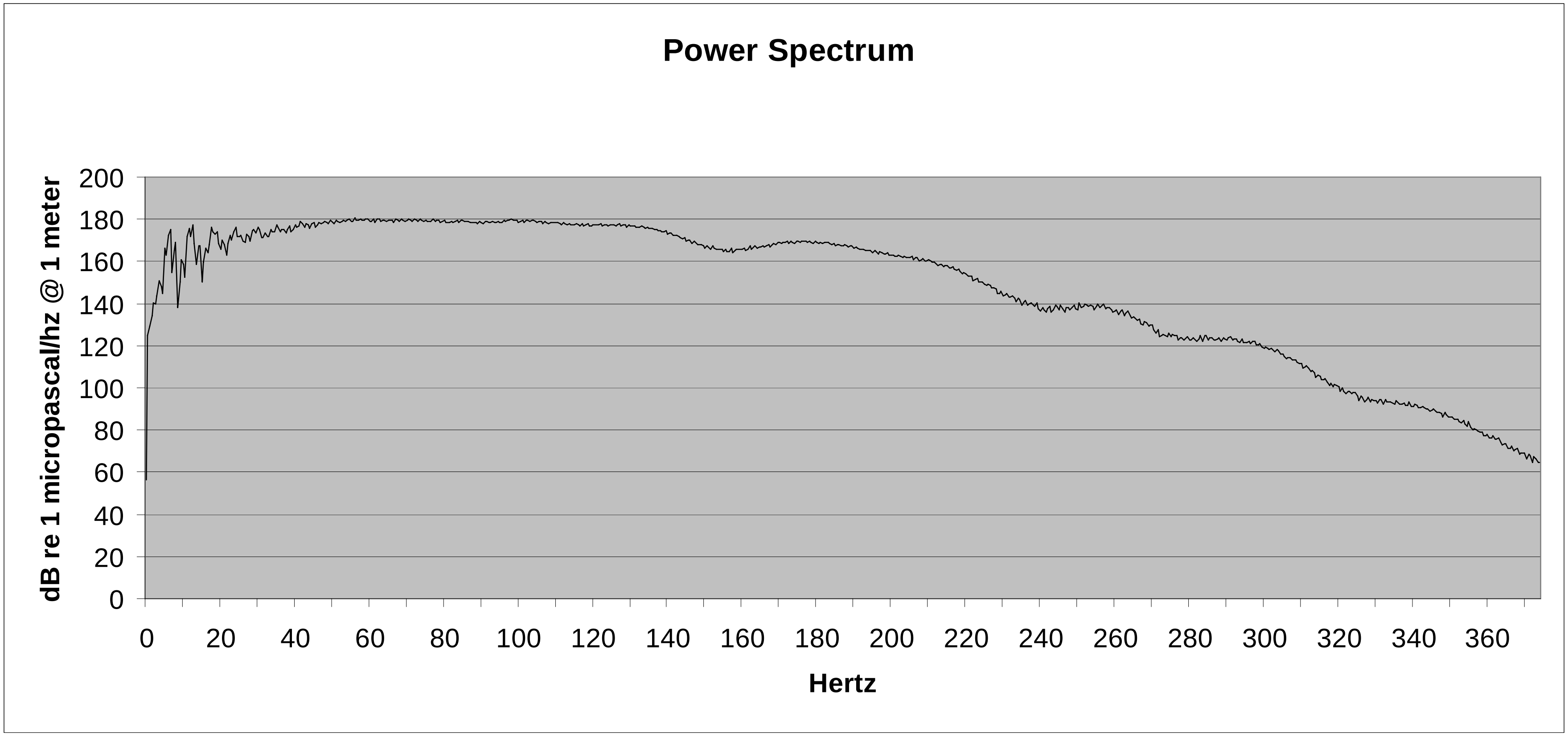
These next series of displays illustrate single guns and clusters from the SeaScan Tri-Cluster set up.

File 2.39: 600 cu in SeaScan Tri-Cluster ® array @ 10 ft



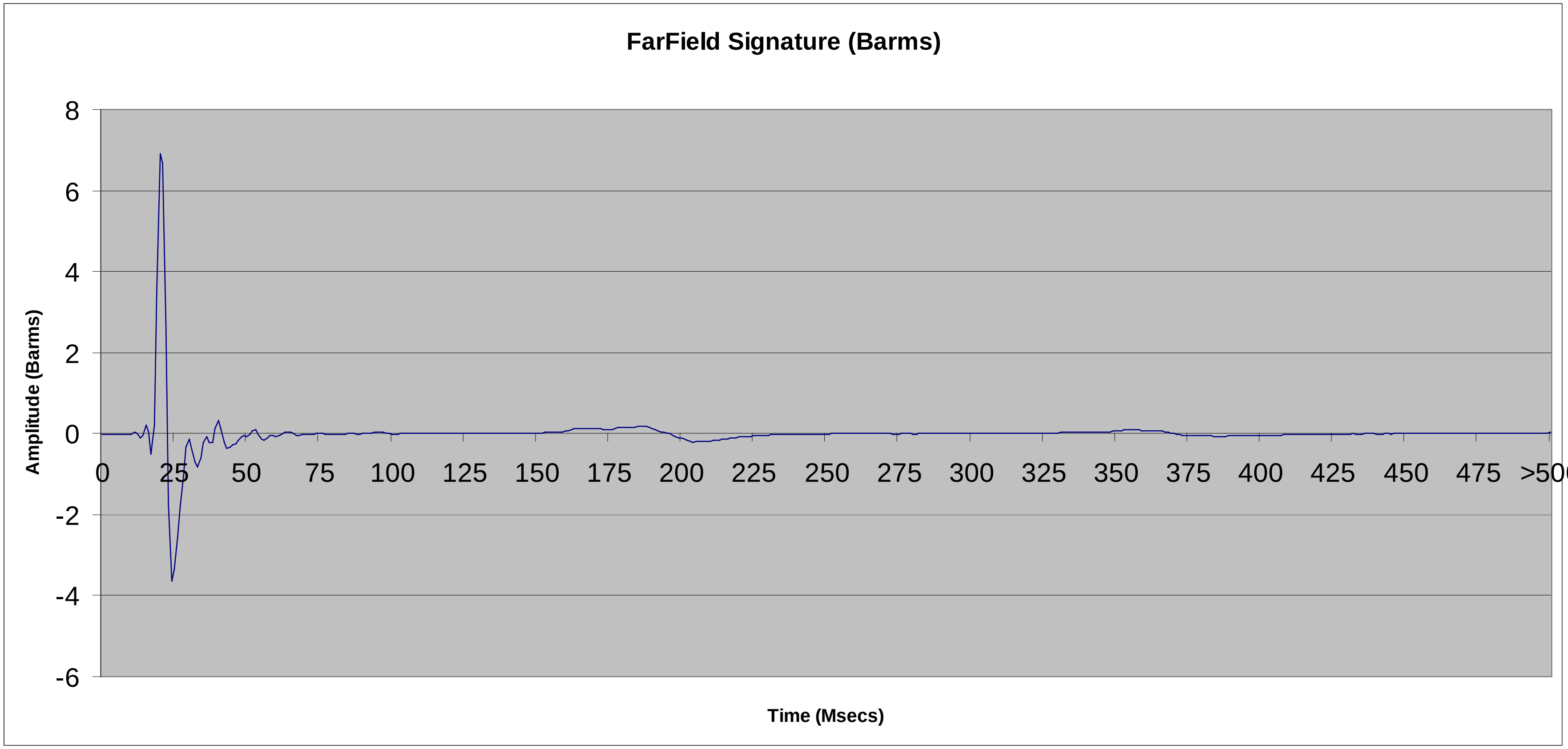
0-P Barm	6.83	P-P Barm	10.21	P/B Ratio =	25.83	Period =	167.50	Depth =	3.00	M	Power =	180.69	Db

File 2.39: 600 cu in SeaScan Tri-Cluster ® array @ 10 ft



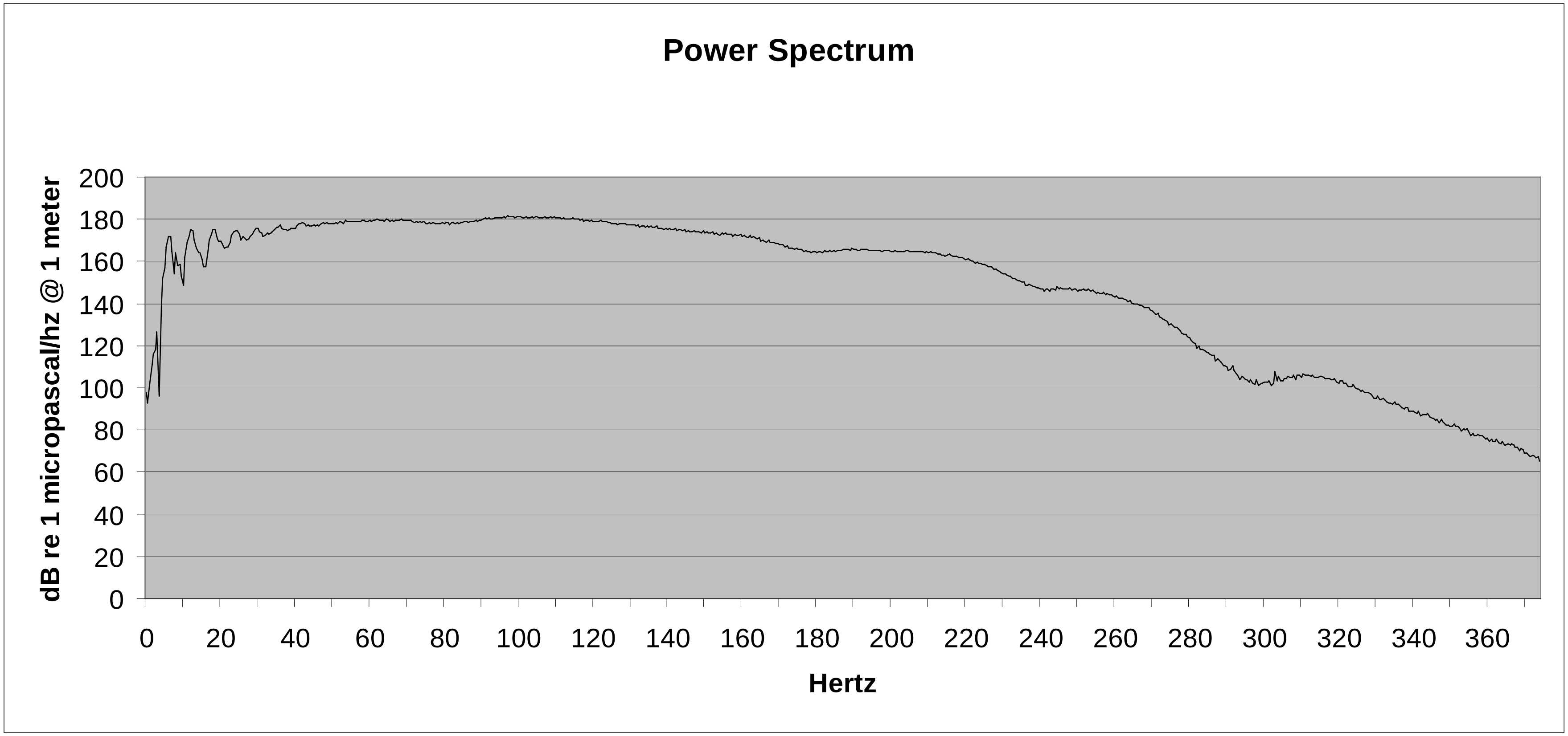
0-P Barm	6.83	P-P Barm	10.21	P/B Ratio =	25.83	Period =	167.50	Depth =	3.00	M	Power =	180.69 Db

File 2.40: 600 cu in SeaScan Tri-Cluster ® array @ 10 ft



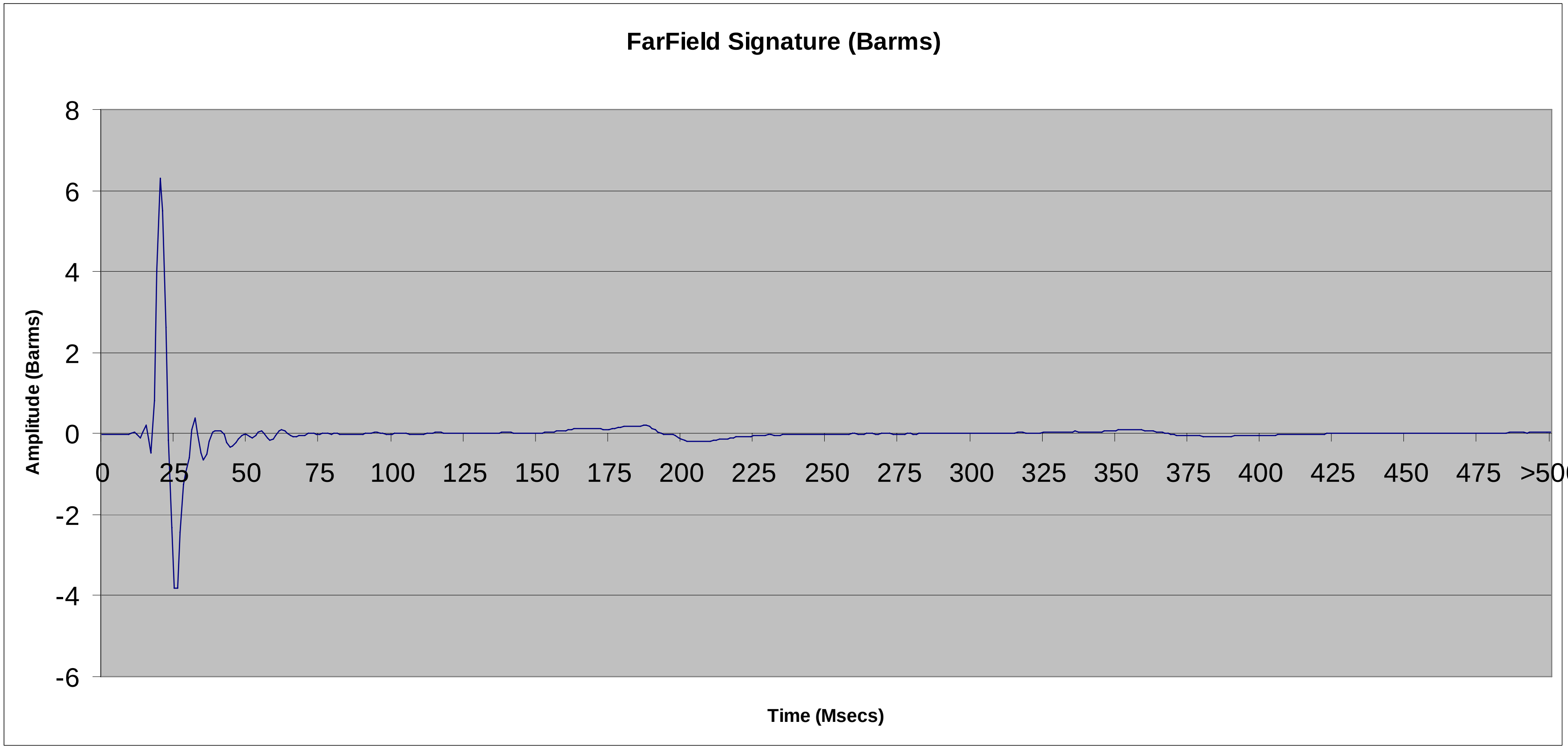
0-P Barm	7.40	P-P Barm	11.09	P/B Ratio =	28.44	Period =	165.75	Depth =	2.81	M	Power =	181.58	Db	

File 2.40: 600 cu in SeaScan Tri-Cluster ® array @ 10 ft



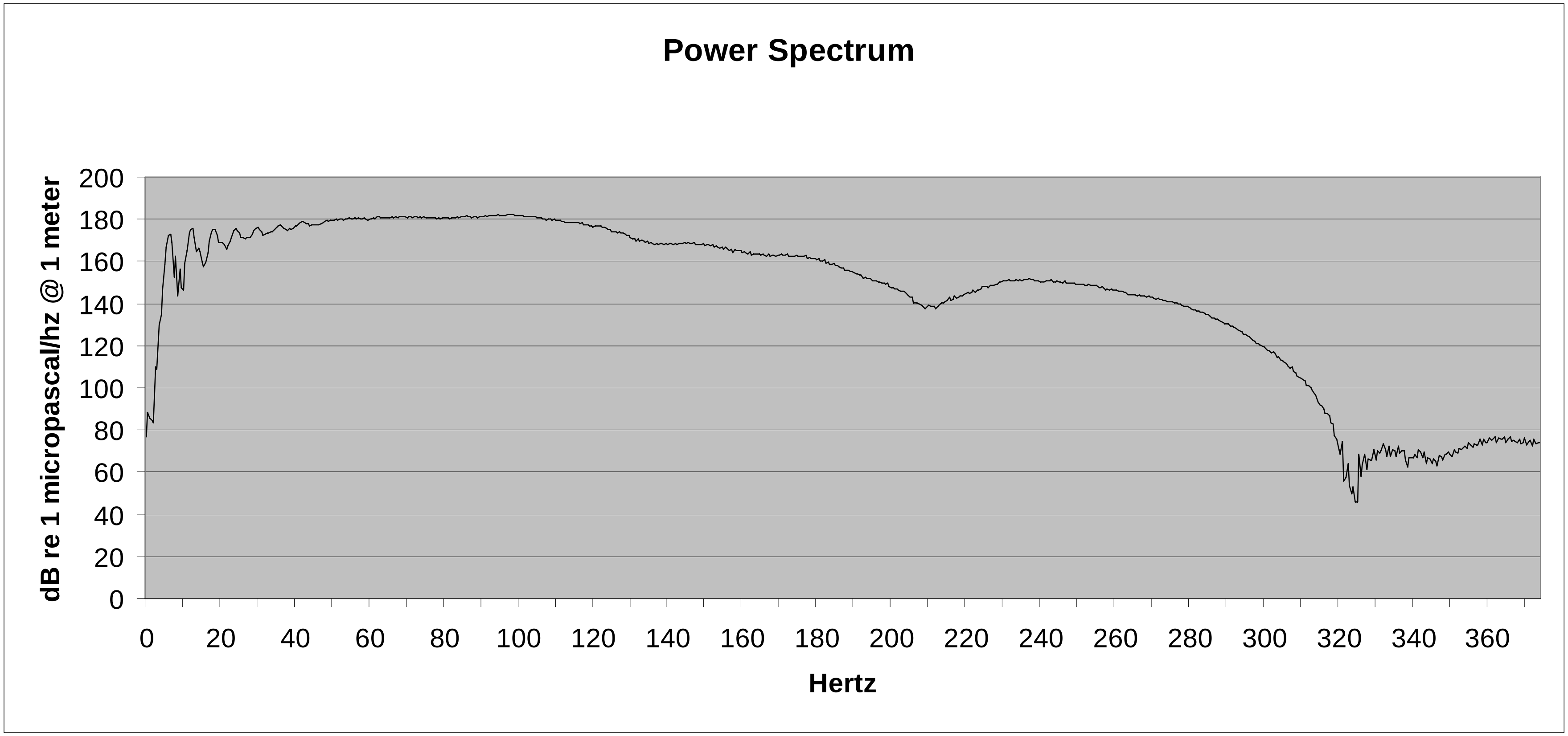
0-P Barm	7.40	P-P Barm	11.09	P/B Ratio =	28.44	Period =	165.75	Depth =	2.81	M	Power =	181.58	Db

File 2.41: 600 cu in SeaScan Tri-Cluster ® array @ 10 ft



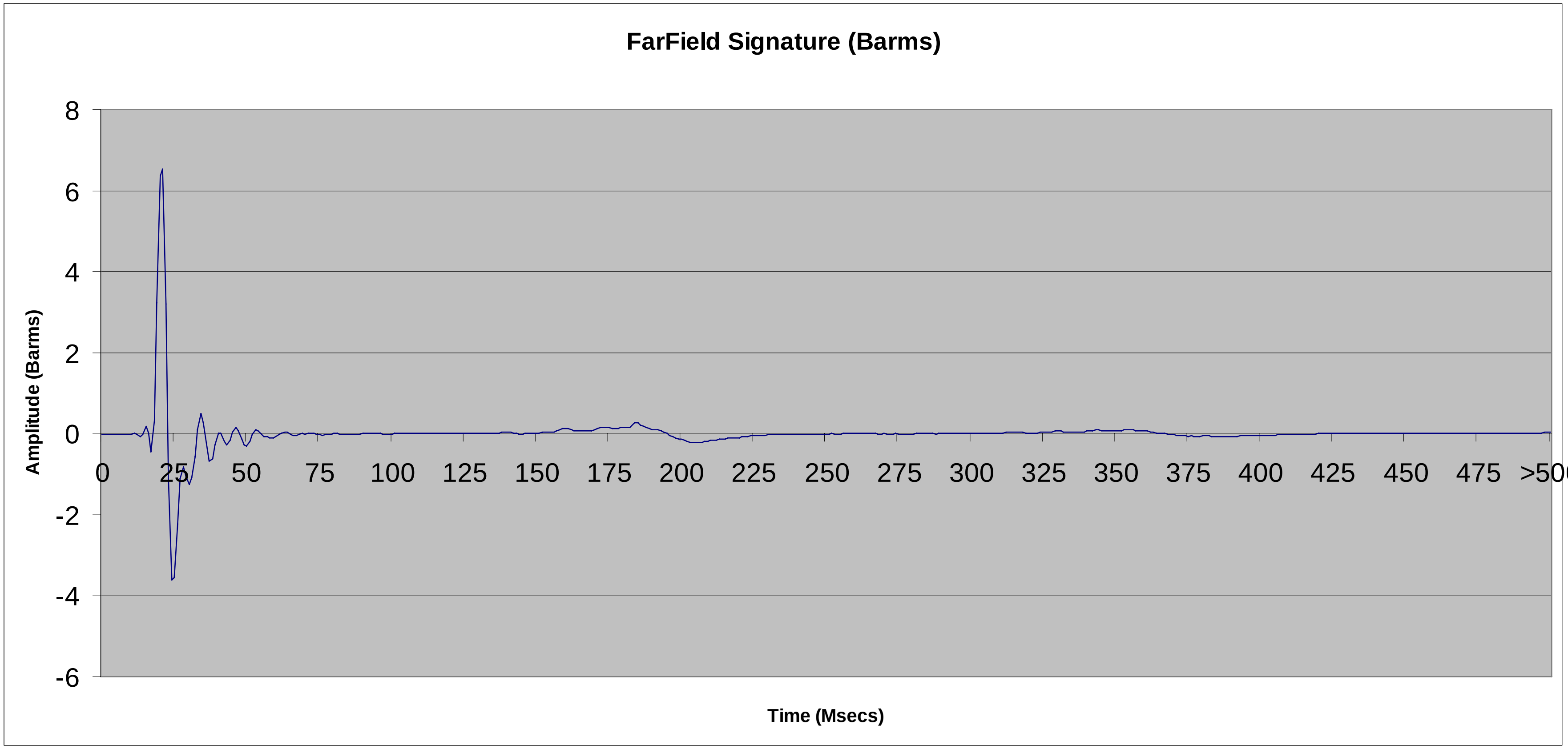
0-P Barm 6.41 P-P Barm 10.45 P/B Ratio = 25.64 Period = 167.50 Depth = 3.94 M Power = 182.42 Db

File 2.41: 600 cu in SeaScan Tri-Cluster ® array @ 10 ft



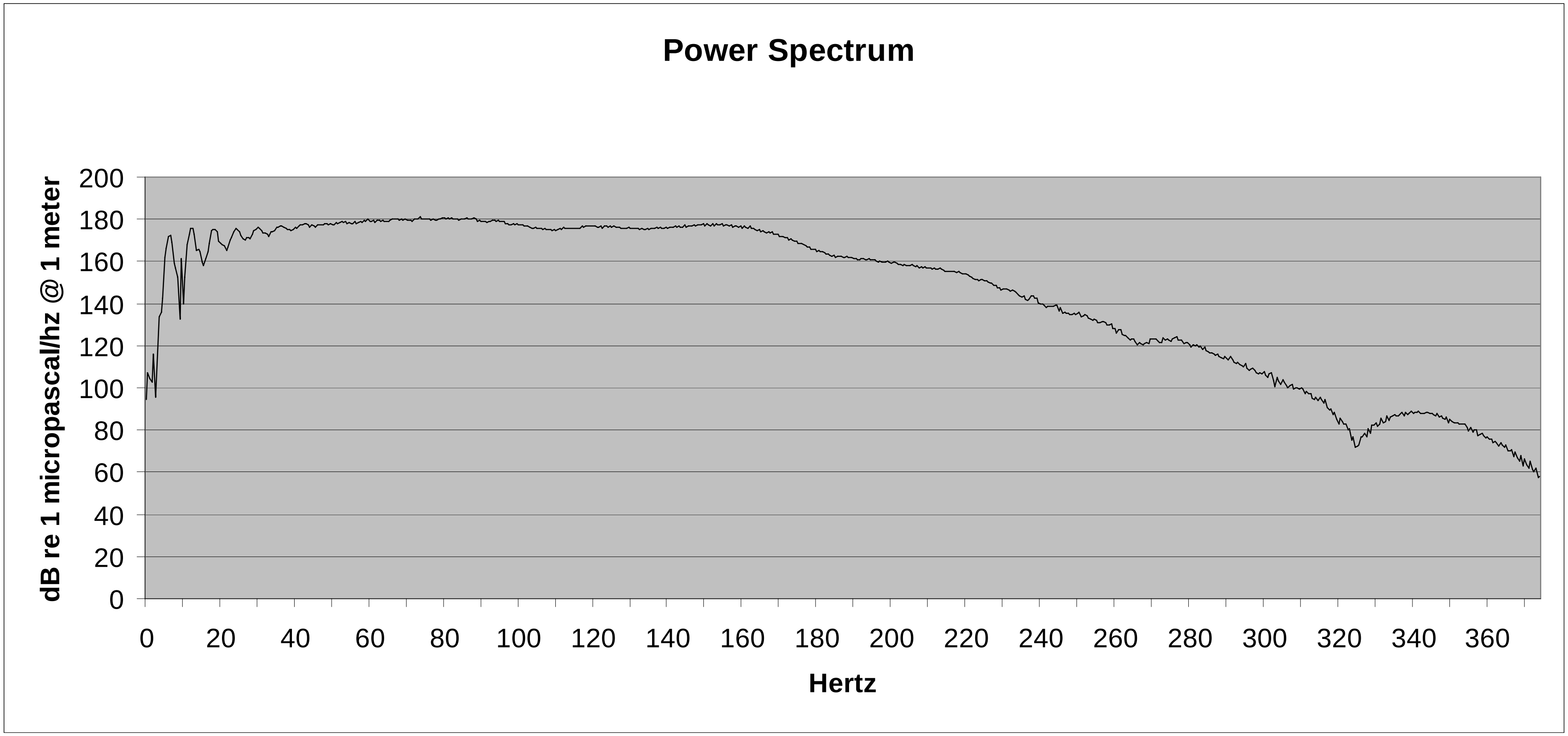
0-P Barm	6.41	P-P Barm	10.45	P/B Ratio =	25.64	Period =	167.50	Depth =	3.94	M	Power =	182.42	Db

File 2.42: 600 cu in SeaScan Tri-Cluster ® array @ 10 ft



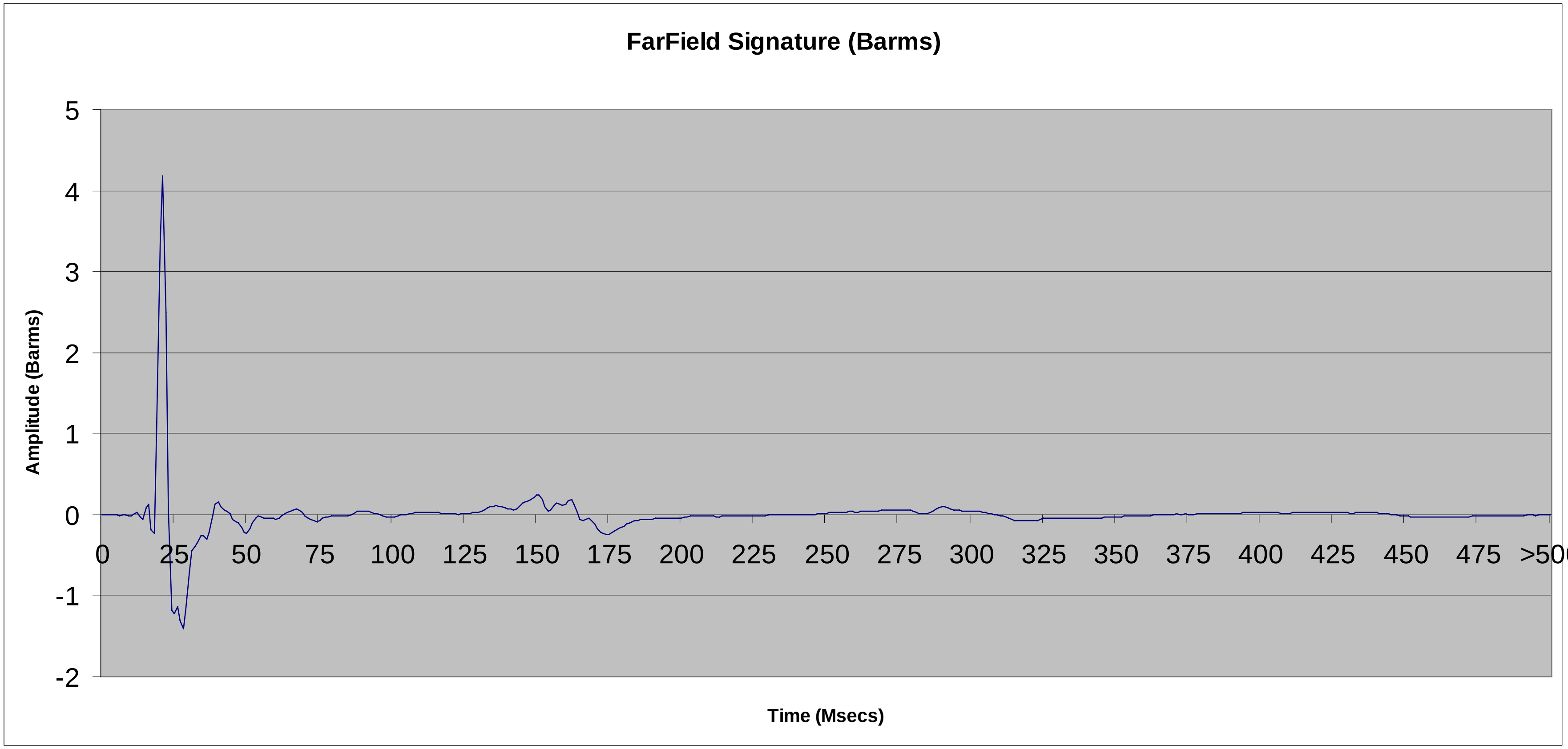
0-P Barm6.94 P-P Barm 10.80 P/B Ratio =19.09 Period =164.00 Depth =3.00 M Power =180.97 Db

File 2.42: 600 cu in SeaScan Tri-Cluster ® array @ 10 ft



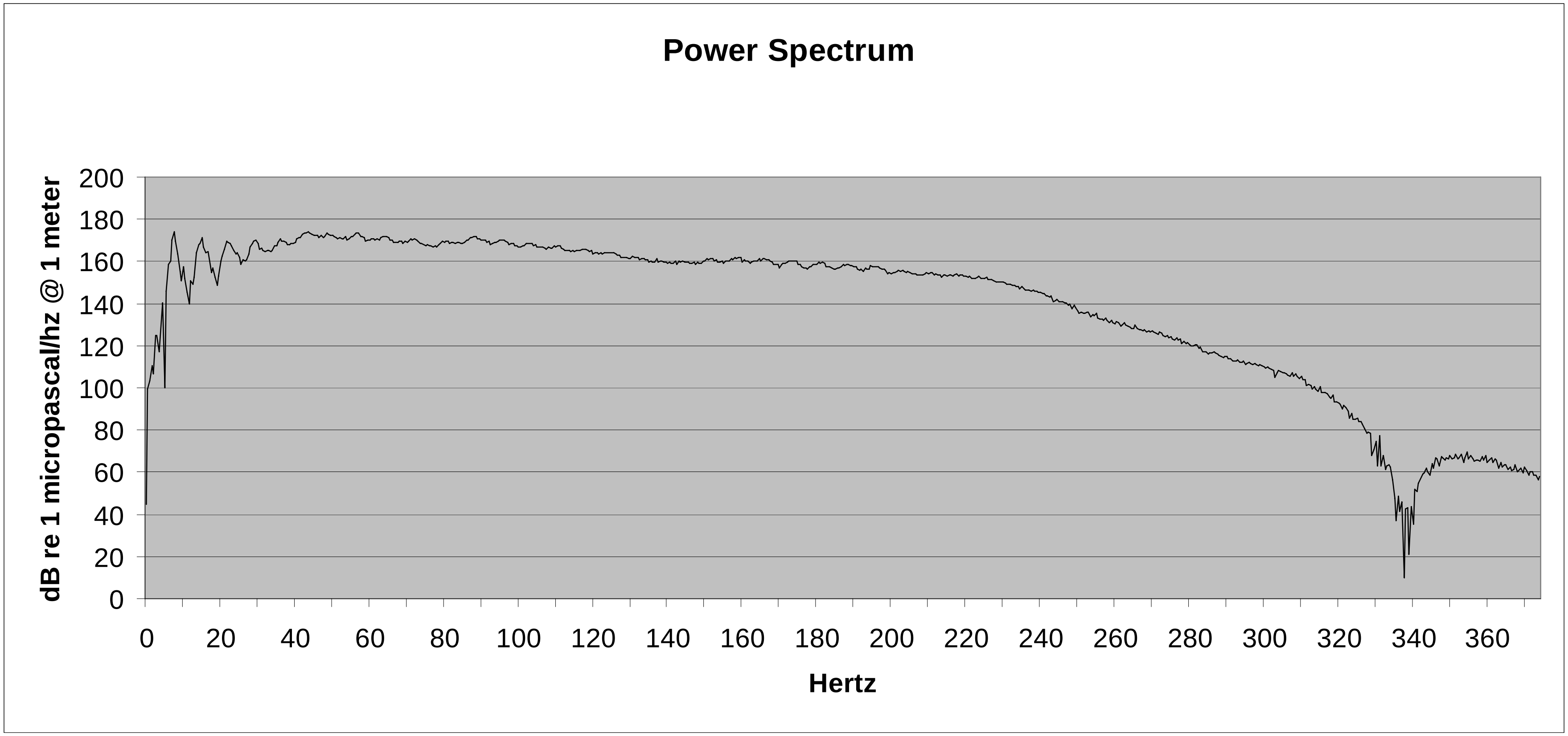
0-P Barm6.94 P-P Barm 10.80 P/B Ratio =19.09 Period =164.00 Depth =3.00 M Power =180.97 Db

File 2.43: 600 cu in SeaScan Tri-Cluster ® array @ 10 ft



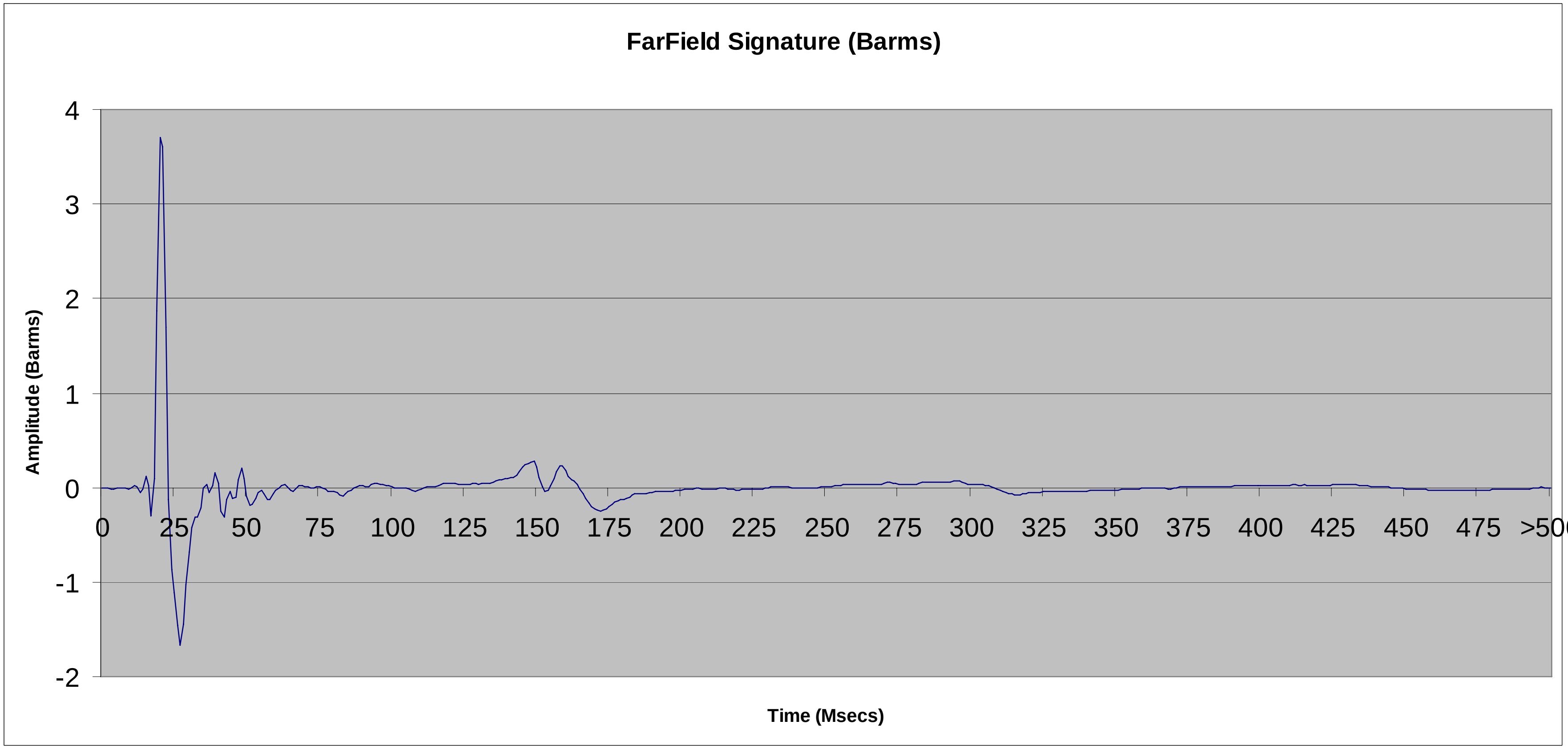
0-P Barm	4.23	P-P Barm	5.64	P/B Ratio =	11.35	Period =	129.75	Depth =	5.25	M	Power =	174.16	Db

File 2.43: 600 cu in SeaScan Tri-Cluster ® array @ 10 ft



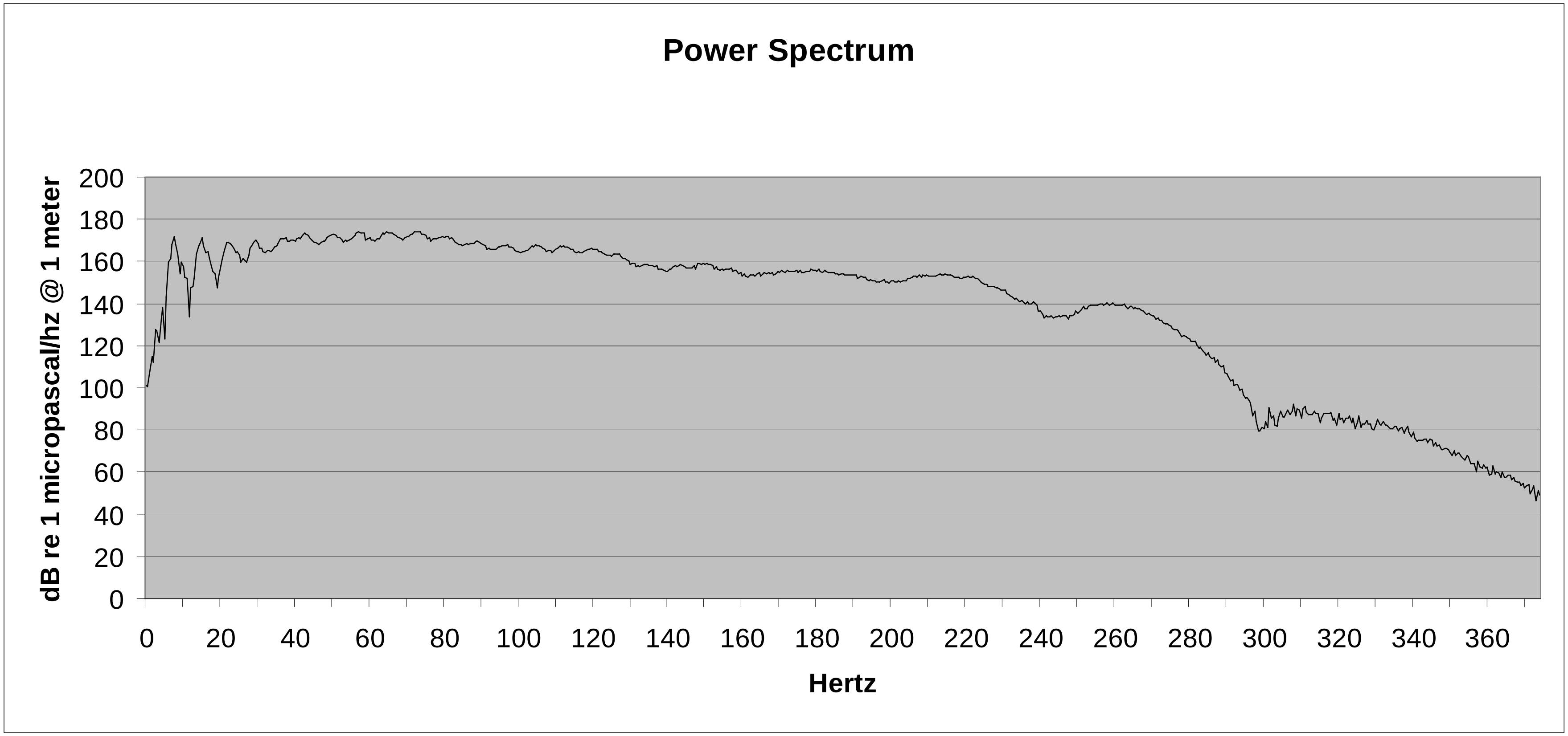
0-P Barm 4.23 P-P Barm 5.64 P/B Ratio = 11.35 Period = 129.75 Depth = 5.25 M Power = 174.16 Db

File 2.44: 300 cu in SeaScan Tri-Cluster ® array (# 1 & 2 only) @ 10 ft



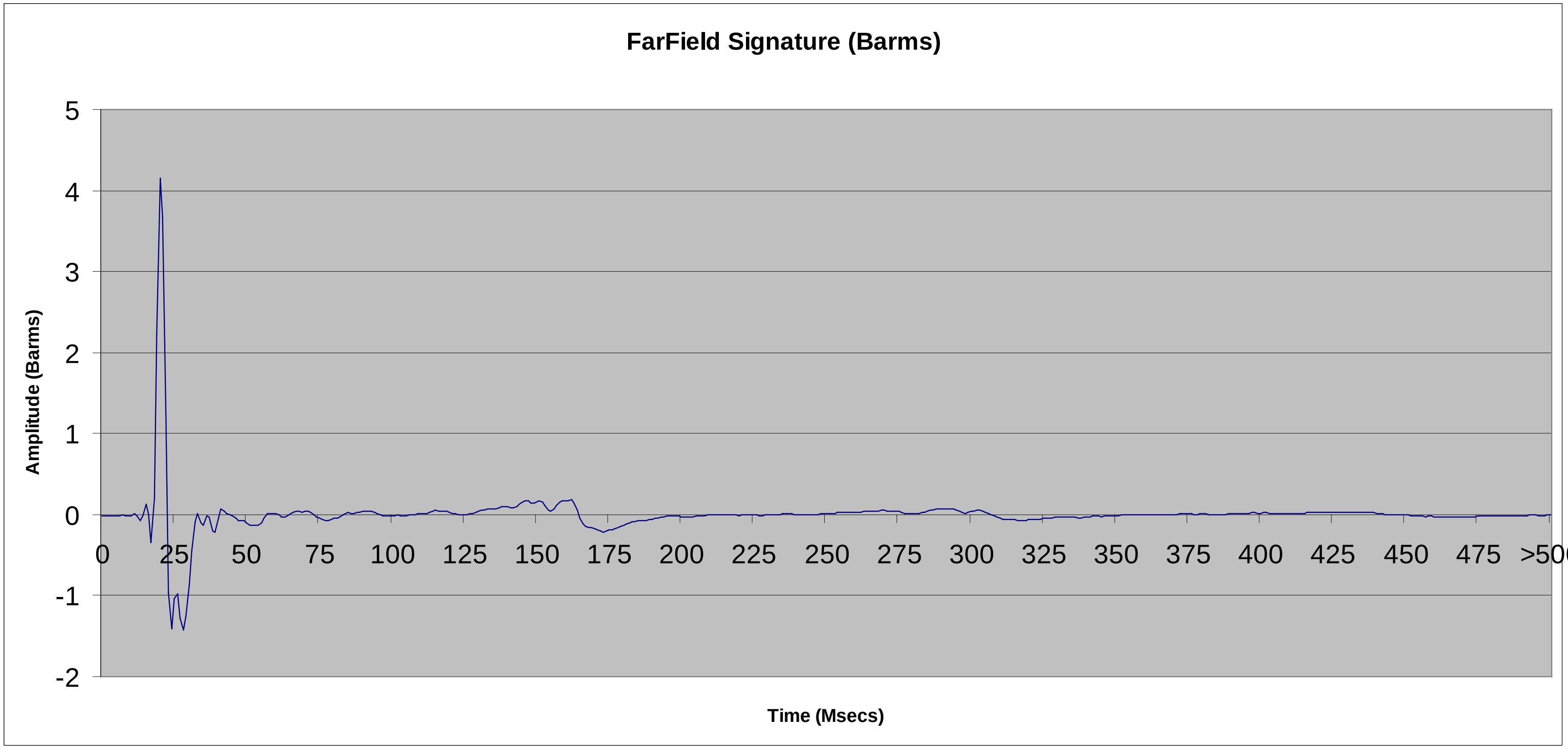
0-P Barm	3.95	P-P Barm	5.62	P/B Ratio =	10.66	Period =	128.00	Depth =	4.88	M	Power =	174.27	Db

File 2.44: 300 cu in SeaScan Tri-Cluster ® array (# 1 & 2 only) @ 10 ft



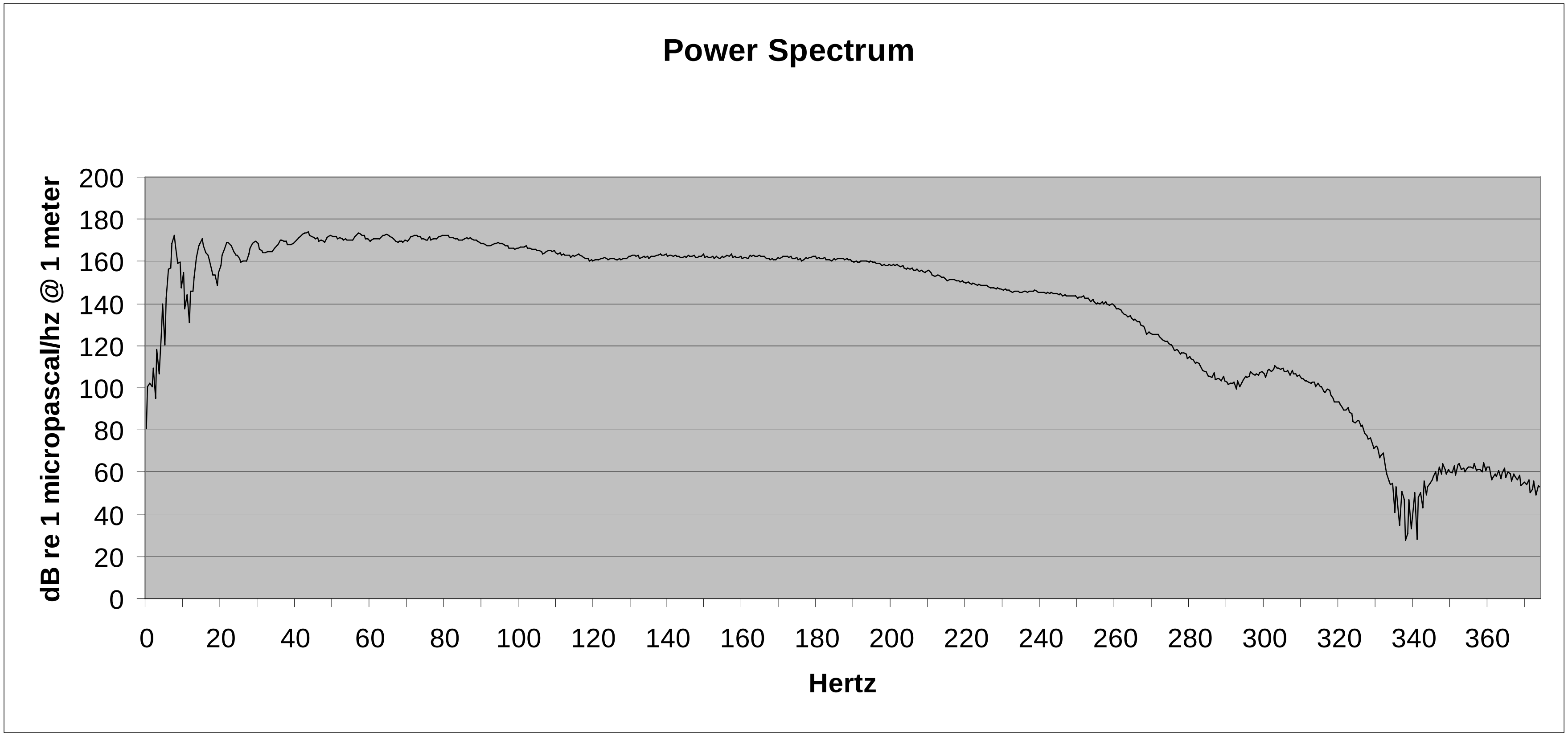
0-P Barm 3.95 P-P Barm 5.62 P/B Ratio = 10.66 Period = 128.00 Depth = 4.88 M Power = 174.27 Db

File 2.45: 300 cu in SeaScan Tri-Cluster ® array (# 1 & 2 only) @ 10 ft



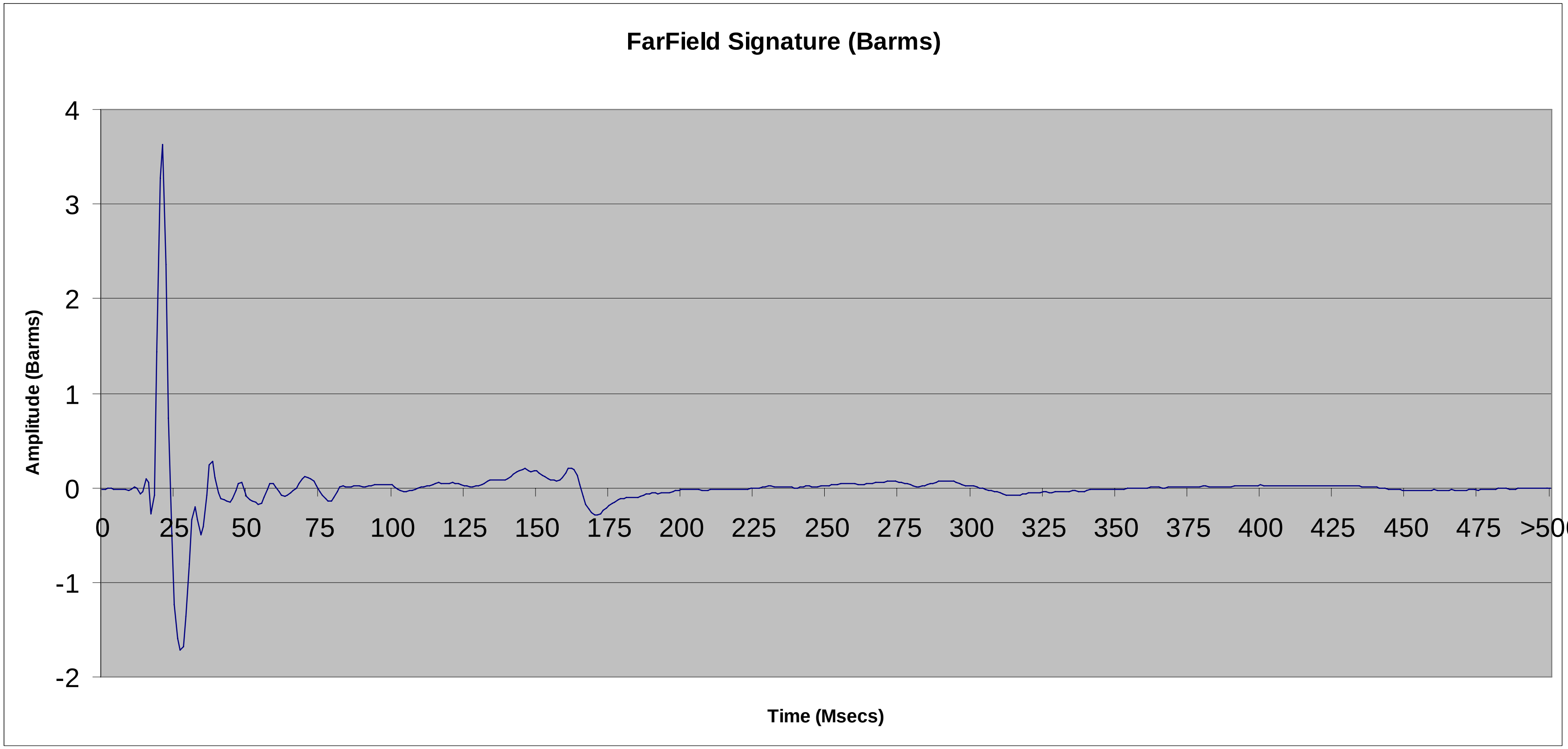
0-P Barm	4.30	P-P Barm	5.73	P/B Ratio =	14.46	Period =	141.50	Depth =	2.63	M	Power =	173.86	Db

File 2.45: 300 cu in SeaScan Tri-Cluster ® array (# 1 & 2 only) @ 10 ft



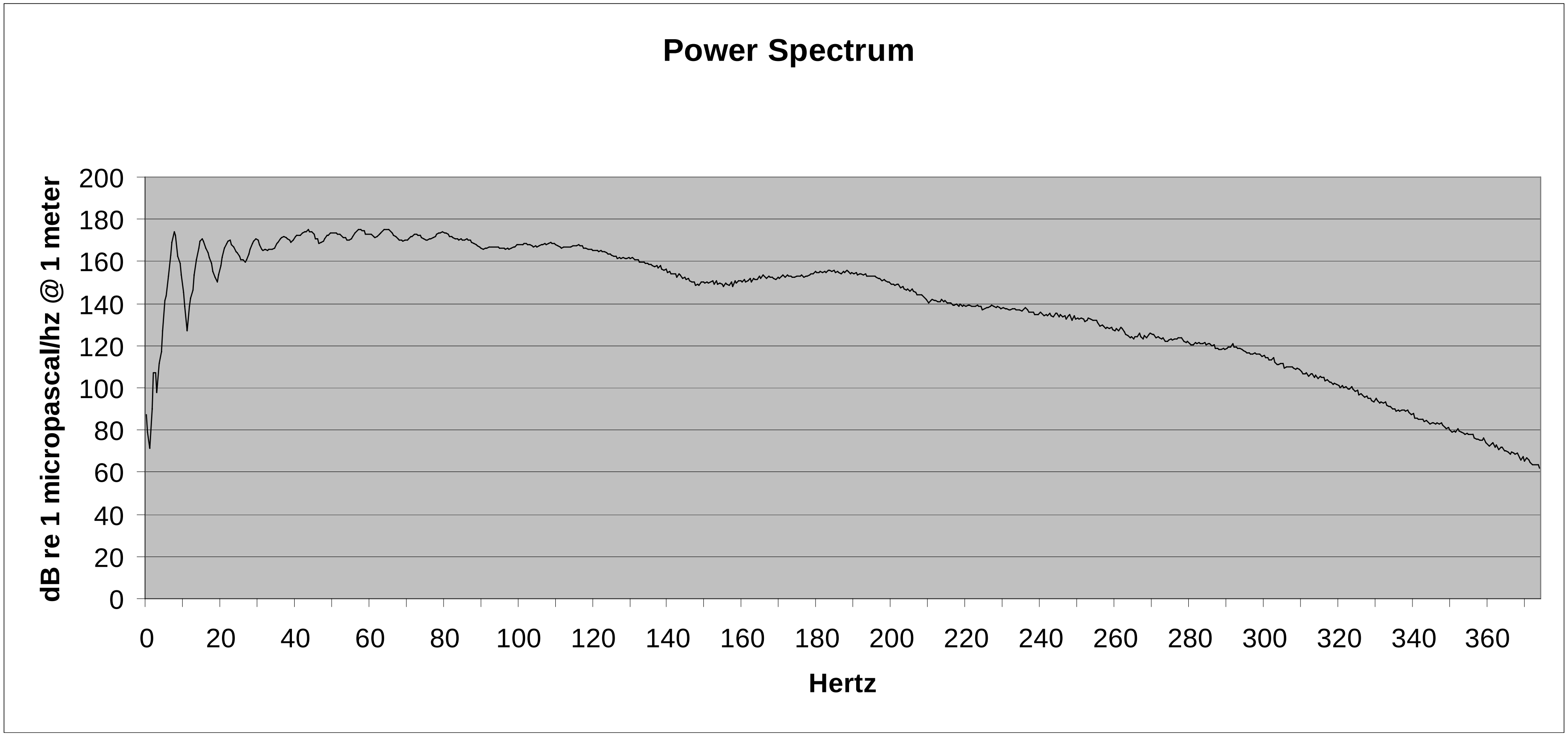
0-P Barm 4.30 P-P Barm 5.73 P/B Ratio = 14.46 Period = 141.50 Depth = 2.63 M Power = 173.86 Db

File 2.46: 300 cu in SeaScan Tri-Cluster ® array (# 1 & 2 only) @ 10 ft



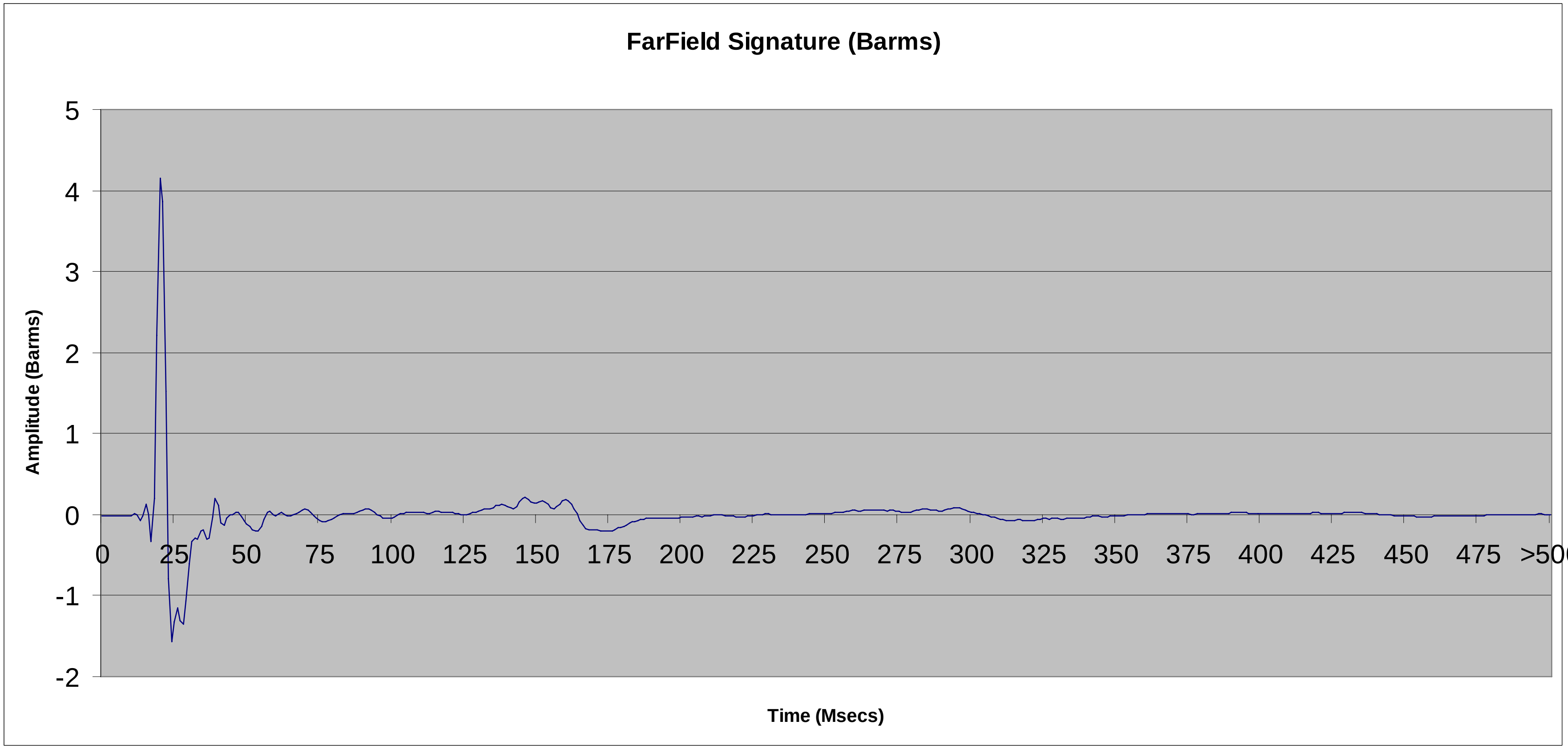
0-P Barm	3.73	P-P Barm	5.46	P/B Ratio =	10.86	Period =	141.25	Depth =	4.88	M	Power =	175.34	Db

File 2.46: 300 cu in SeaScan Tri-Cluster ® array (# 1 & 2 only) @ 10 ft



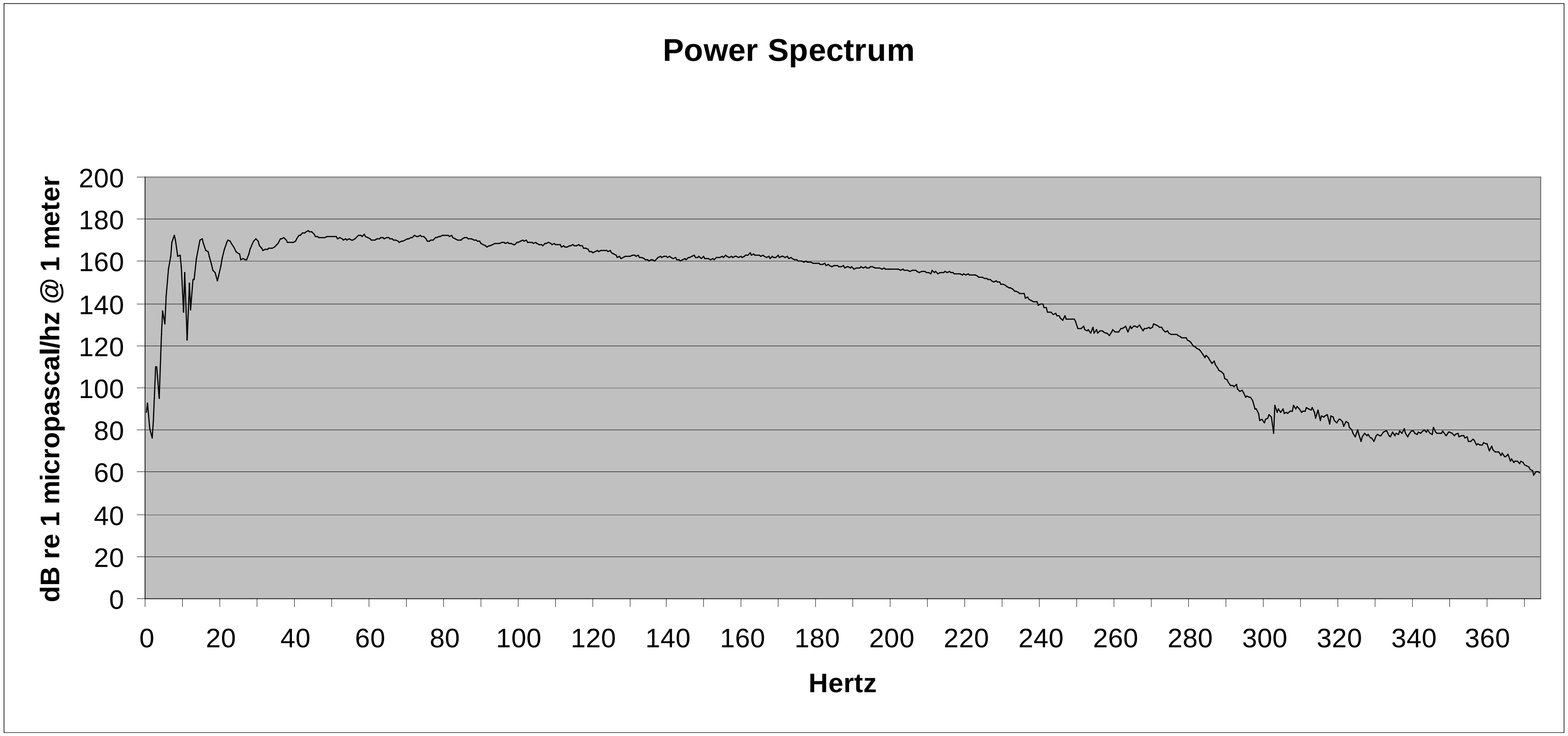
0-P Barm	3.73	P-P Barm	5.46	P/B Ratio =	10.86	Period =	141.25	Depth =	4.88	M	Power =	175.34	Db

File 2.47: 300 cu in SeaScan Tri-Cluster ® array (# 1 & 2 only) @ 10 ft



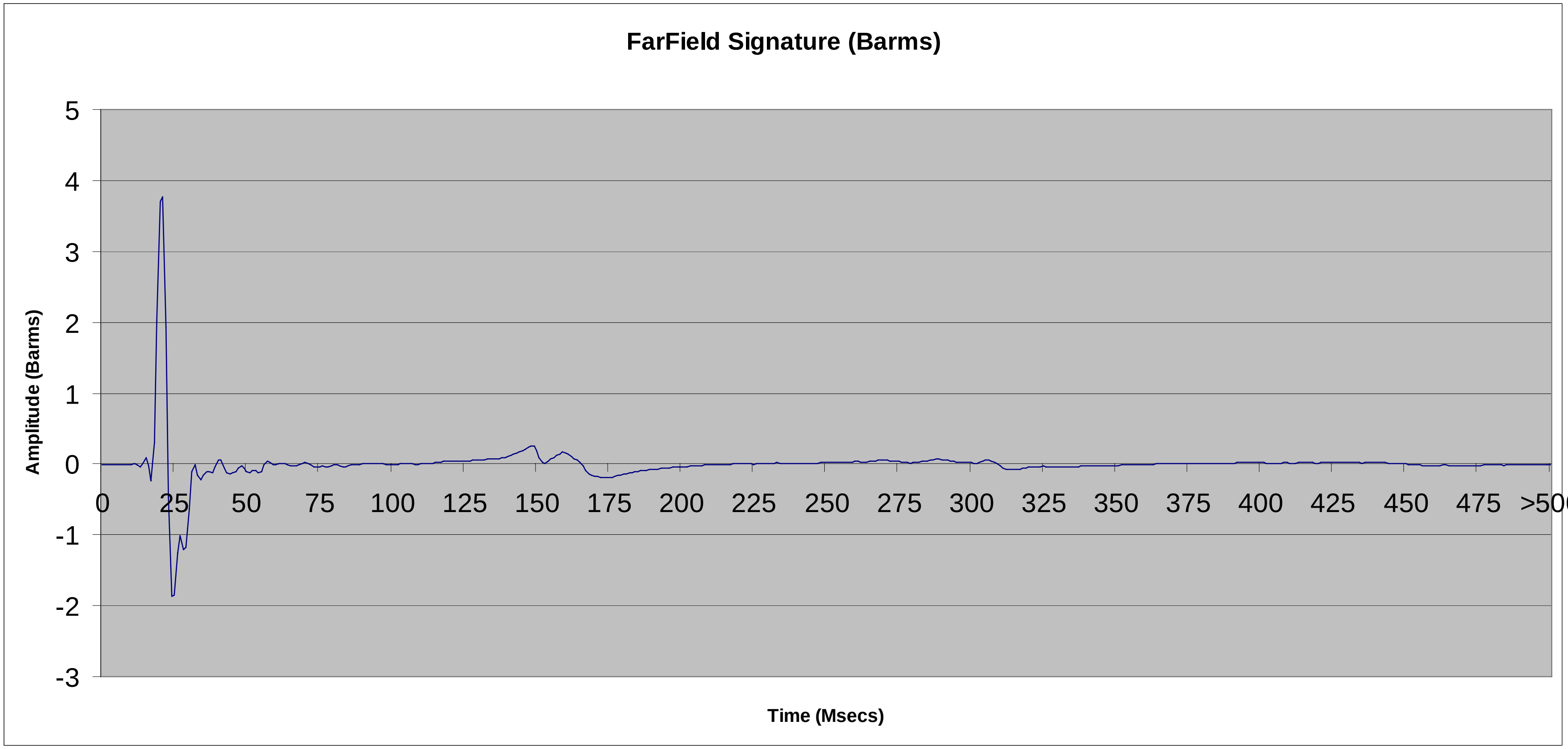
0-P Barm	4.35	P-P Barm	5.92	P/B Ratio =	14.05	Period =	125.00	Depth =	2.63	M	Power =	174.80	Db

File 2.47: 300 cu in SeaScan Tri-Cluster ® array (# 1 & 2 only) @ 10 ft



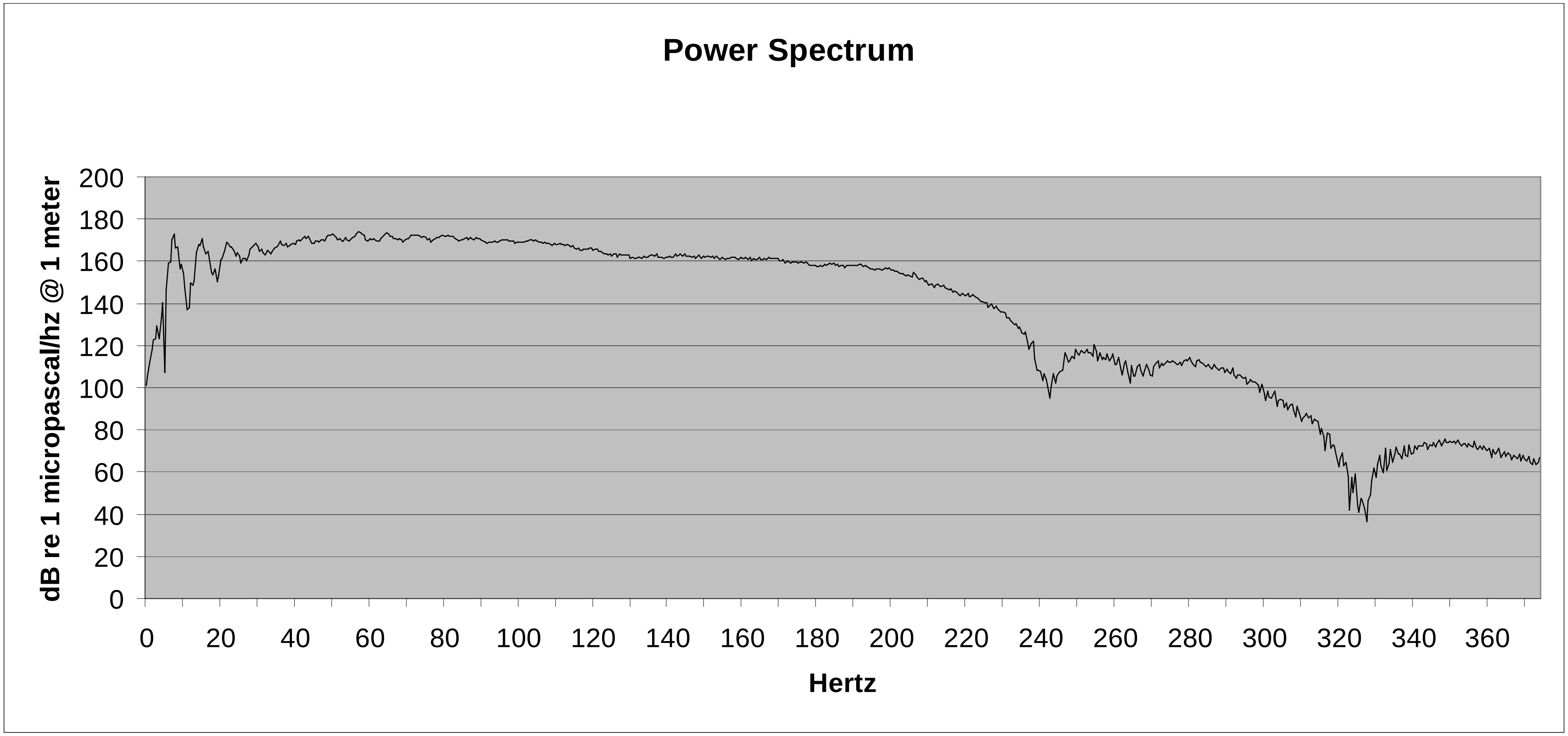
0-P Barm	4.35	P-P Barm	5.92	P/B Ratio =	14.05	Period =	125.00	Depth =	2.63	M	Power =	174.80	Db		

File 2.48: 300 cu in SeaScan Tri-Cluster ® array (# 7 & 8 only) @ 10 ft



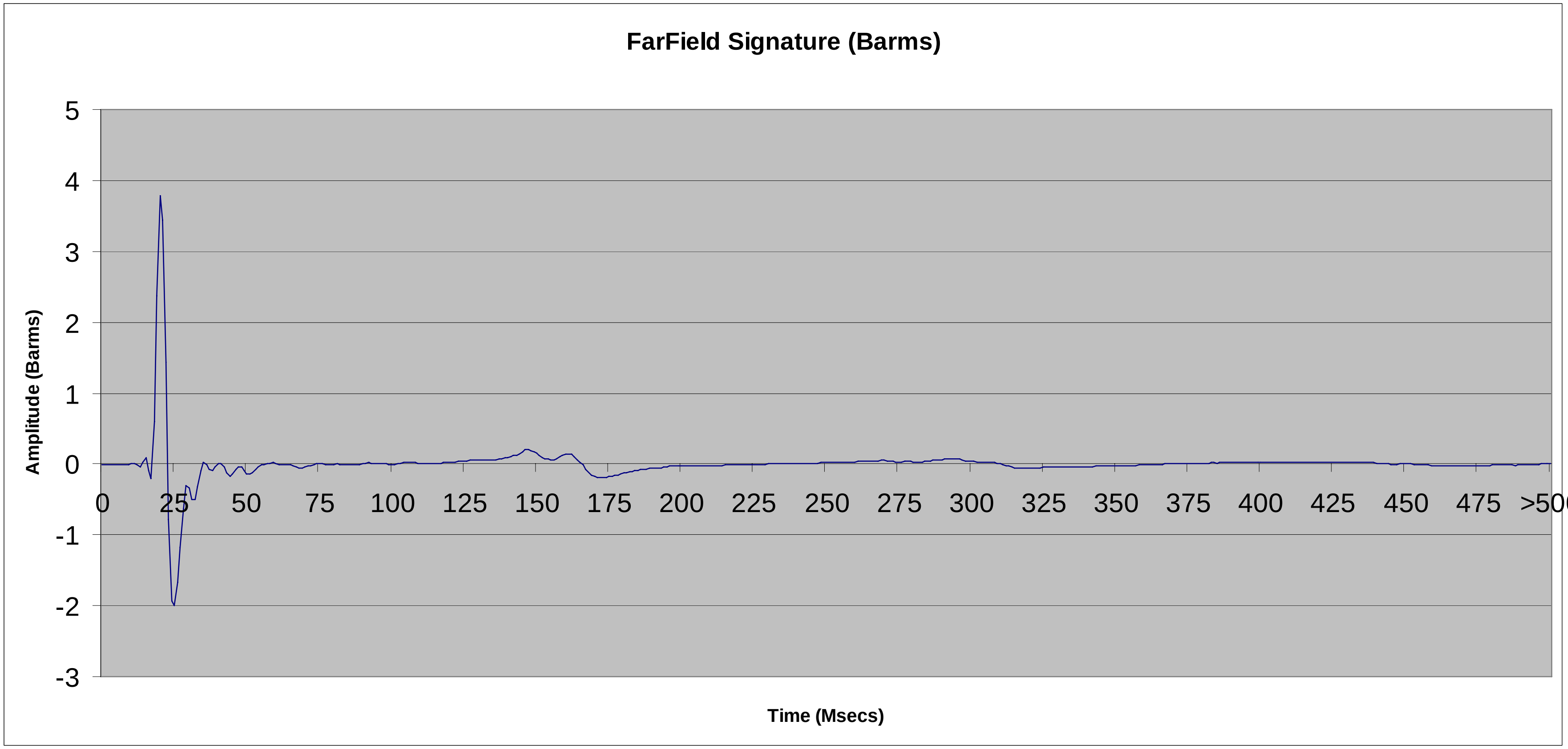
0-P Barm	4.00	P-P Barm	6.00	P/B Ratio =	13.18	Period =	127.75	Depth =	3.00	M	Power =	174.20	Db

File 2.48: 300 cu in SeaScan Tri-Cluster ® array (# 7 & 8 only) @ 10 ft



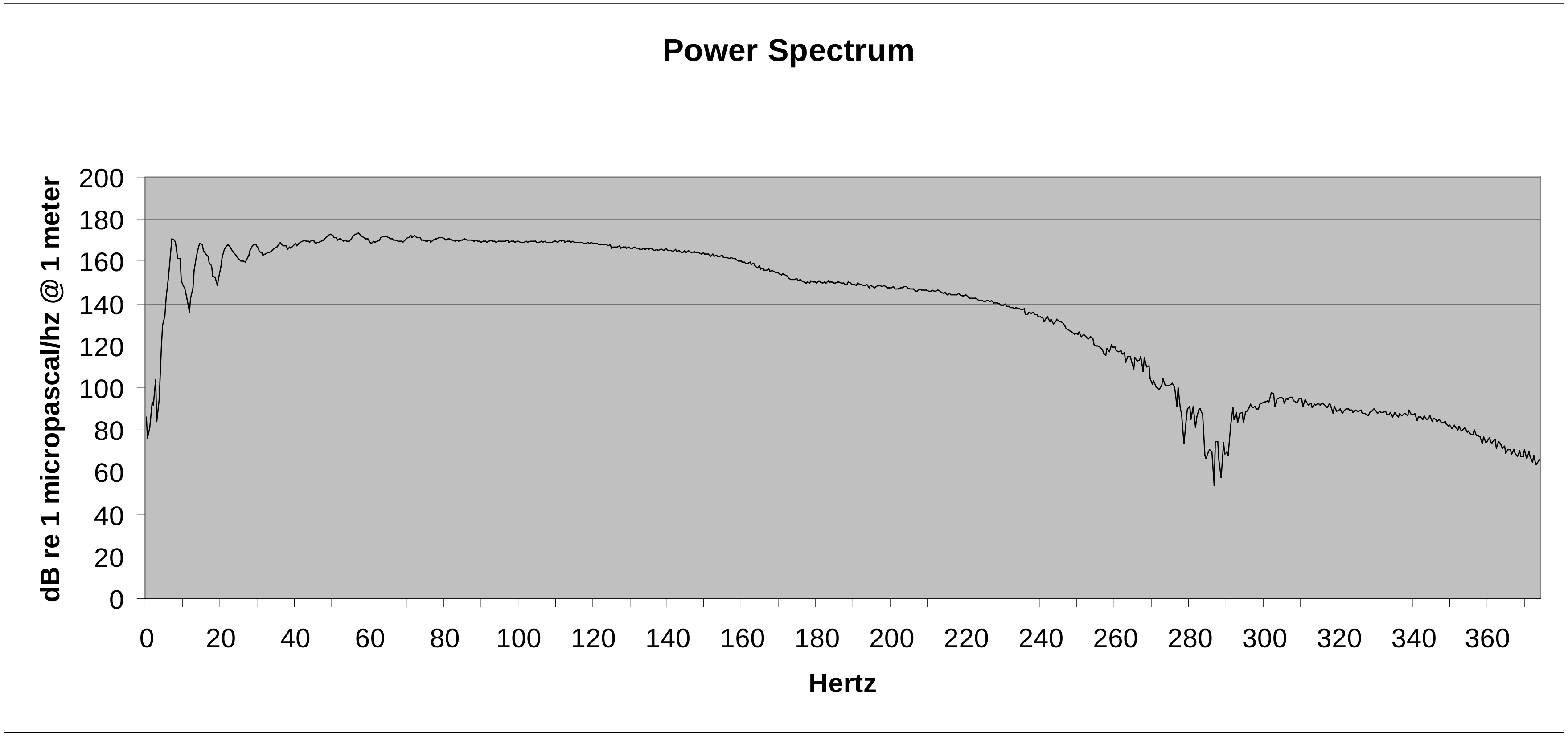
0-P Barm	4.00	P-P Barm	6.00	P/B Ratio =	13.18	Period =	127.75	Depth =	3.00	M	Power =	174.20	Db

File 2.51: 300 cu in SeaScan Tri-Cluster ® array (# 7 & 8 only) @ 10 ft



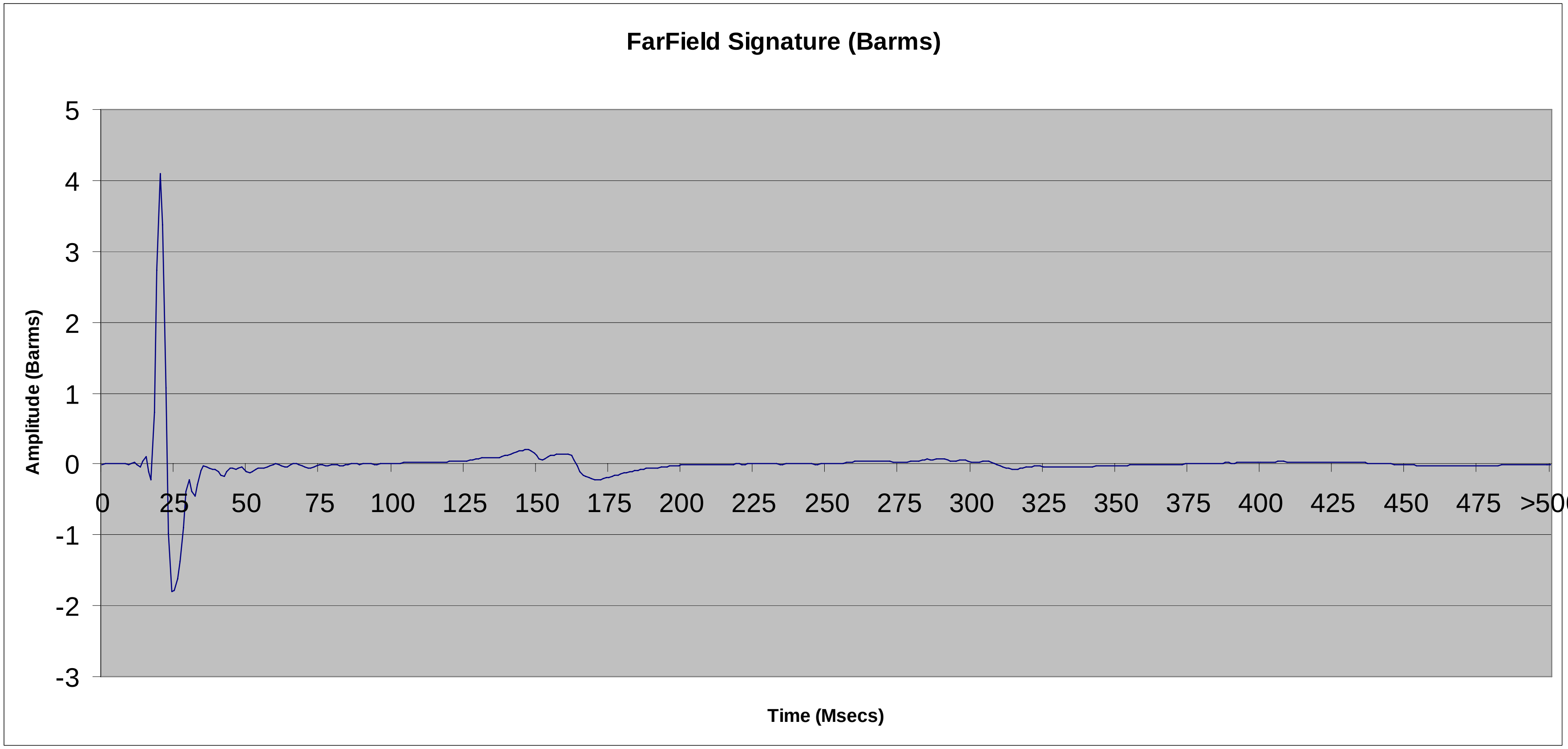
0-P Barm 3.89 P-P Barm 5.95 P/B Ratio = 14.59 Period = 126.50 Depth = 3.19 M Power = 173.28 Db

File 2.51: 300 cu in SeaScan Tri-Cluster ® array (# 7 & 8 only) @ 10 ft



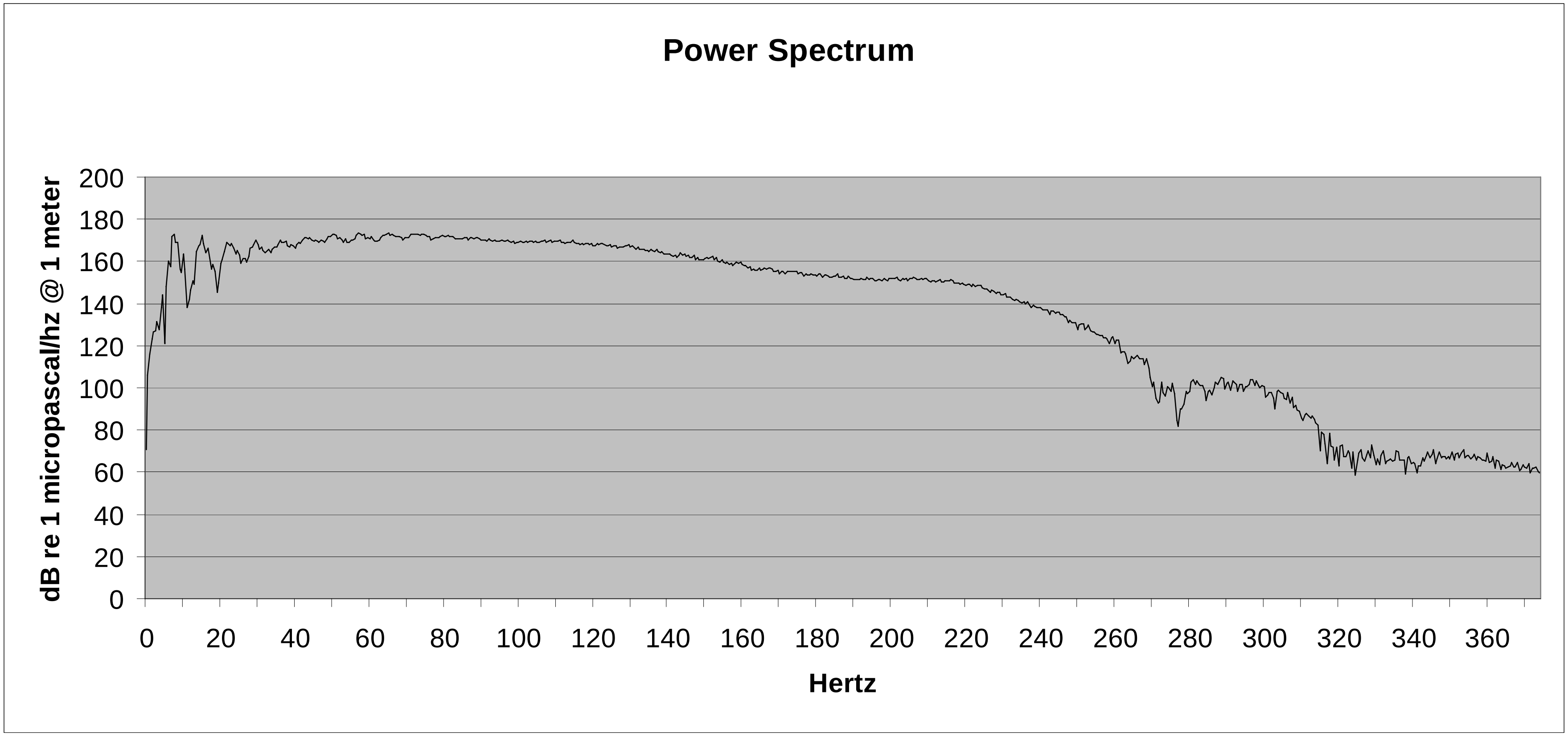
0-P Barm 3.89 P-P Barm 5.95 P/B Ratio = 14.59 Period = 126.50 Depth = 3.19 M Power = 173.28 Db

File 2.52: 300 cu in SeaScan Tri-Cluster ® array (# 7 & 8 only) @ 10 ft



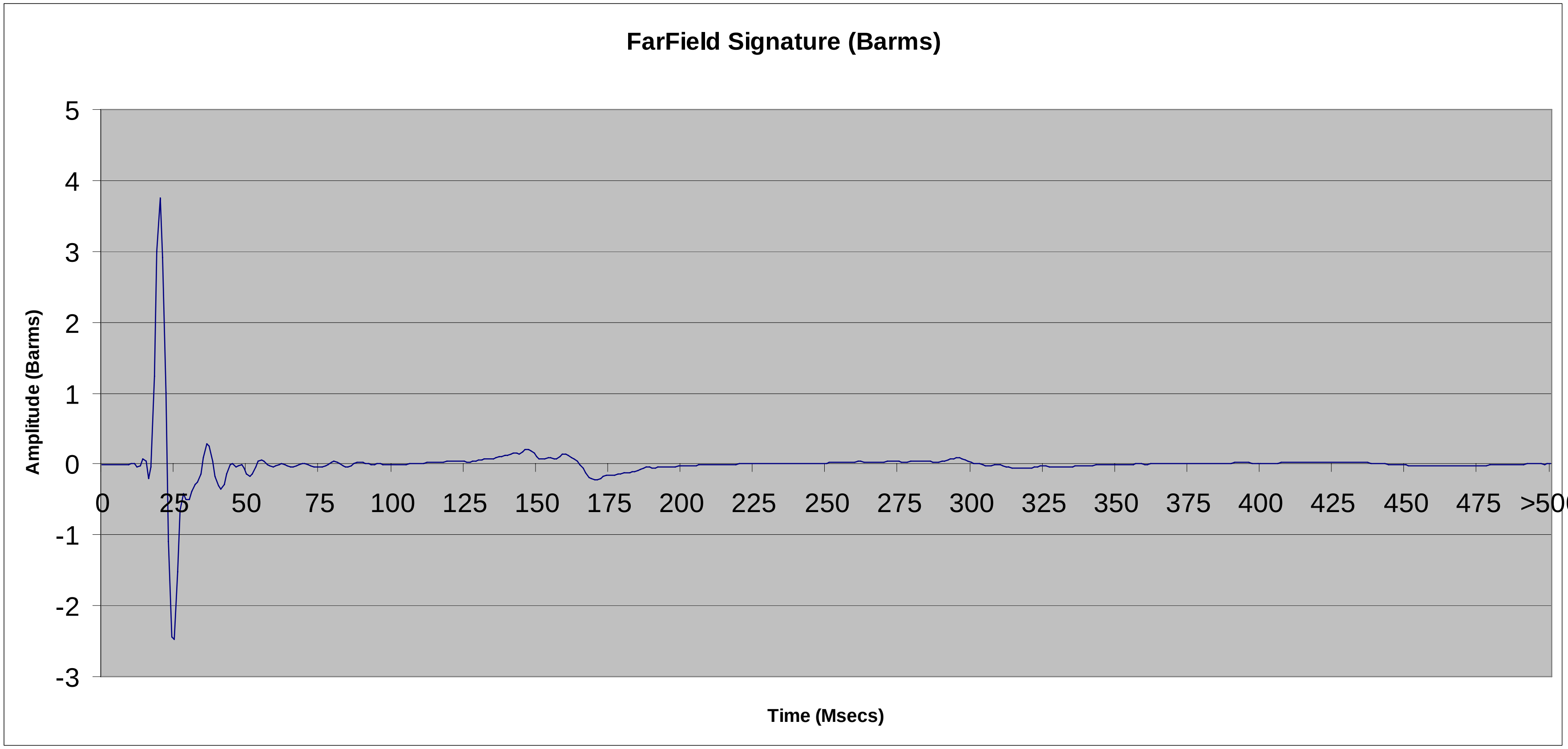
0-P Barm	4.12	P-P Barm	5.97	P/B Ratio =	13.79	Period =	126.50	Depth =	3.00	M	Power =	173.36	Db

File 2.52: 300 cu in SeaScan Tri-Cluster ® array (# 7 & 8 only) @ 10 ft



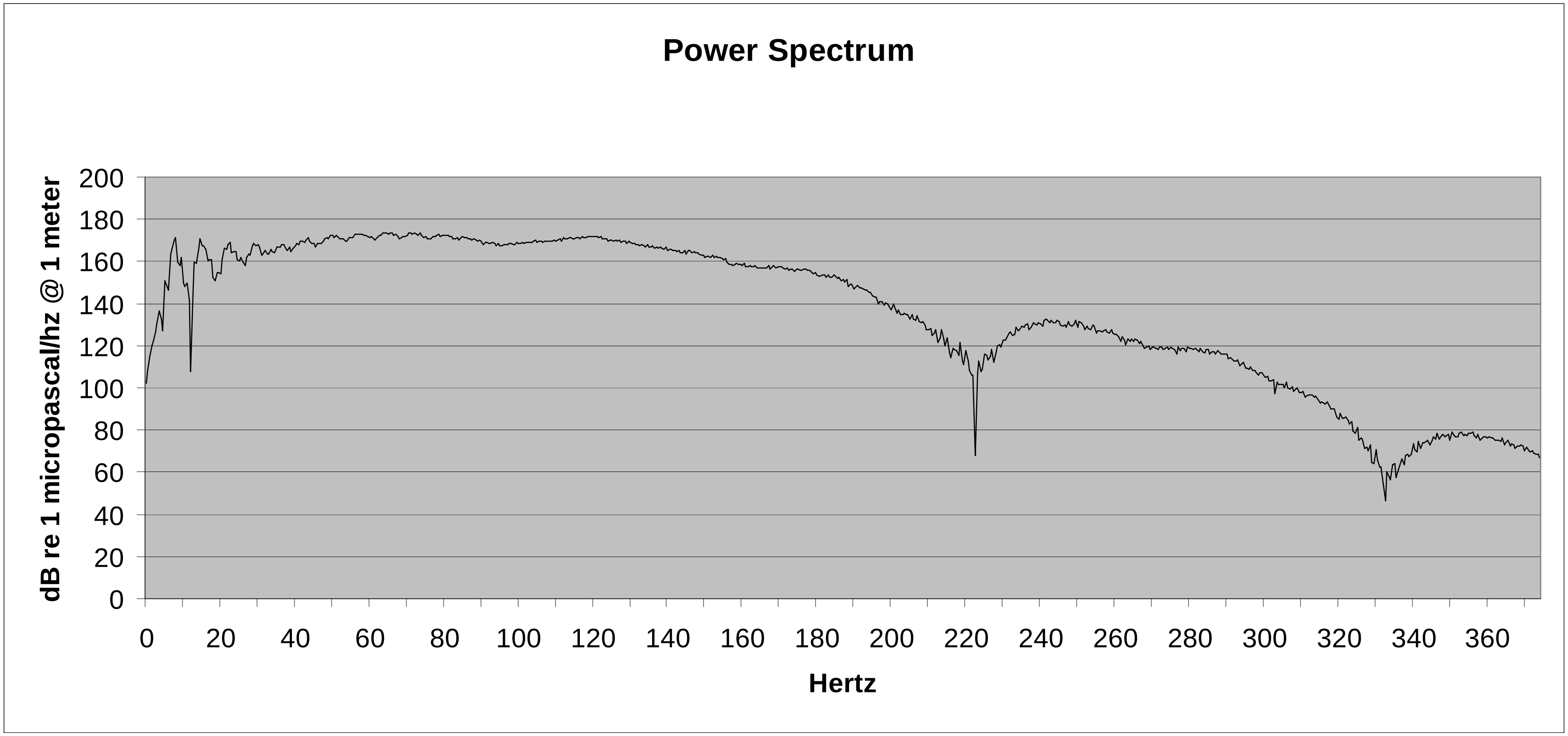
0-P Barm 4.12 P-P Barm 5.97 P/B Ratio = 13.79 Period = 126.50 Depth = 3.00 M Power = 173.36 Db

File 2.53: 300 cu in SeaScan Tri-Cluster ® array (# 7 & 8 only) @ 10 ft



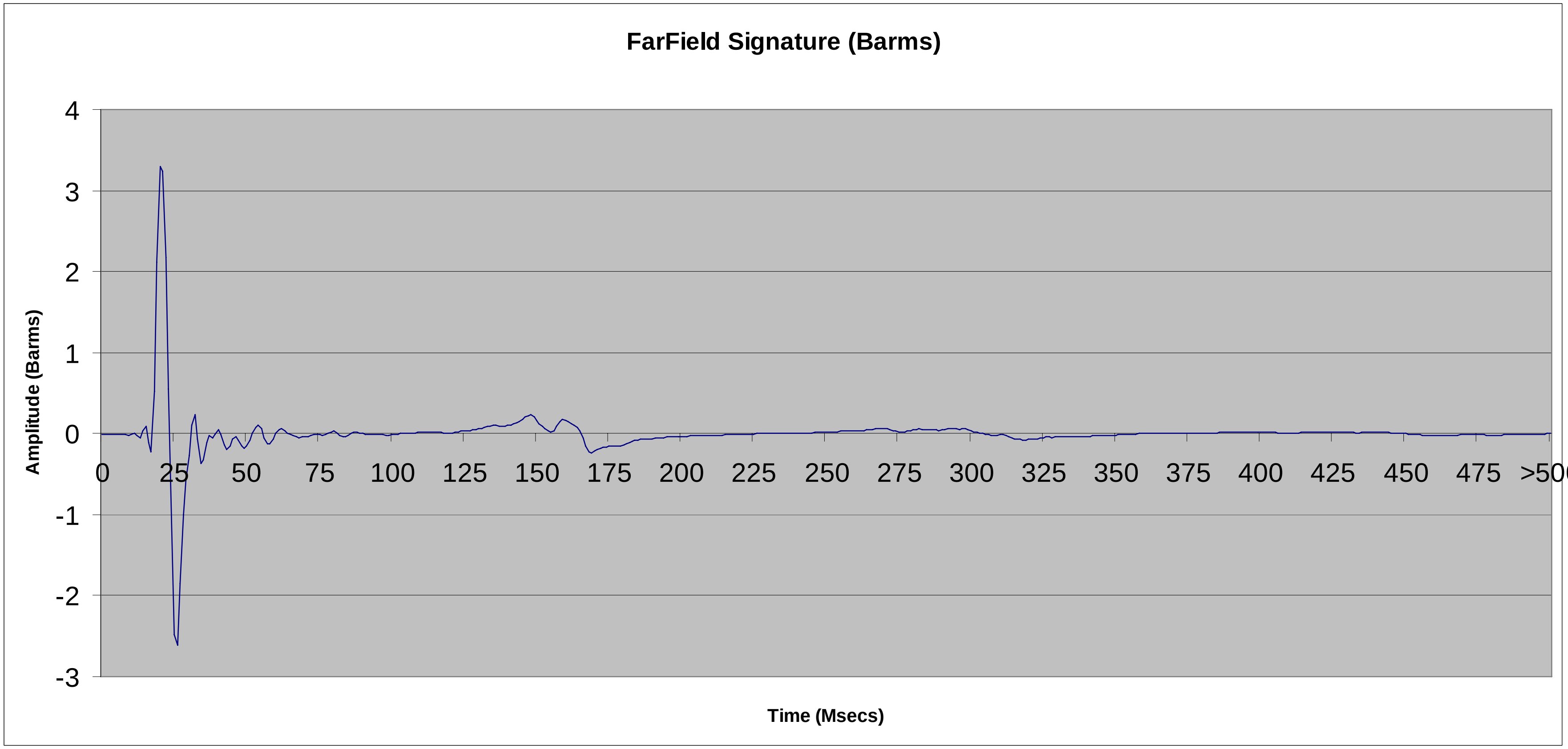
0-P Barm	3.76	P-P Barm	6.38	P/B Ratio =	14.61	Period =	127.00	Depth =	3.38	M	Power =	173.62	Db

File 2.53: 300 cu in SeaScan Tri-Cluster ® array (# 7 & 8 only) @ 10 ft



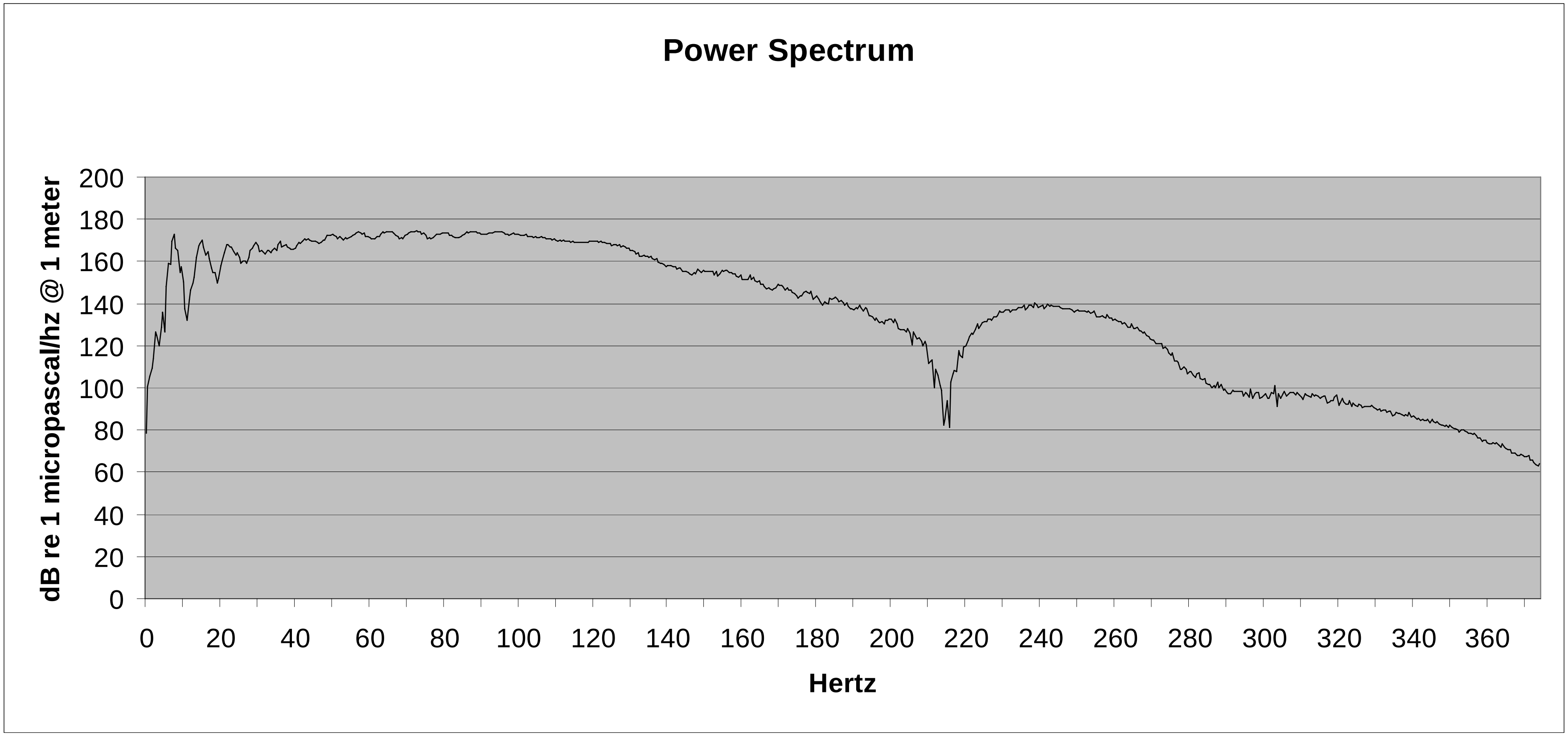
0-P Barm	3.76	P-P Barm	6.38	P/B Ratio =	14.61	Period =	127.00	Depth =	3.38	M	Power =	173.62	Db

File 2.54: 300 cu in SeaScan Tri-Cluster ® array (# 7 & 8 only) @ 10 ft



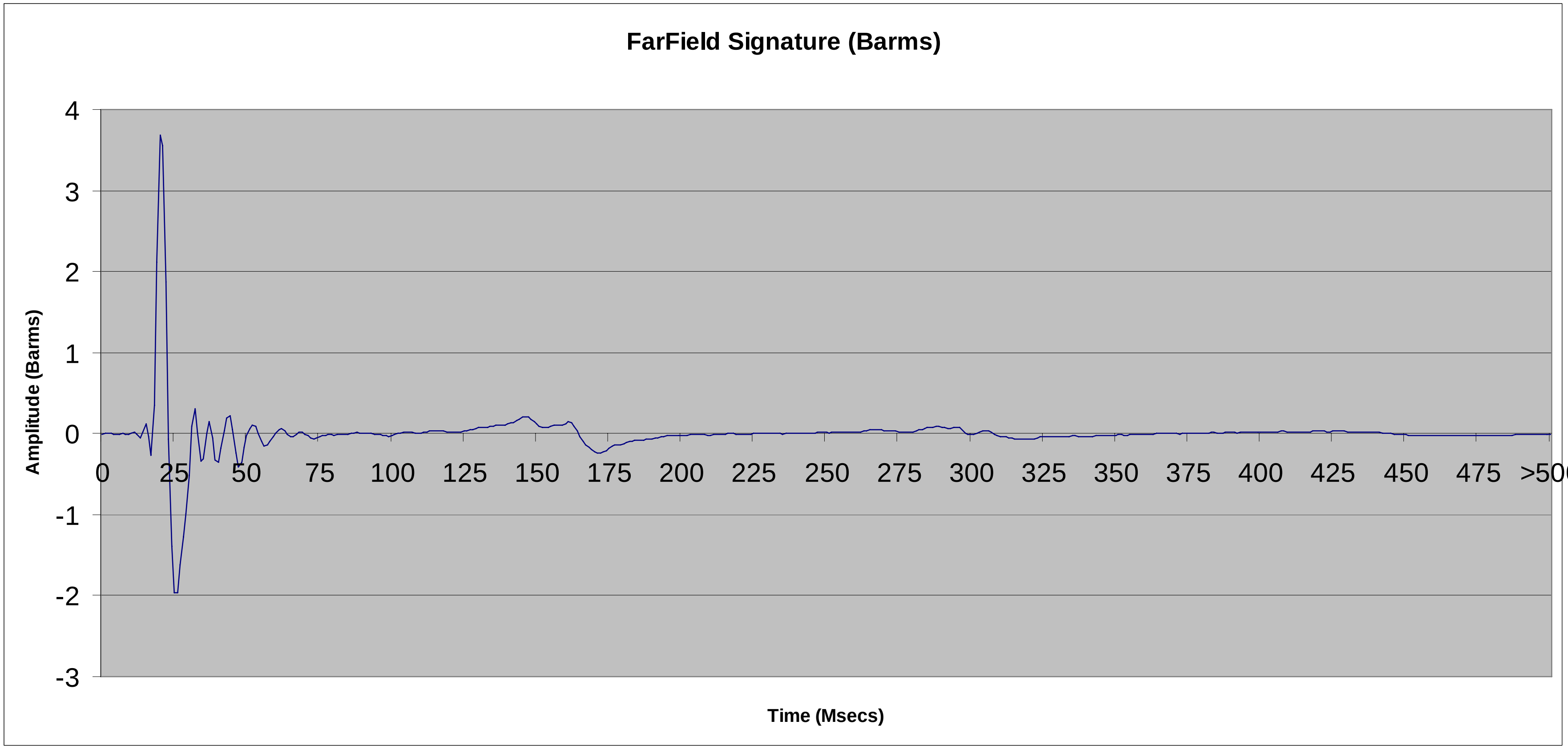
0-P Barm	3.43	P-P Barm	6.12	P/B Ratio =	13.12	Period =	127.25	Depth =	3.75	M	Power =	174.46	Db

File 2.54: 300 cu in SeaScan Tri-Cluster ® array (# 7 & 8 only) @ 10 ft



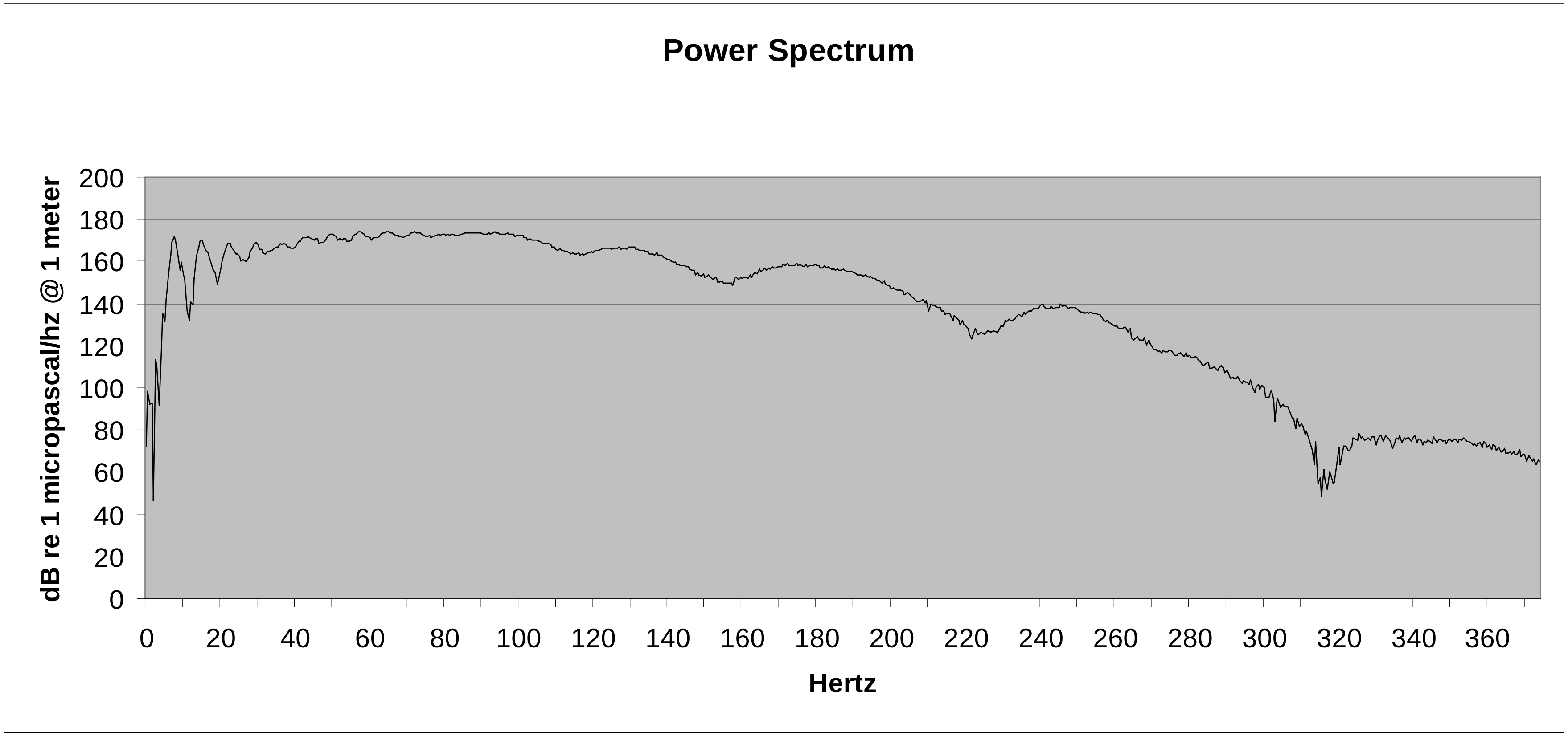
0-P Barm	3.43	P-P Barm	6.12	P/B Ratio =	13.12	Period =	127.25	Depth =	3.75	M	Power =	174.46	Db

File 2.55: 150 cu in SeaScan Tri-Cluster ® array (# 8 only) @ 10 ft



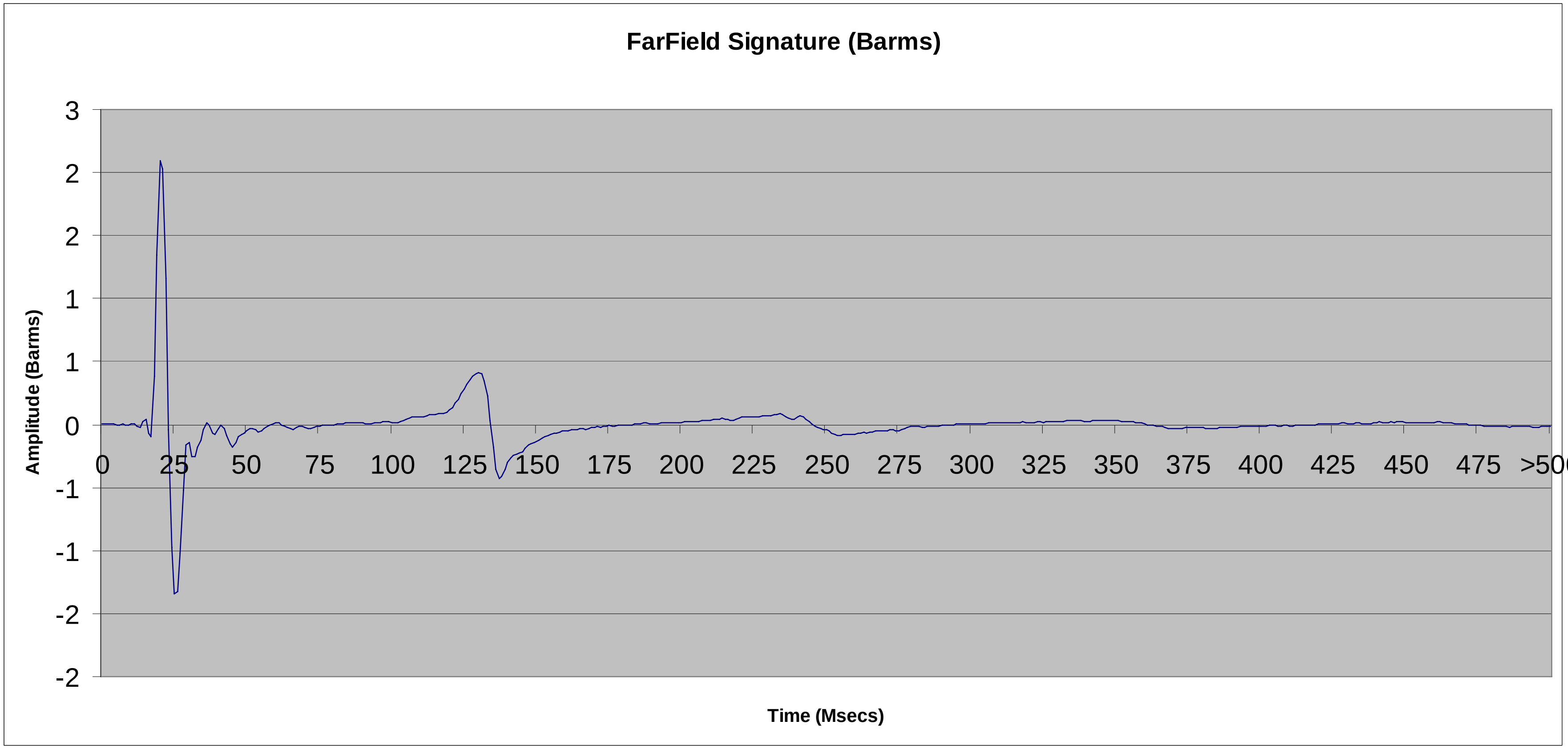
0-P Barm	3.87	P-P Barm	5.89	P/B Ratio =	13.11	Period =	125.50	Depth =	3.75	M	Power =	174.14	Db

File 2.55: 150 cu in SeaScan Tri-Cluster ® array (# 8 only) @ 10 ft



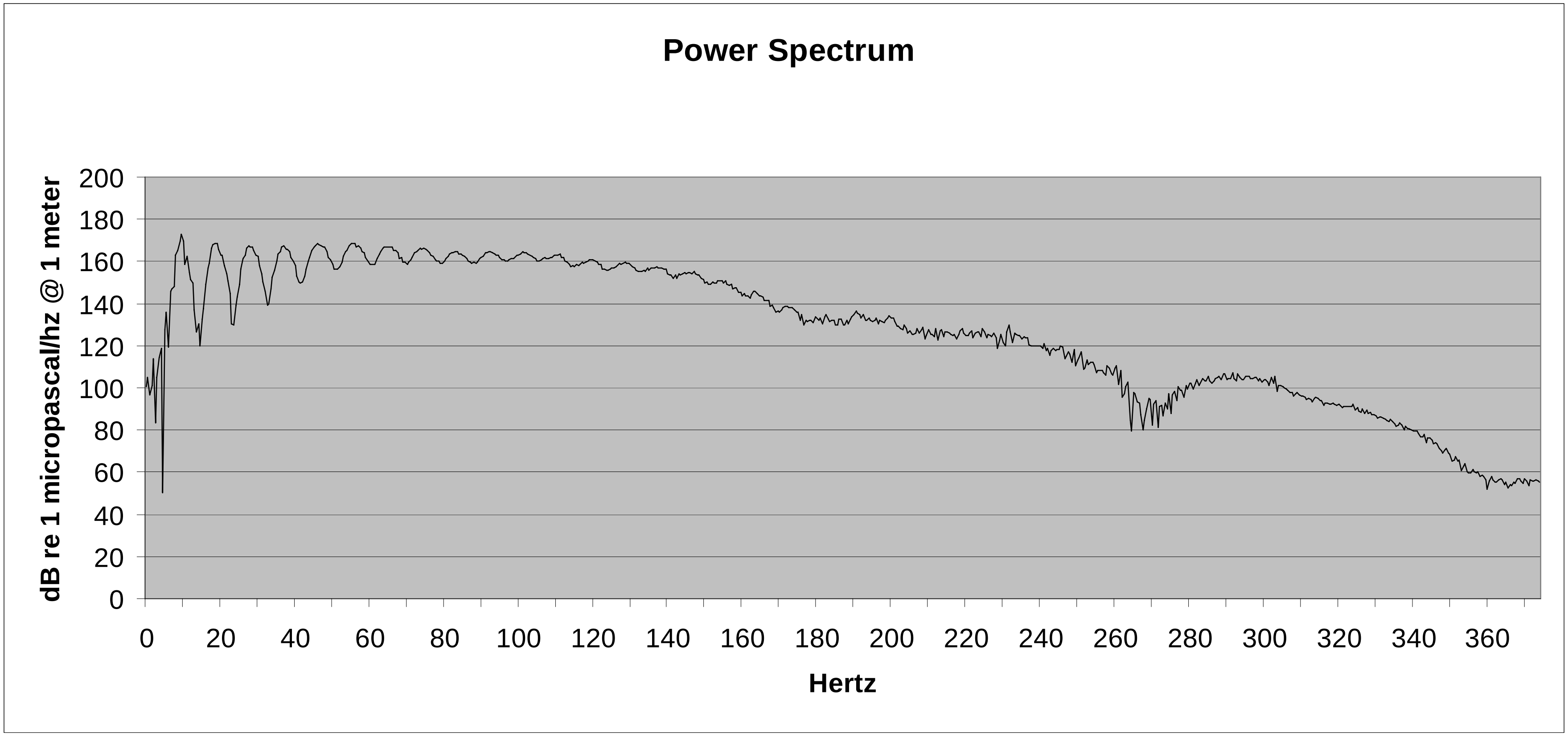
0-P Barm 3.87 P-P Barm 5.89 P/B Ratio = 13.11 Period = 125.50 Depth = 3.75 M Power = 174.14 Db

File 2.56: 150 cu in SeaScan Tri-Cluster ® array (# 8 only) @ 10 ft



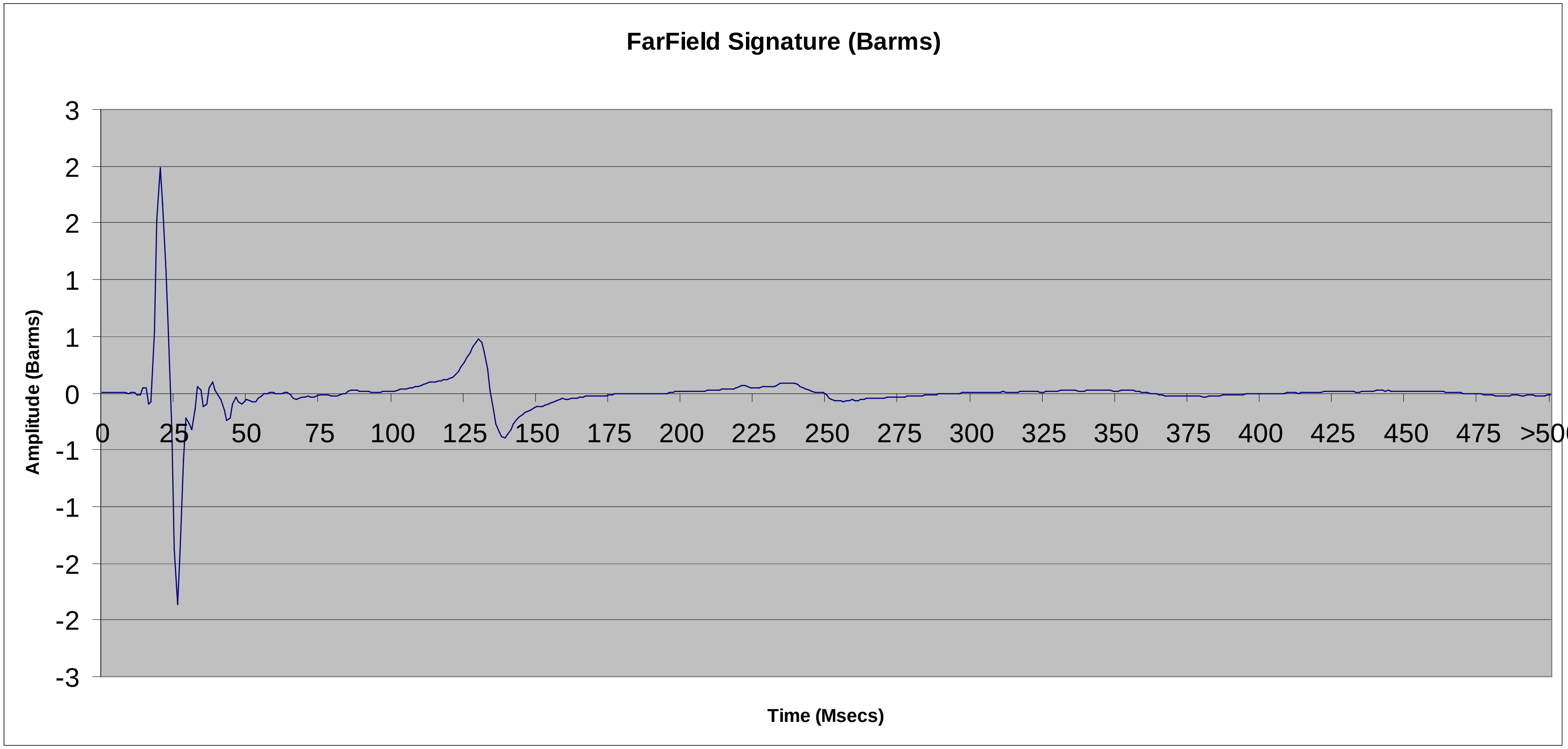
0-P Barm	2.17	P-P Barm	3.55	P/B Ratio =	4.23	Period =	109.50	Depth =	3.75	M	Power =	173.03	Db

File 2.56: 150 cu in SeaScan Tri-Cluster ® array (# 8 only) @ 10 ft



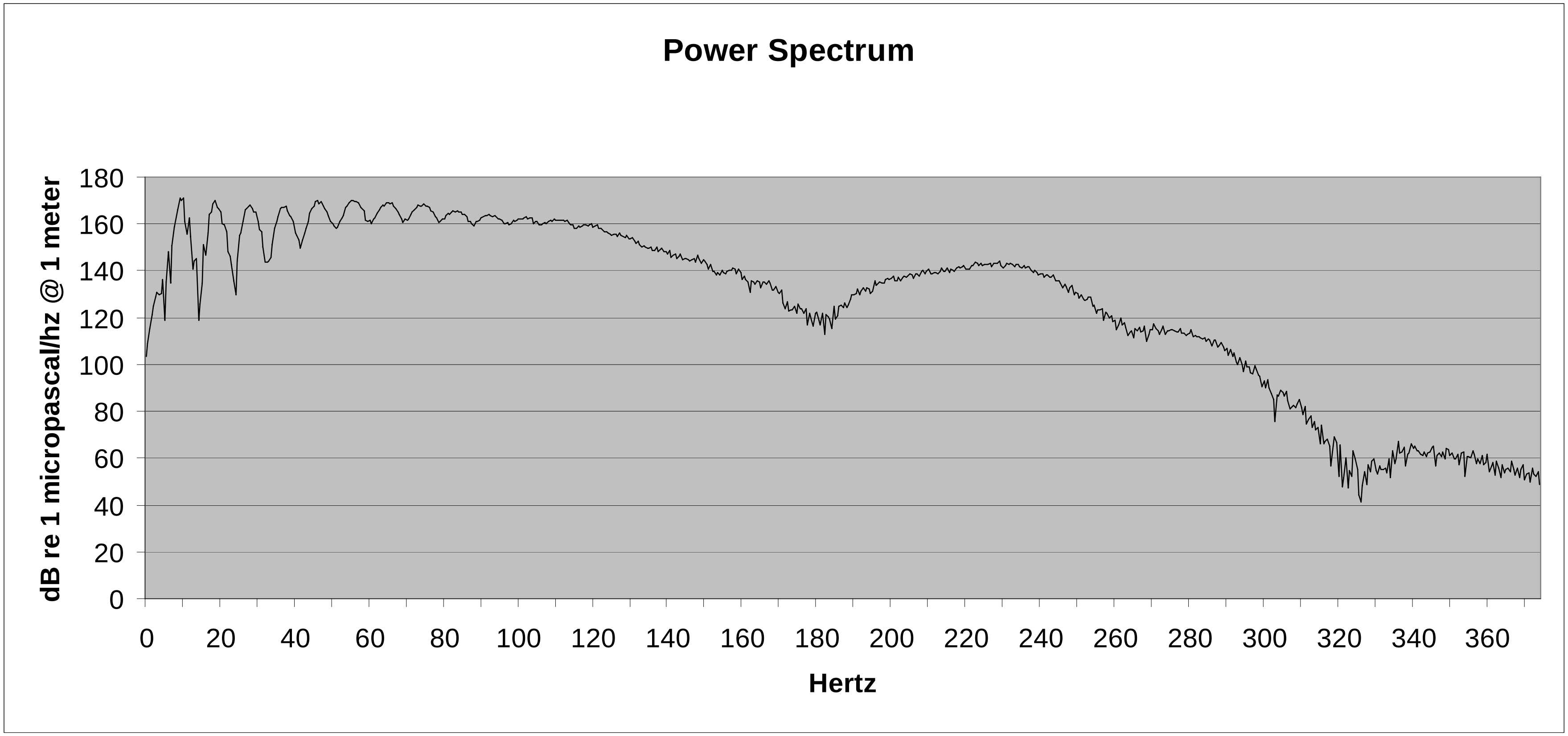
0-P Barm	2.17	P-P Barm	3.55	P/B Ratio =	4.23	Period =	109.50	Depth =	3.75	M	Power =	173.03	Db

File 2.57: 150 cu in SeaScan Tri-Cluster ® array (# 8 only) @ 10 ft



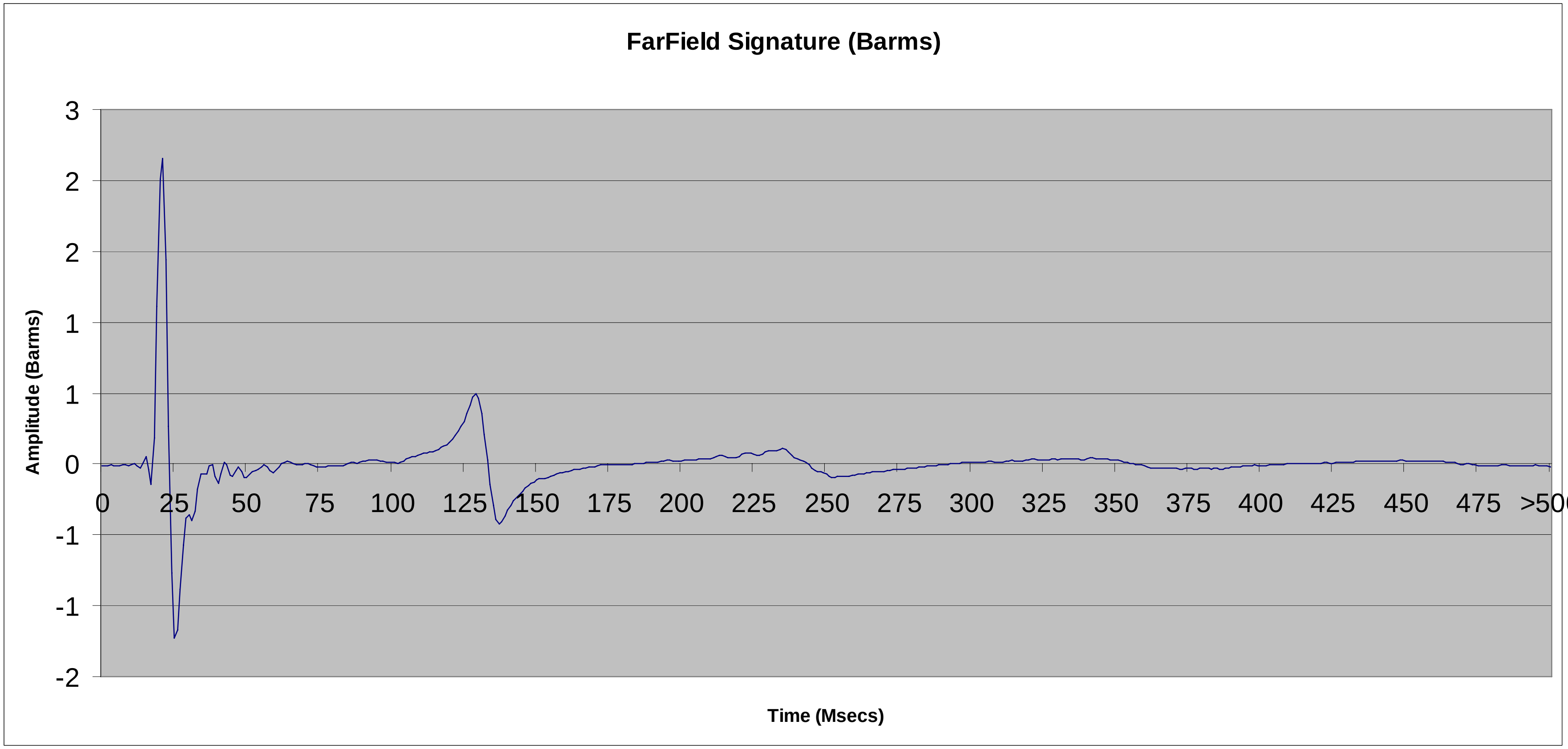
0-P Barm 1.99 P-P Barm 3.85 P/B Ratio = 4.44 Period = 110.00 Depth = 4.50 M Power = 171.22 Db

File 2.57: 150 cu in SeaScan Tri-Cluster ® array (# 8 only) @ 10 ft



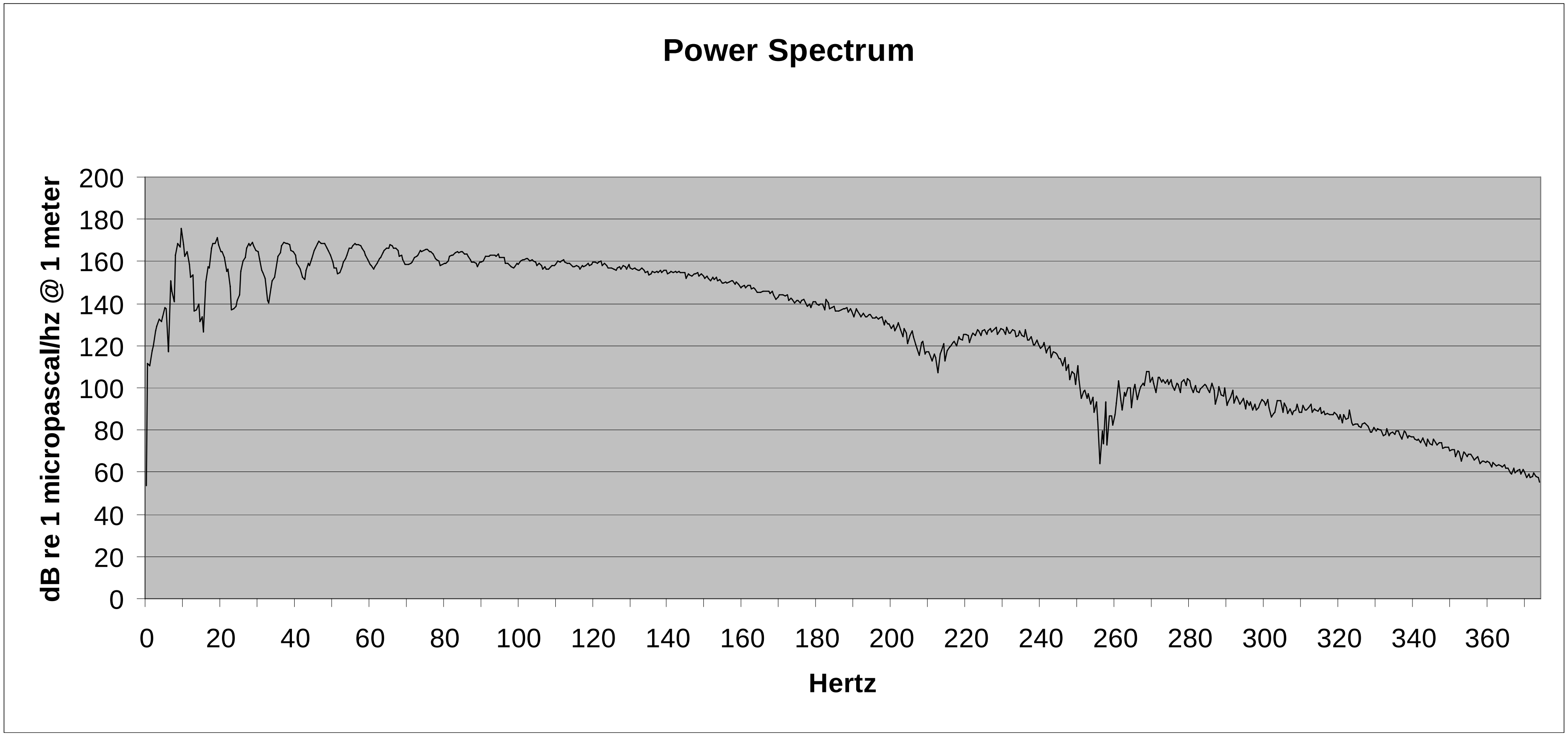
0-P Barm 1.99 P-P Barm 3.85 P/B Ratio = 4.44 Period = 110.00 Depth = 4.50 M Power = 171.22 Db

File 2.58: 150 cu in SeaScan Tri-Cluster ® array (# 8 only) @ 10 ft



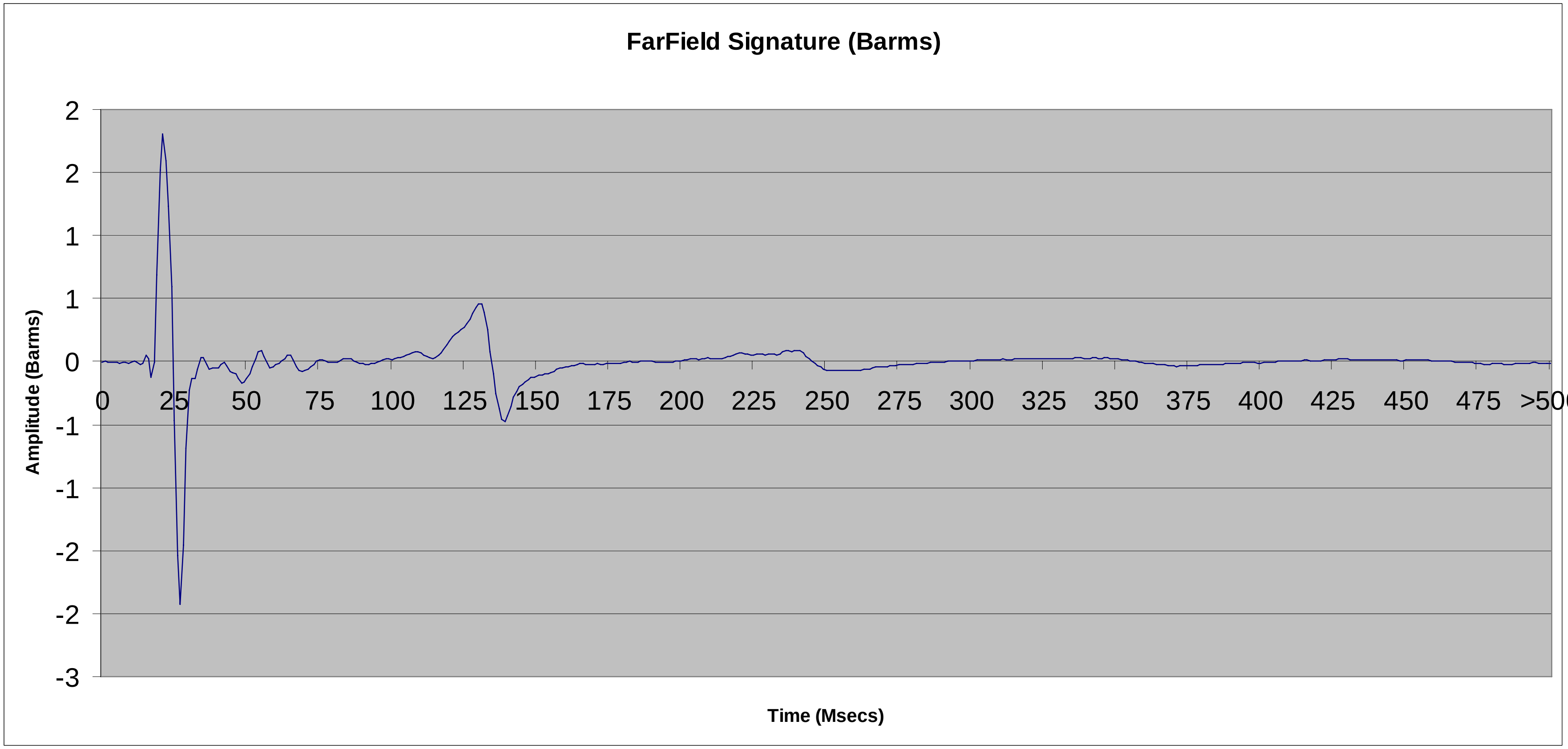
0-P Barm	2.20	P-P Barm	3.45	P/B Ratio =	3.76	Period =	108.25	Depth =	3.38	M	Power =	175.44	Db

File 2.58: 150 cu in SeaScan Tri-Cluster ® array (# 8 only) @ 10 ft



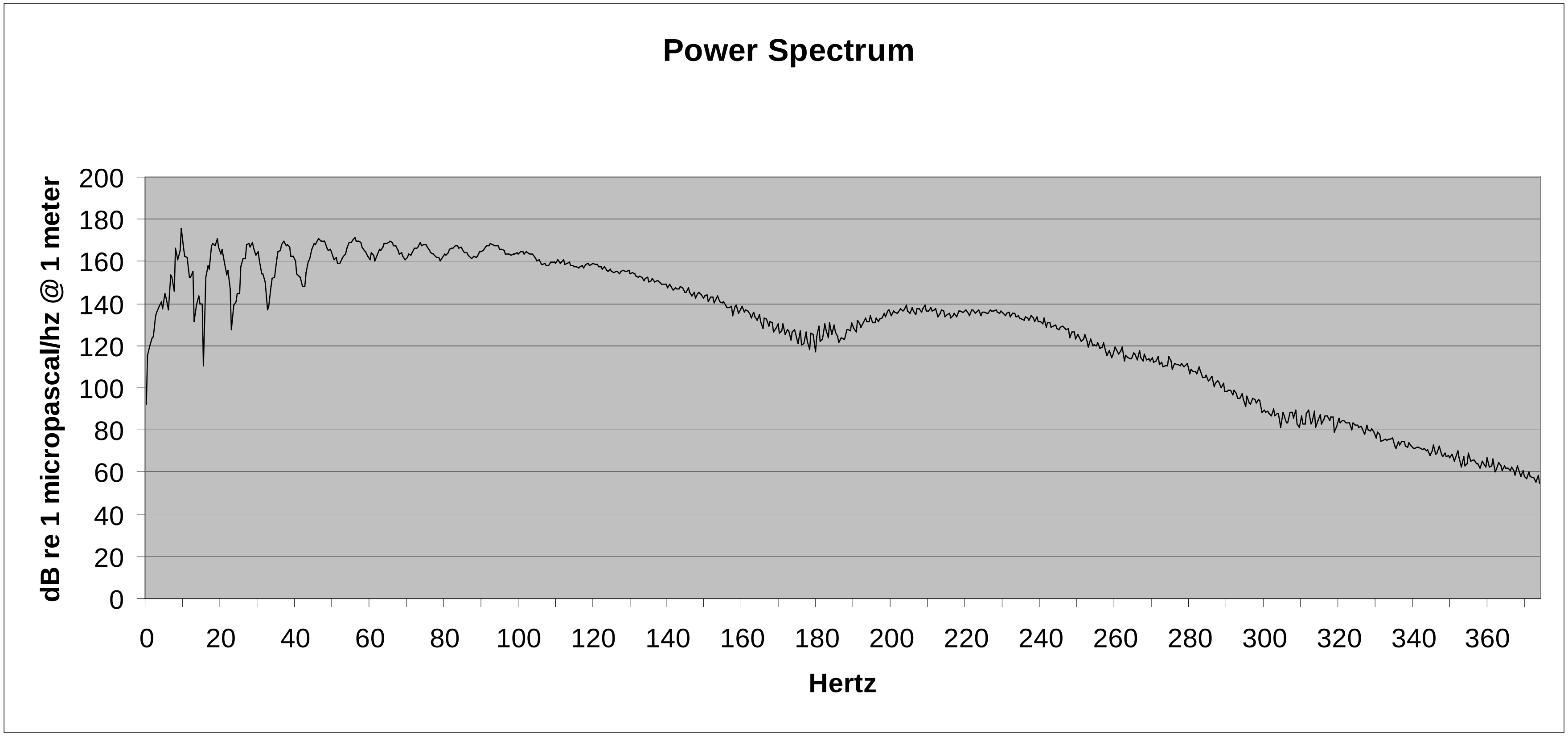
0-P Barm	2.20	P-P Barm	3.45	P/B Ratio =	3.76	Period =	108.25	Depth =	3.38	M	Power =	175.44	Db

File 2.59: 150 cu in SeaScan Tri-Cluster ® array (# 8 only) @ 10 ft



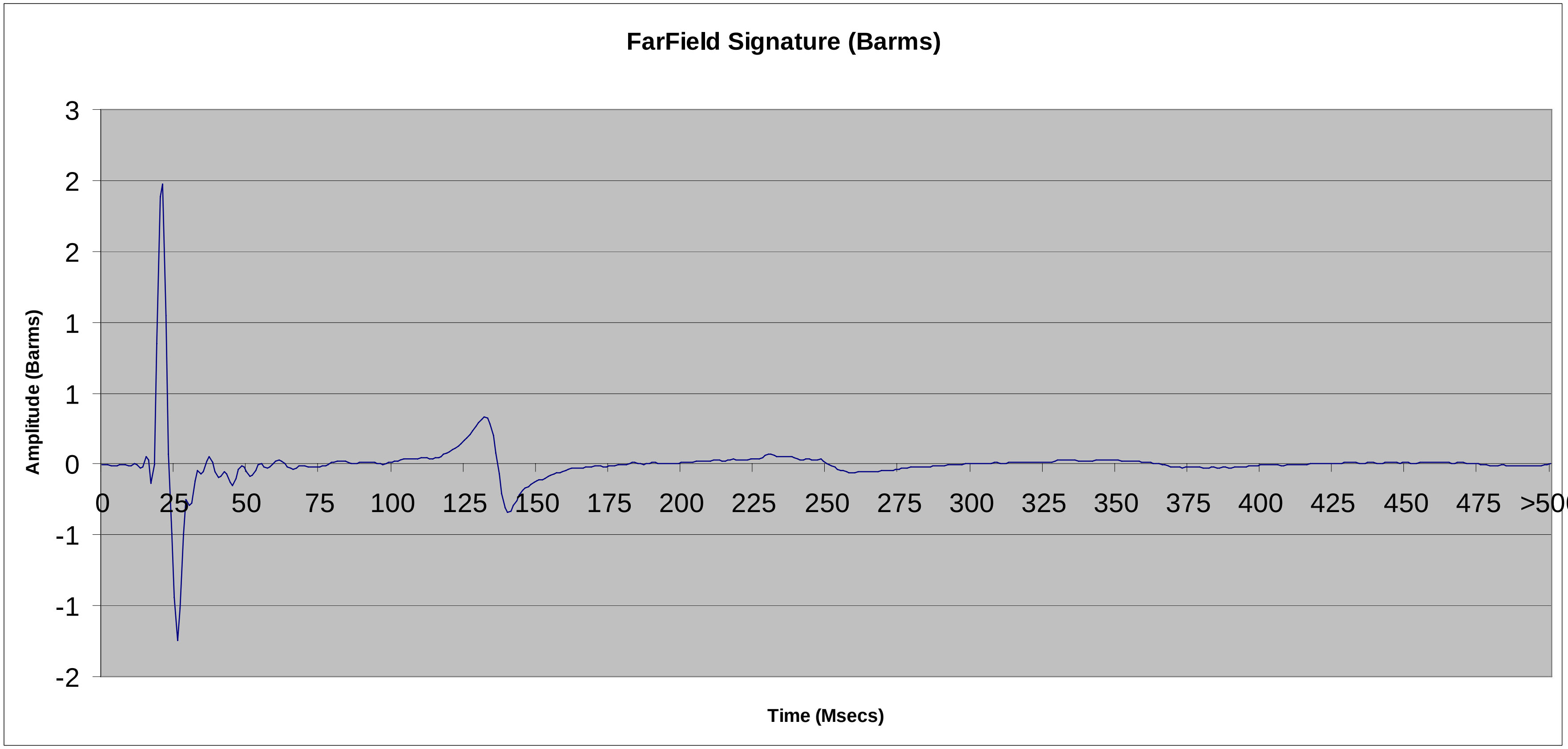
0-P Barm	1.81	P-P Barm	3.74	P/B Ratio =	3.98	Period =	109.50	Depth =	4.50	M	Power =	175.58	Db

File 2.59: 150 cu in SeaScan Tri-Cluster ® array (# 8 only) @ 10 ft



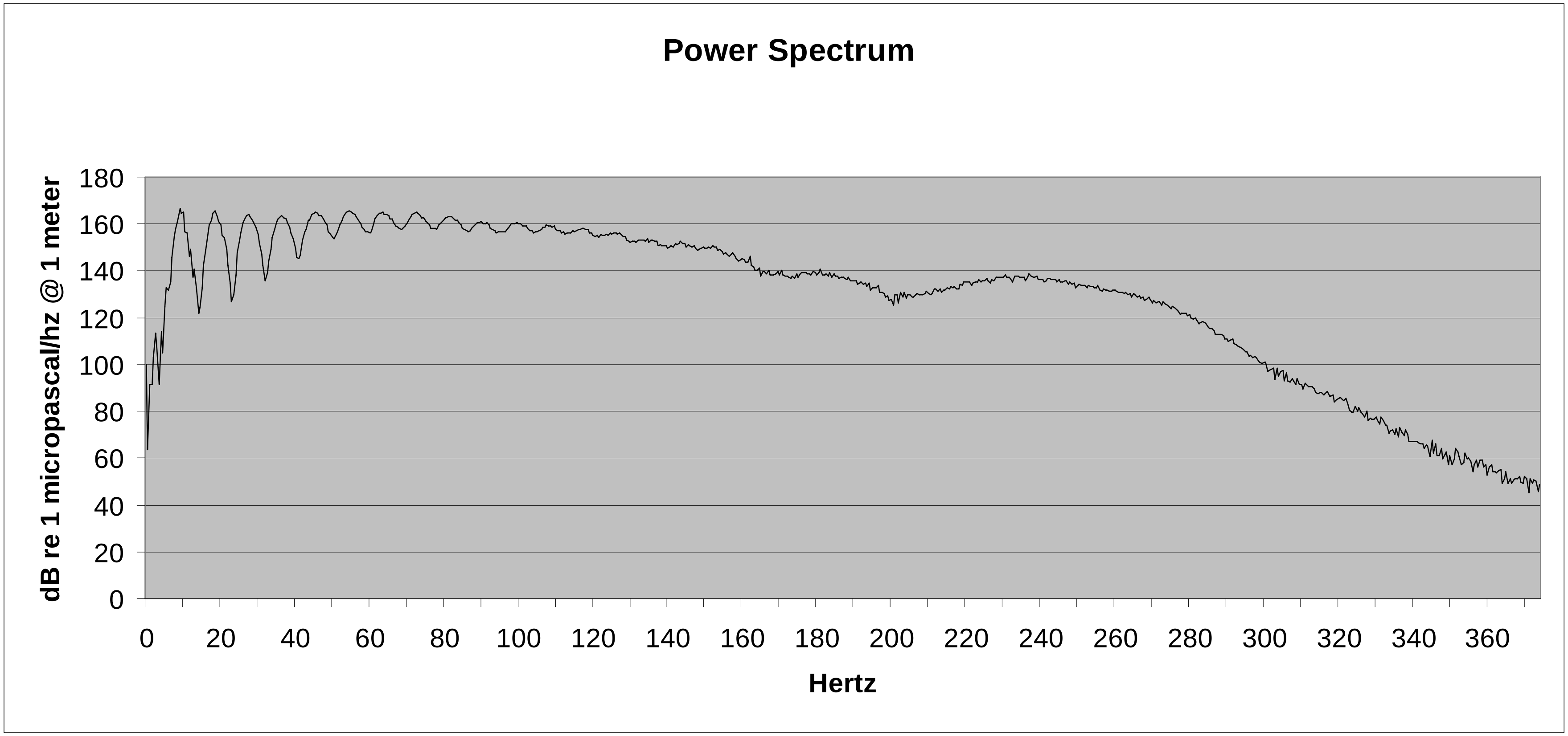
0-P Barm 1.81 P-P Barm 3.74 P/B Ratio = 3.98 Period = 109.50 Depth = 4.50 M Power = 175.58 Db

File 2.60: 150 cu in SeaScan Tri-Cluster ® array (# 3 only) @ 10 ft



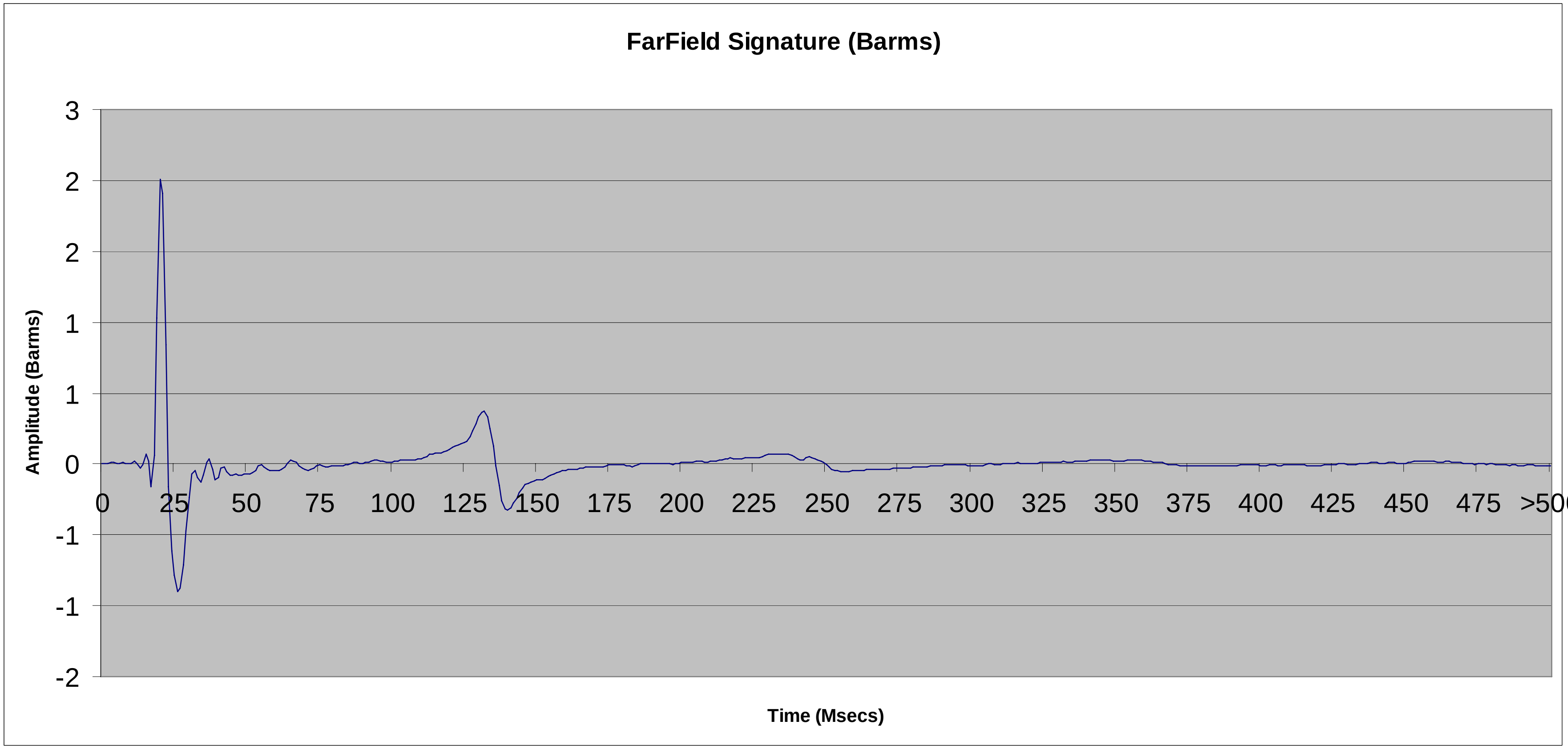
0-P Barm 2.09 P-P Barm 3.33 P/B Ratio = 4.94 Period = 111.75 Depth = 4.13 M Power = 166.78 Db

File 2.60: 150 cu in SeaScan Tri-Cluster ® array (# 3 only) @ 10 ft



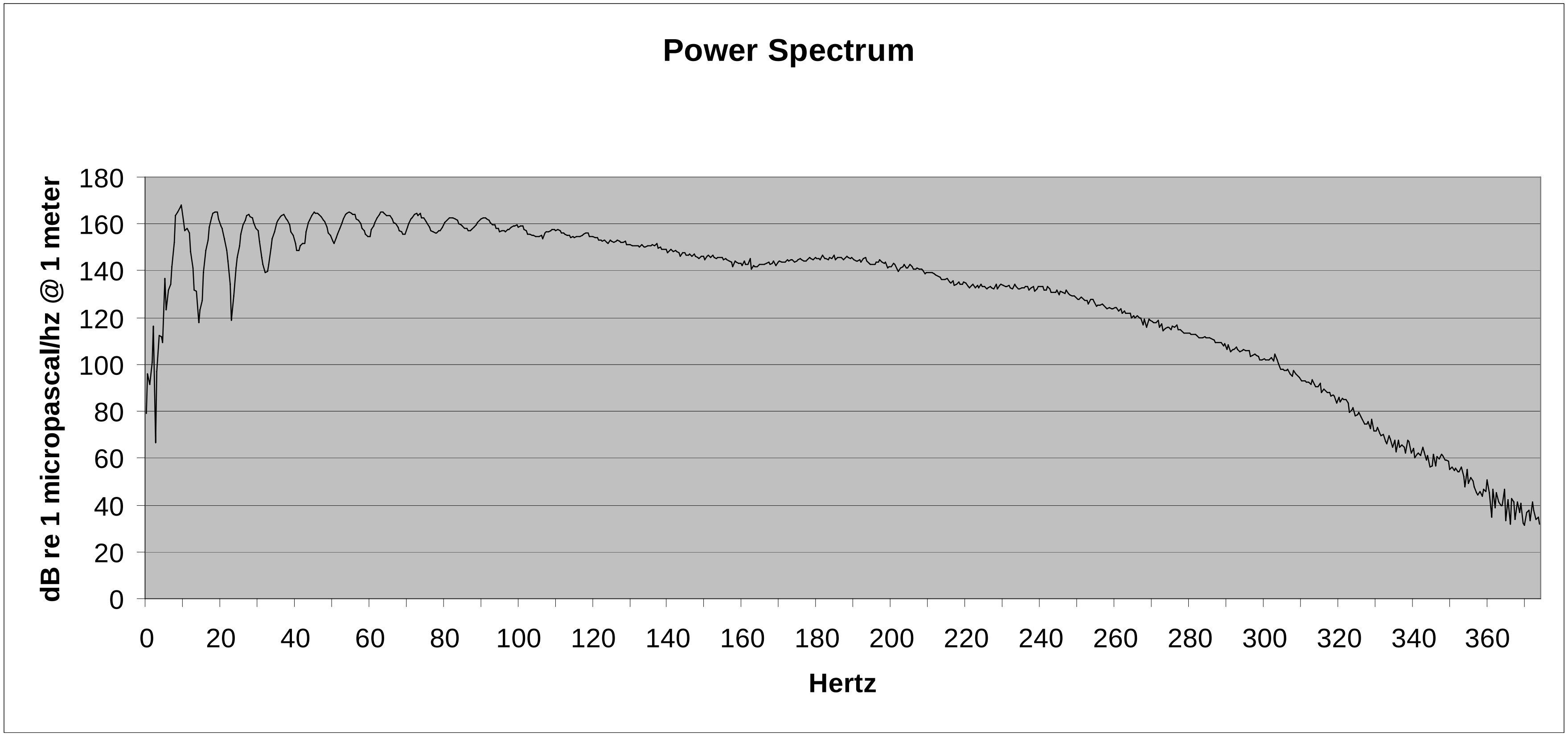
0-P Barm	2.09	P-P Barm	3.33	P/B Ratio =	4.94	Period =	111.75	Depth =	4.13	M	Power =	166.78	Db

File 2.61: 150 cu in SeaScan Tri-Cluster ® array (# 3 only) @ 10 ft



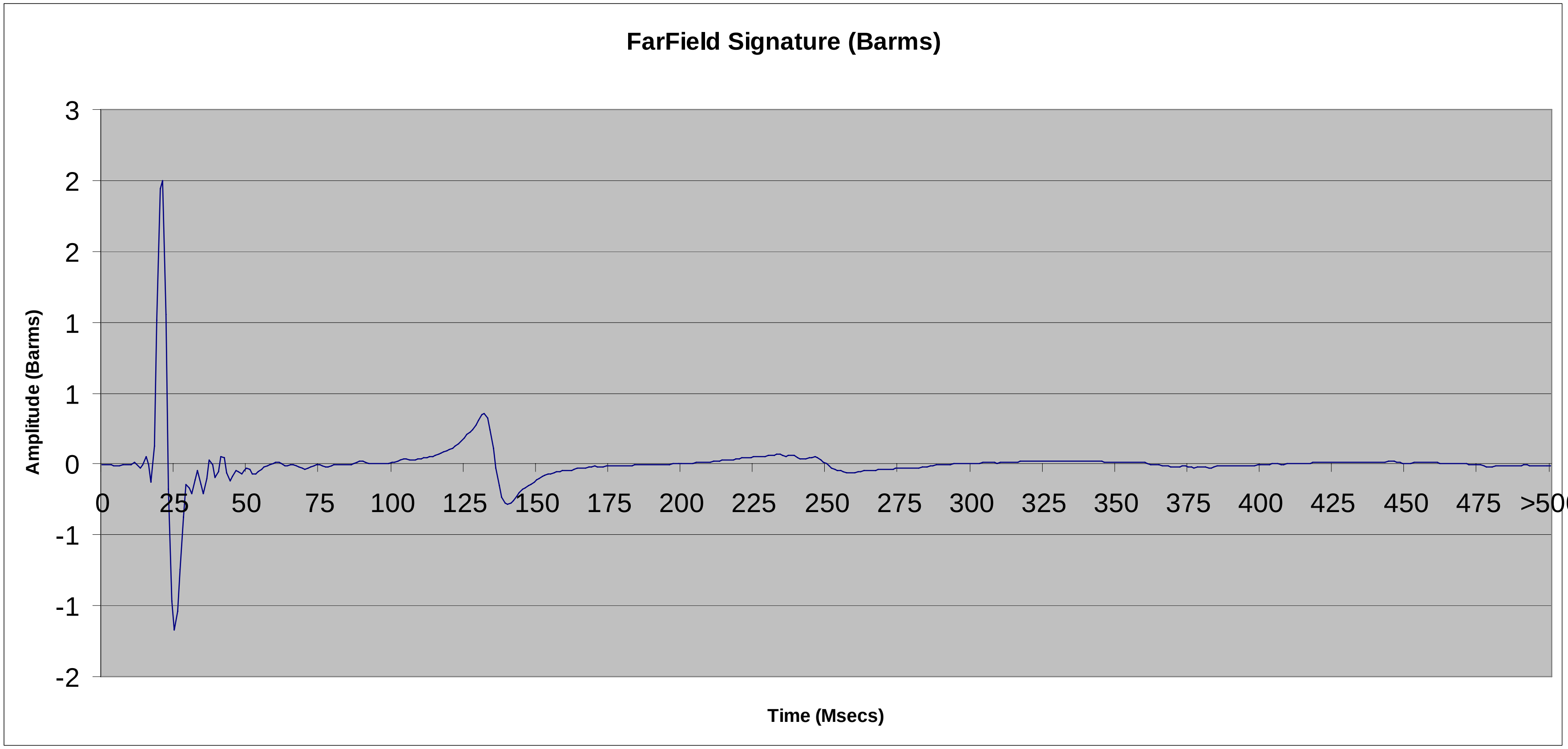
0-P Barm	2.13	P-P Barm	3.03	P/B Ratio =	4.31	Period =	111.00	Depth =	4.31	M	Power =	168.06	Db

File 2.61: 150 cu in SeaScan Tri-Cluster ® array (# 3 only) @ 10 ft



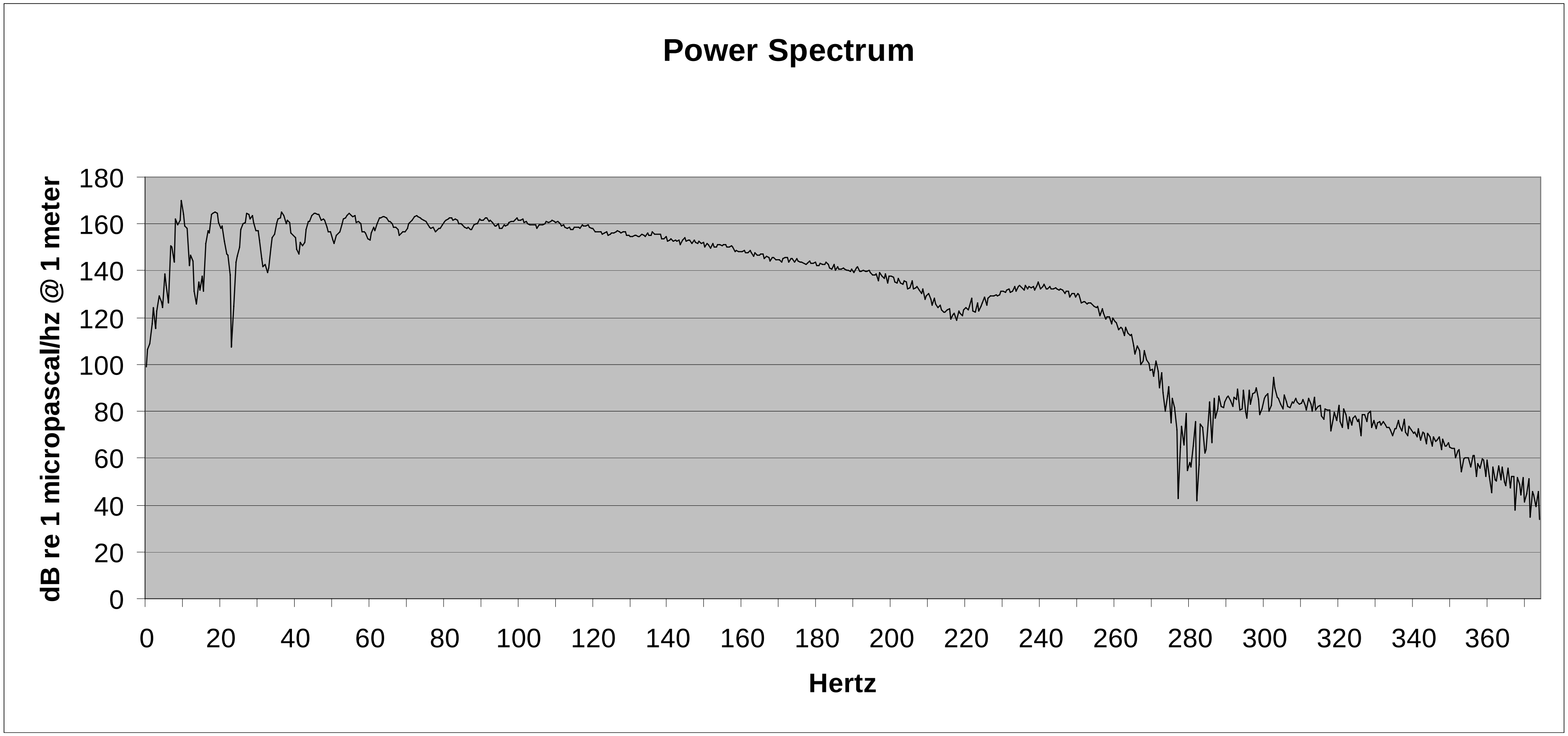
0-P Barm	2.13	P-P Barm	3.03	P/B Ratio =	4.31	Period =	111.00	Depth =	4.31	M	Power =	168.06	Db

File 2.62: 150 cu in SeaScan Tri-Cluster ® array (# 3 only) @ 10 ft



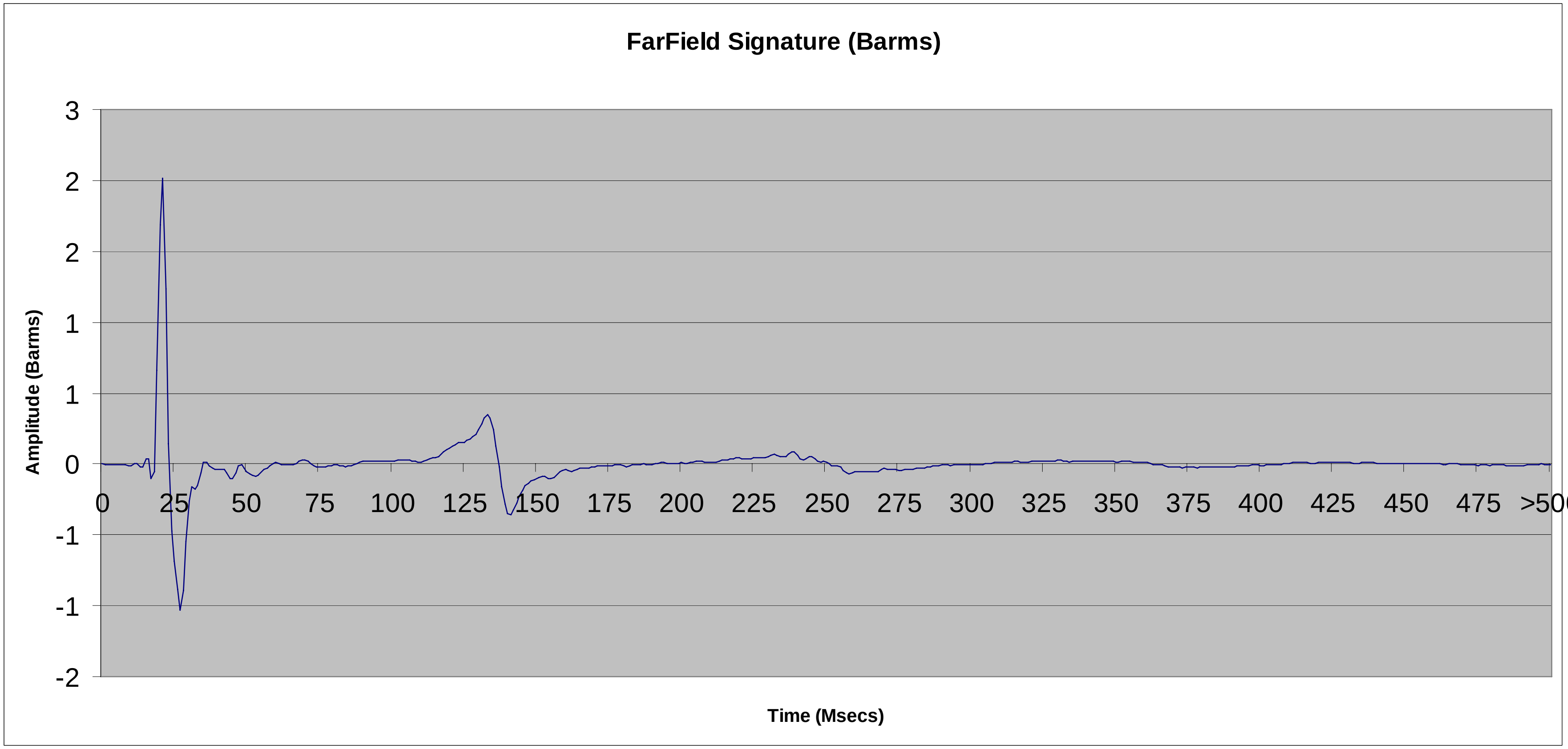
0-P Barm	2.11	P-P Barm	3.28	P/B Ratio =	5.10	Period =	111.25	Depth =	3.38	M	Power =	170.17	Db

File 2.62: 150 cu in SeaScan Tri-Cluster ® array (# 3 only) @ 10 ft



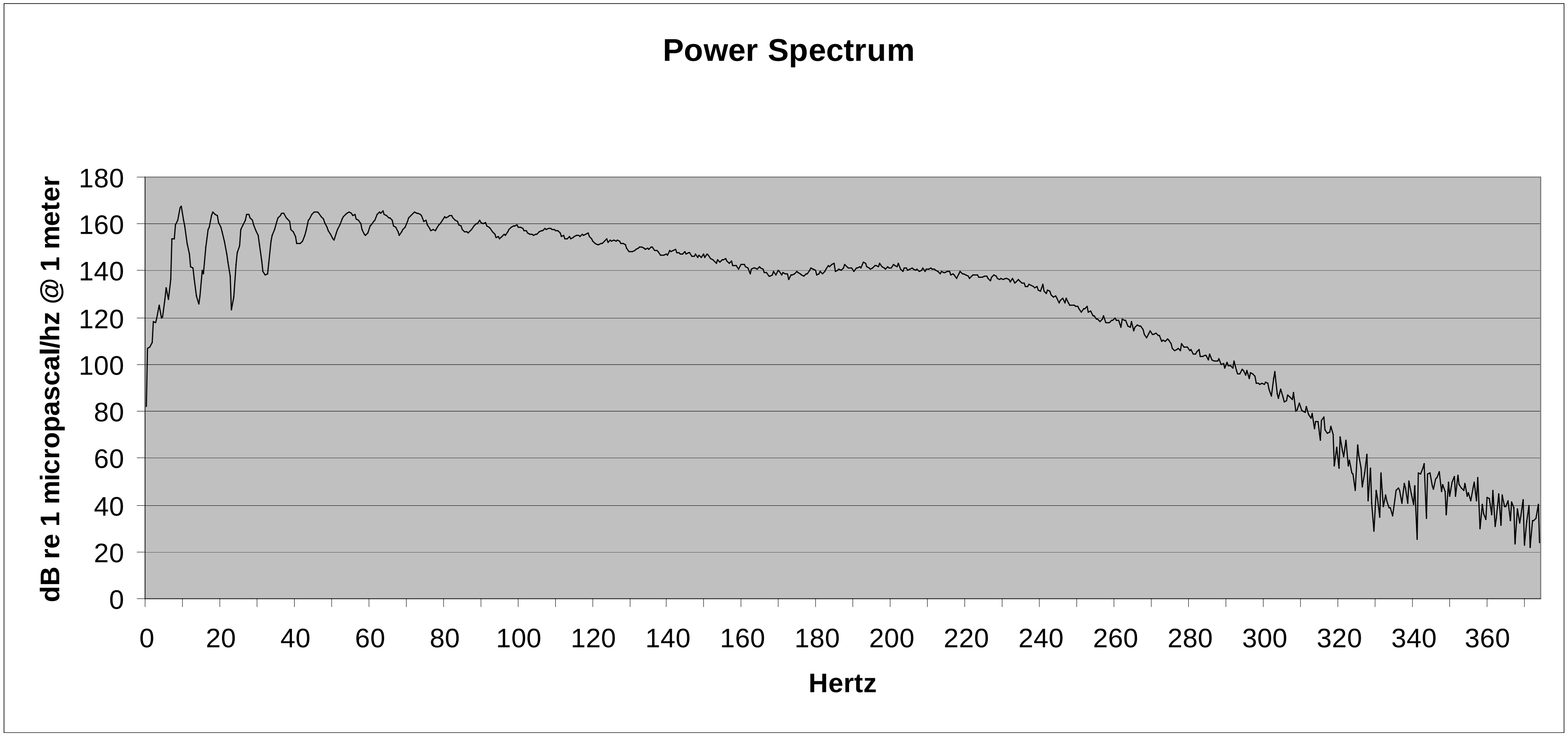
0-P Barm 2.11 P-P Barm 3.28 P/B Ratio = 5.10 Period = 111.25 Depth = 3.38 M Power = 170.17 Db

File 2.63: 150 cu in SeaScan Tri-Cluster ® array (# 3 only) @ 10 ft



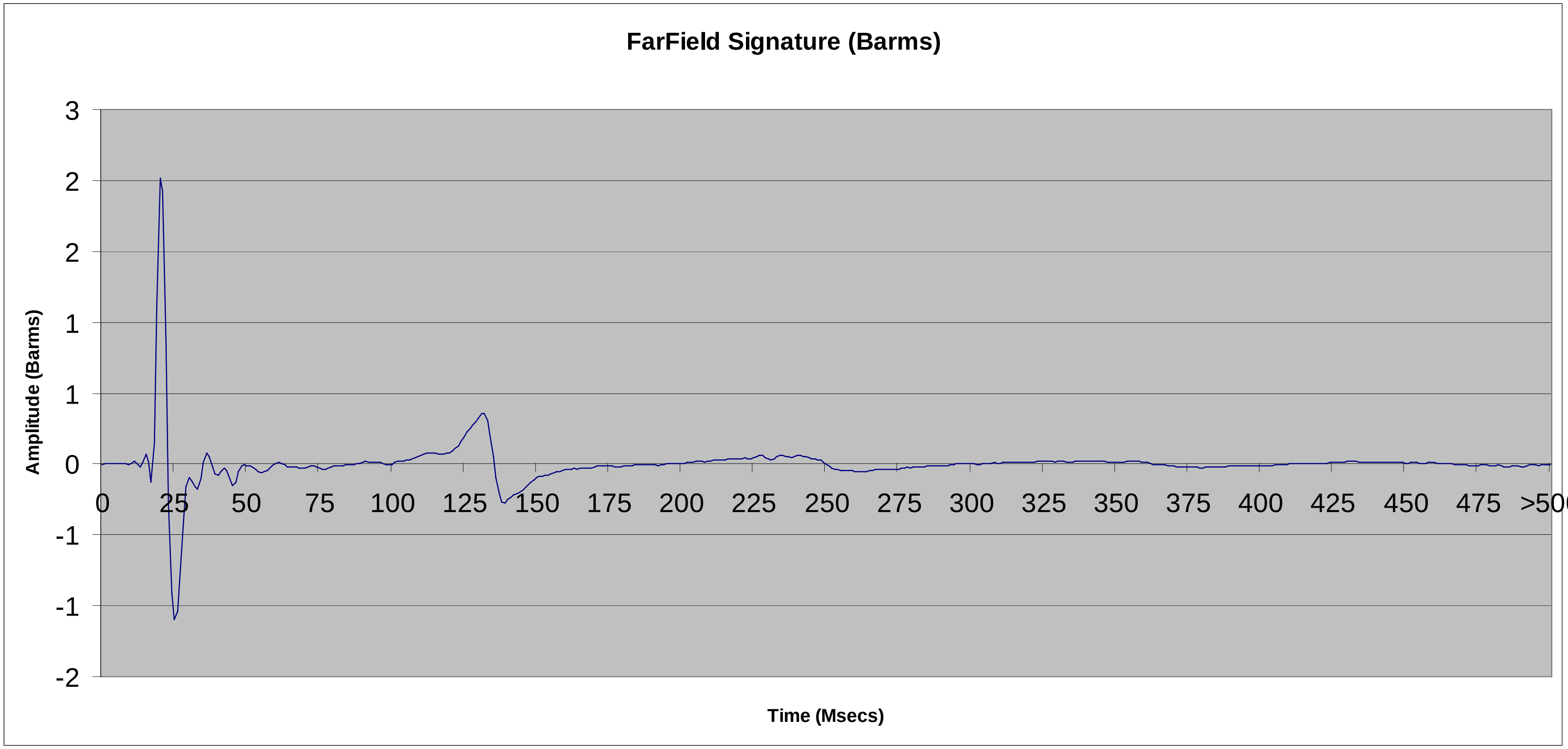
0-P Barm	2.04	P-P Barm	3.07	P/B Ratio =	4.34	Period =	112.25	Depth =	4.69	M	Power =	167.65	Db

File 2.63: 150 cu in SeaScan Tri-Cluster ® array (# 3 only) @ 10 ft



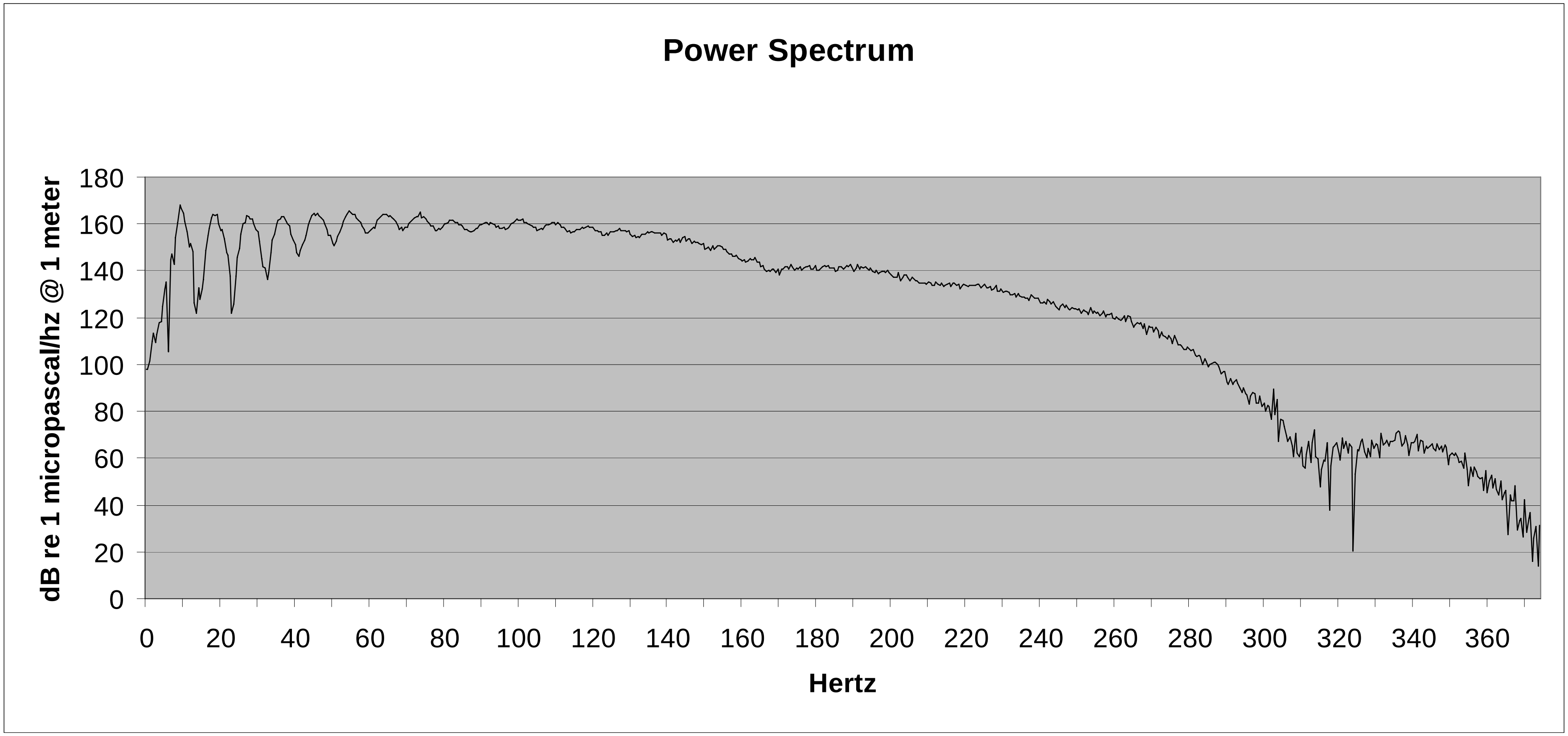
0-P Barm 2.04 P-P Barm 3.07 P/B Ratio = 4.34 Period = 112.25 Depth = 4.69 M Power = 167.65 Db

File 2.64: 150 cu in SeaScan Tri-Cluster ® array (# 3 only) @ 10 ft



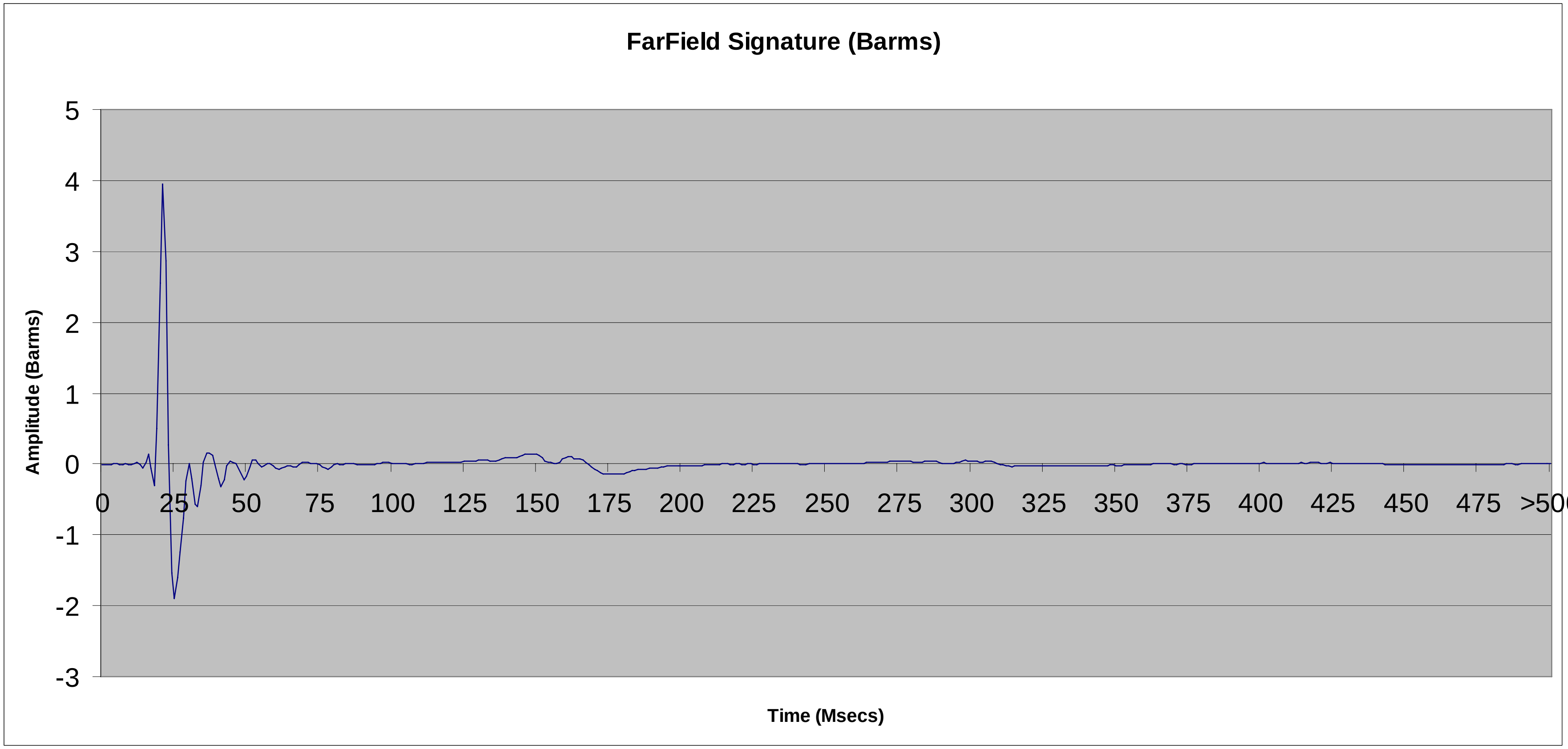
0-P Barm	2.12	P-P Barm	3.23	P/B Ratio =	5.08	Period =	111.00	Depth =	3.56	M	Power =	167.89	Db

File 2.64: 150 cu in SeaScan Tri-Cluster ® array (# 3 only) @ 10 ft



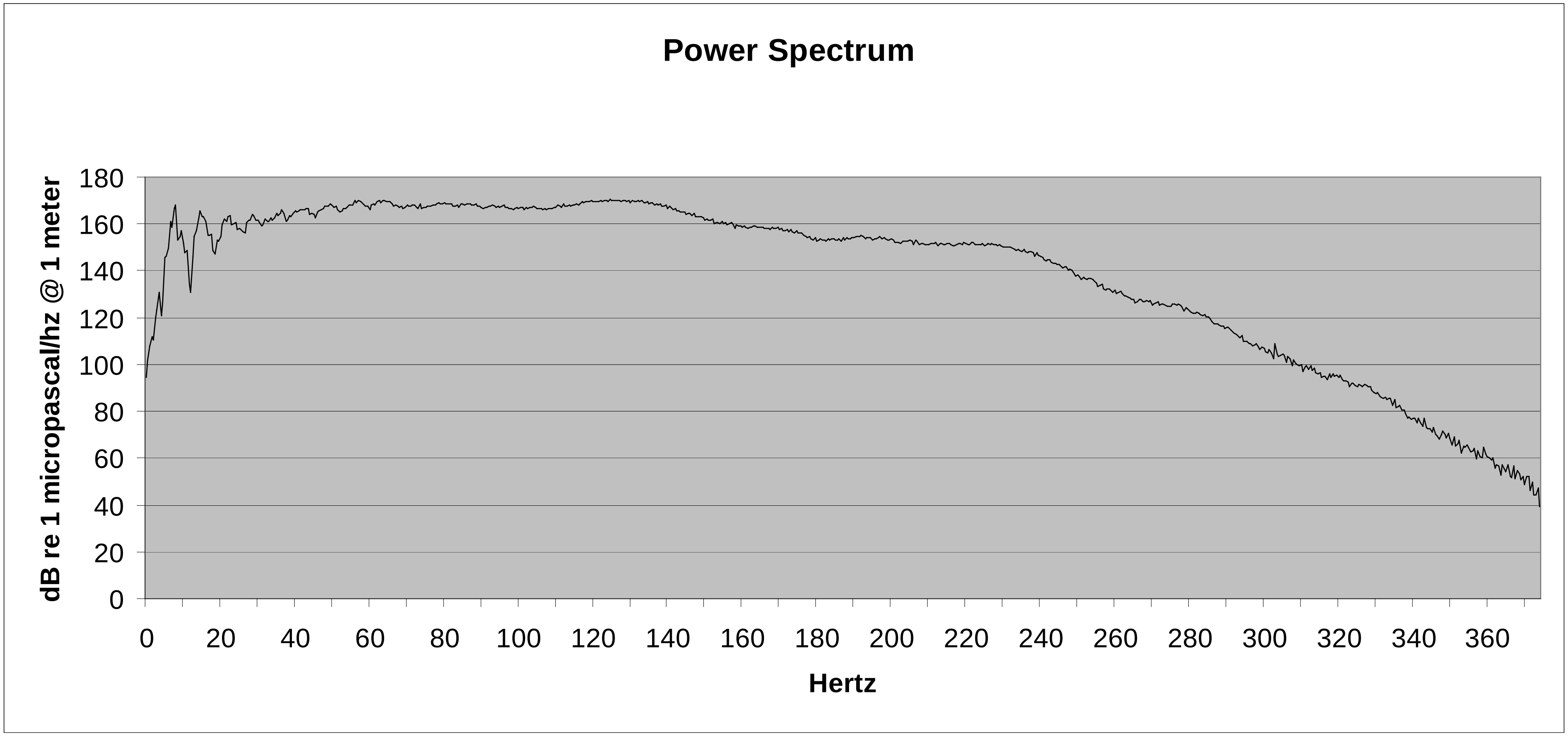
0-P Barm	2.12	P-P Barm	3.23	P/B Ratio =	5.08	Period =	111.00	Depth =	3.56	M	Power =	167.89	Db

File 2.65: 300 cu in SeaScan Tri-Cluster ® array (# 3 & 4 only) @ 10 ft



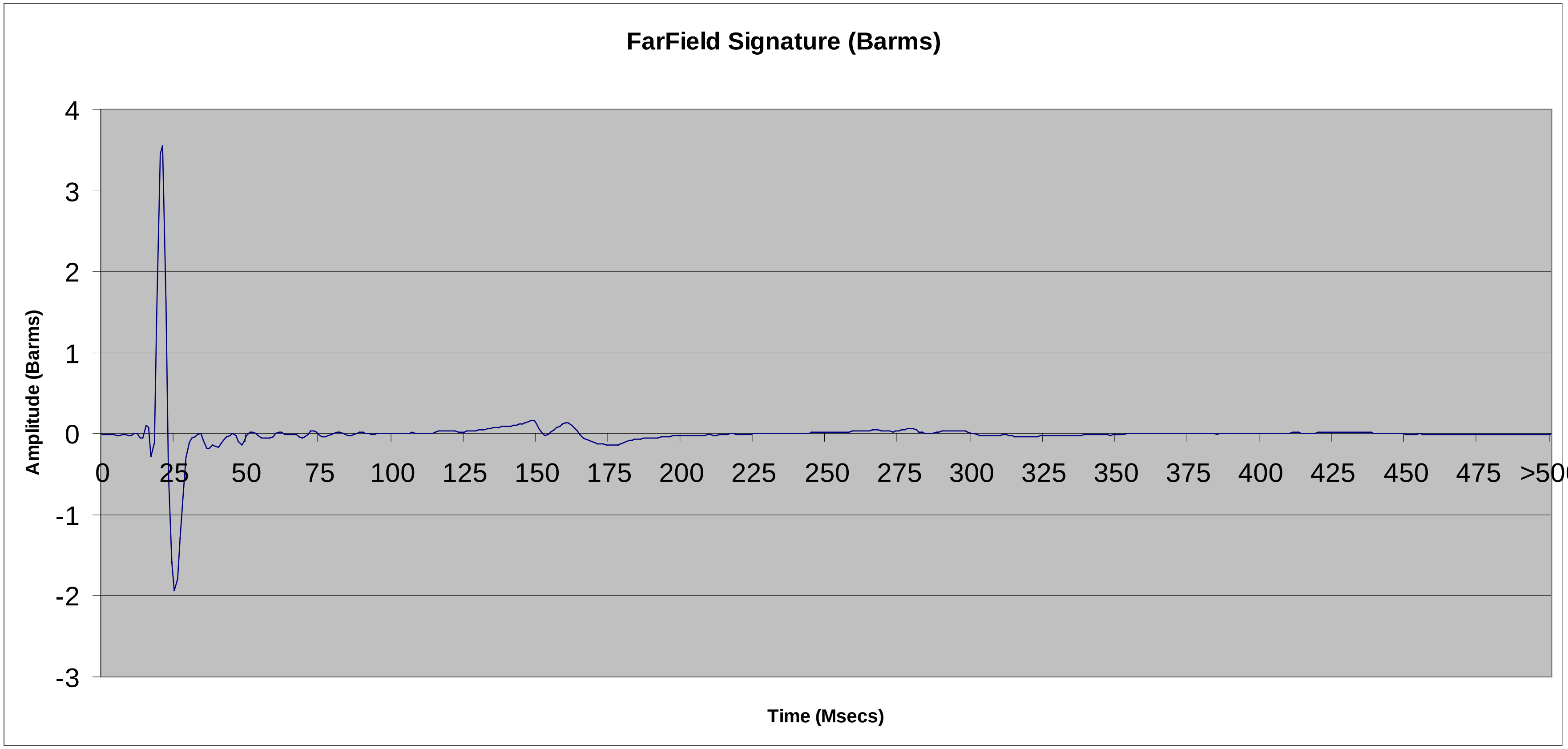
0-P Barm	3.94	P-P Barm	5.85	P/B Ratio =	18.30	Period =	128.75	Depth =	2.81	M	Power =	170.35	Db

File 2.65: 300 cu in SeaScan Tri-Cluster ® array (# 3 & 4 only) @ 10 ft



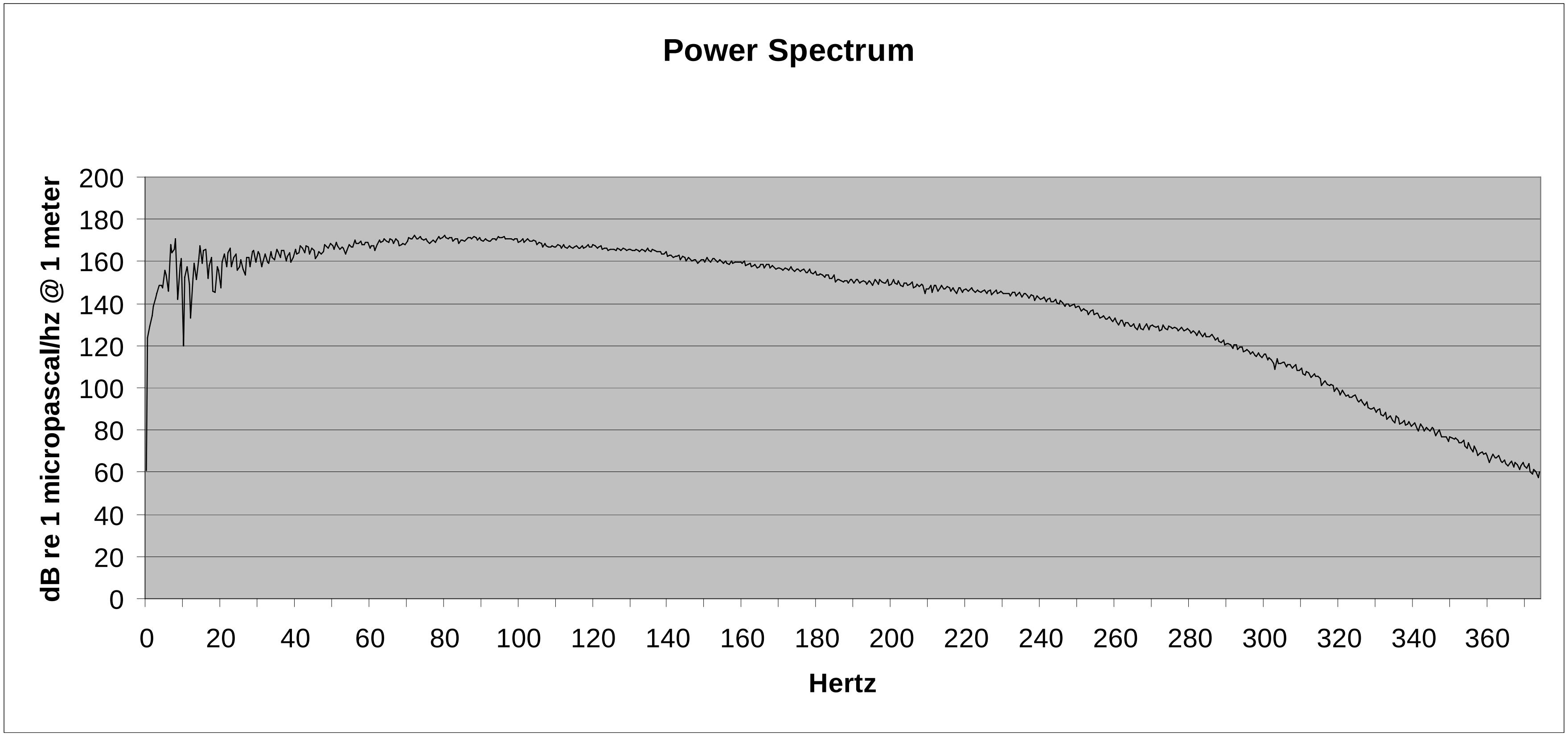
0-P Barm 3.94 P-P Barm 5.85 P/B Ratio = 18.30 Period = 128.75 Depth = 2.81 M Power = 170.35 Db

File 2.66: 300 cu in SeaScan Tri-Cluster ® array (# 3 & 4 only) @ 10 ft



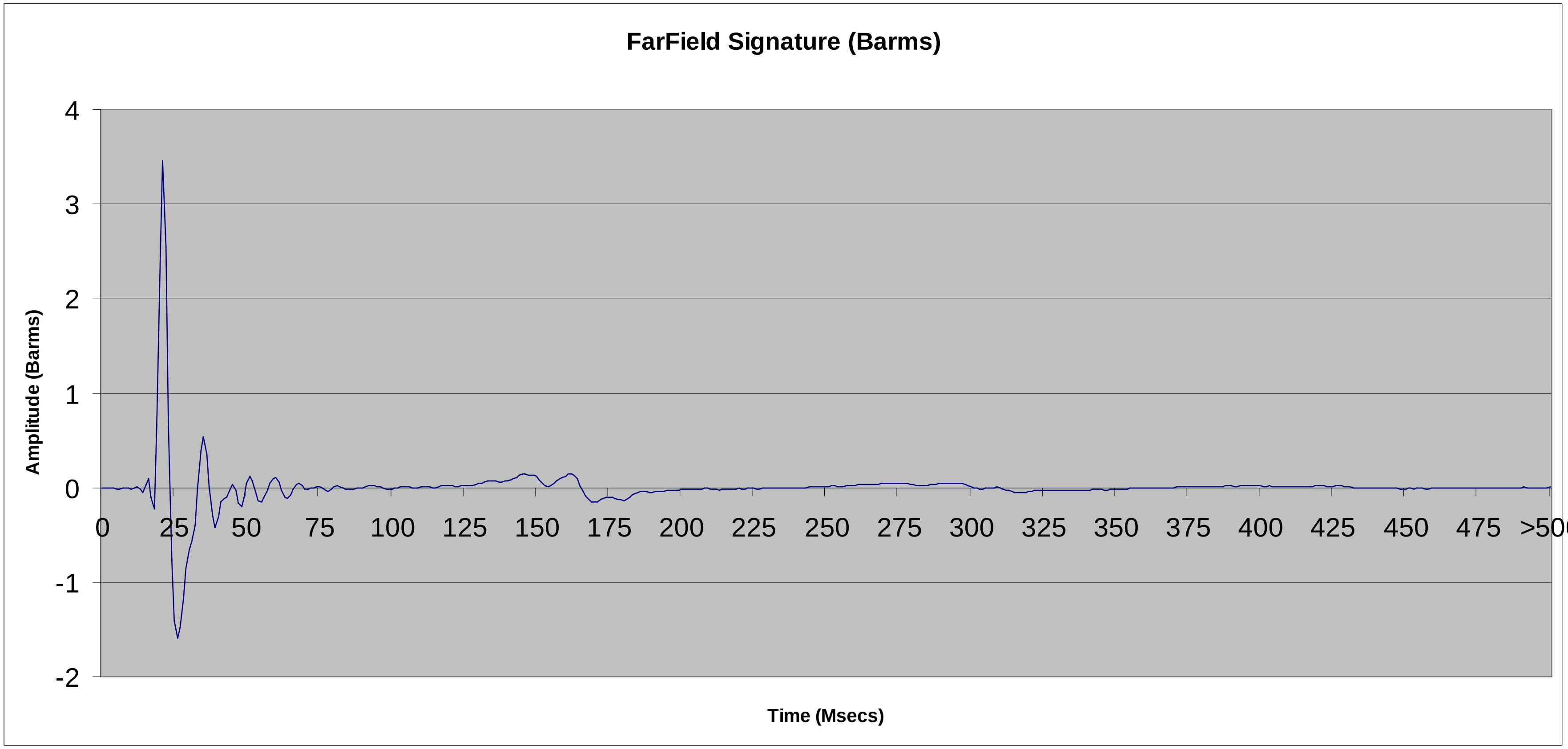
0-P Barm 3.82 P-P Barm 5.75 P/B Ratio = 19.27 Period = 127.75 Depth = 3.56 M Power = 172.36 Db

File 2.66: 300 cu in SeaScan Tri-Cluster ® array (# 3 & 4 only) @ 10 ft



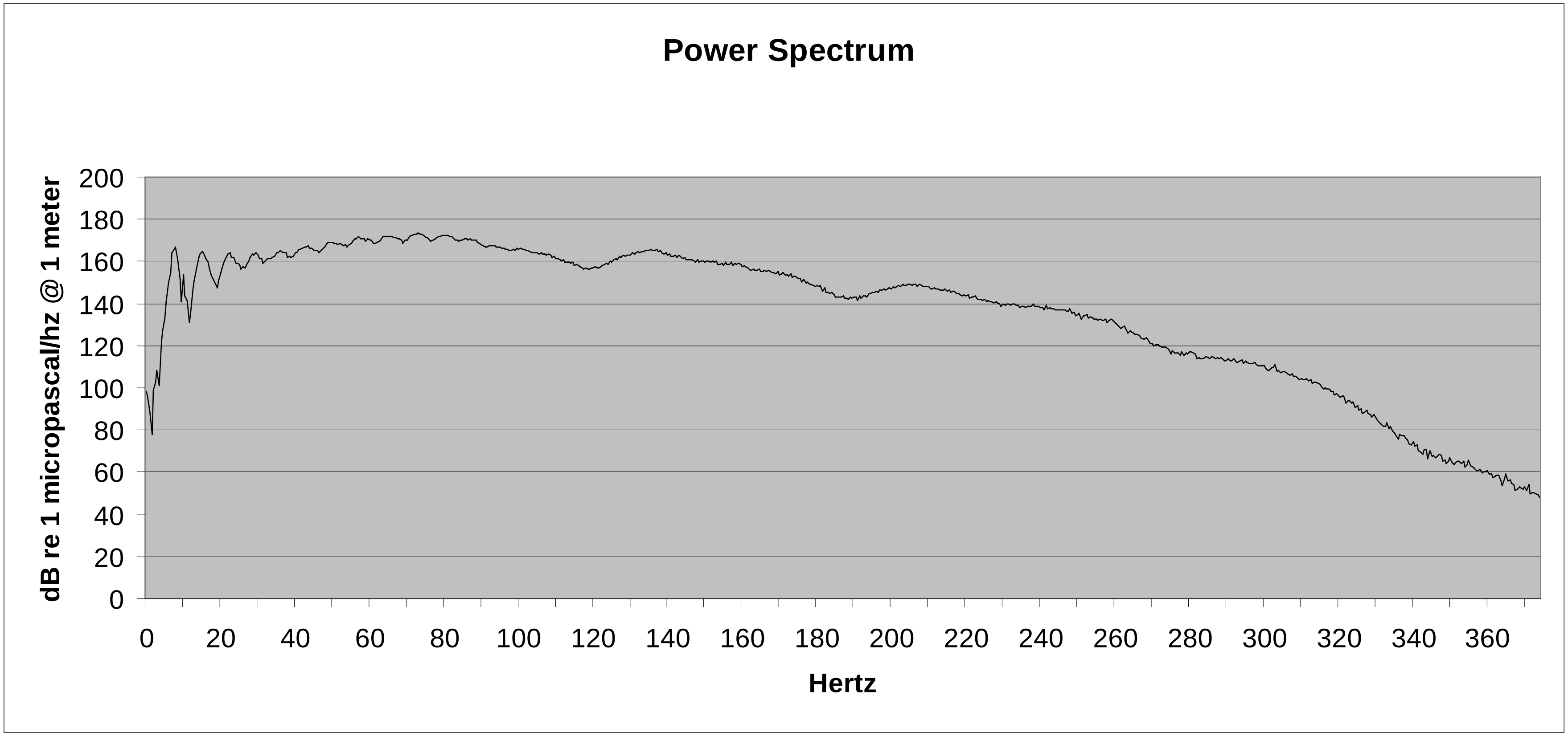
0-P Barm	3.82	P-P Barm	5.75	P/B Ratio =	19.27	Period =	127.75	Depth =	3.56	M	Power =	172.36	Db

File 2.67: 300 cu in SeaScan Tri-Cluster ® array (# 3 & 4 only) @ 10 ft



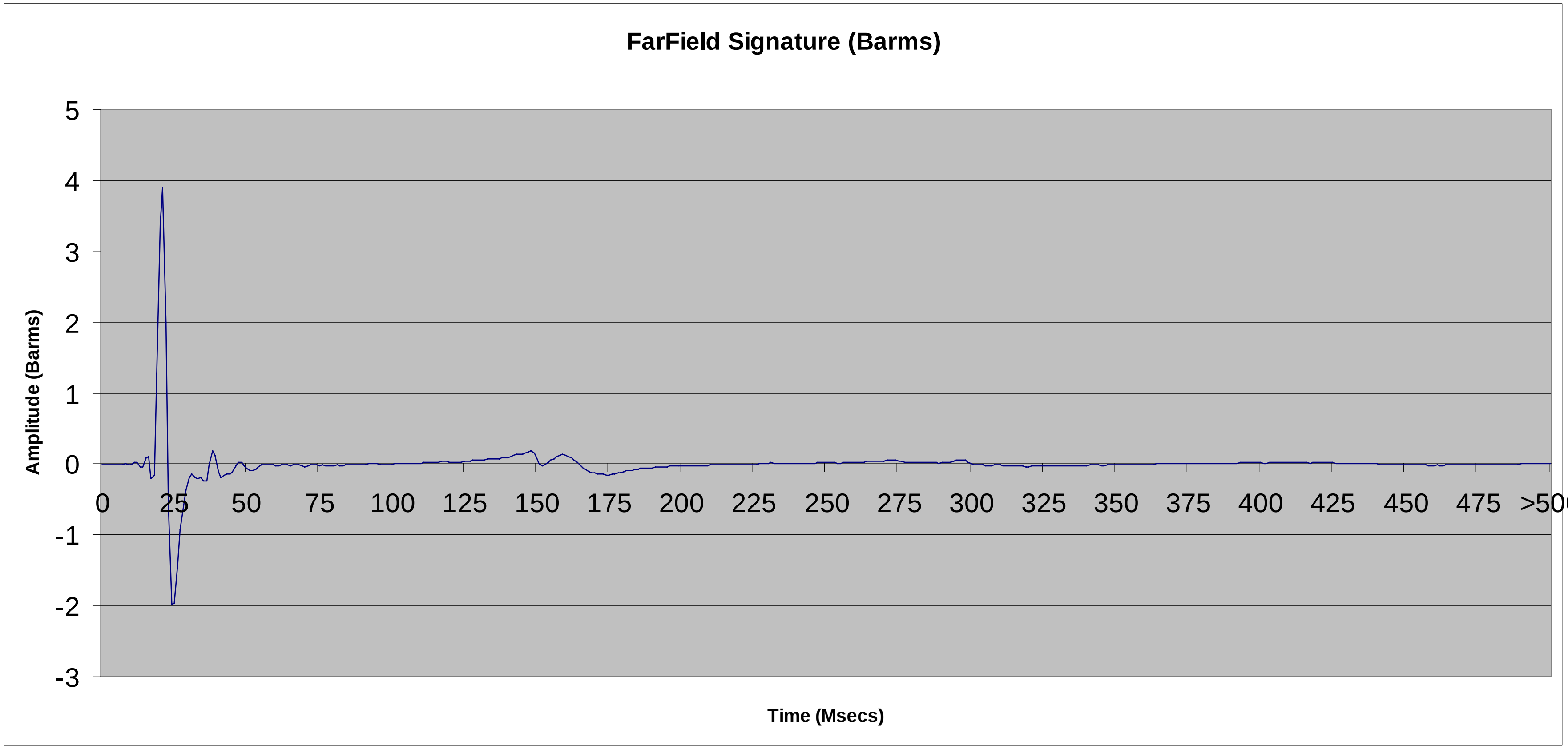
0-P Barm 3.45 P-P Barm 5.05 P/B Ratio = 16.41 Period = 141.00 Depth = 3.75 M Power = 173.52 Db

File 2.67: 300 cu in SeaScan Tri-Cluster ® array (# 3 & 4 only) @ 10 ft



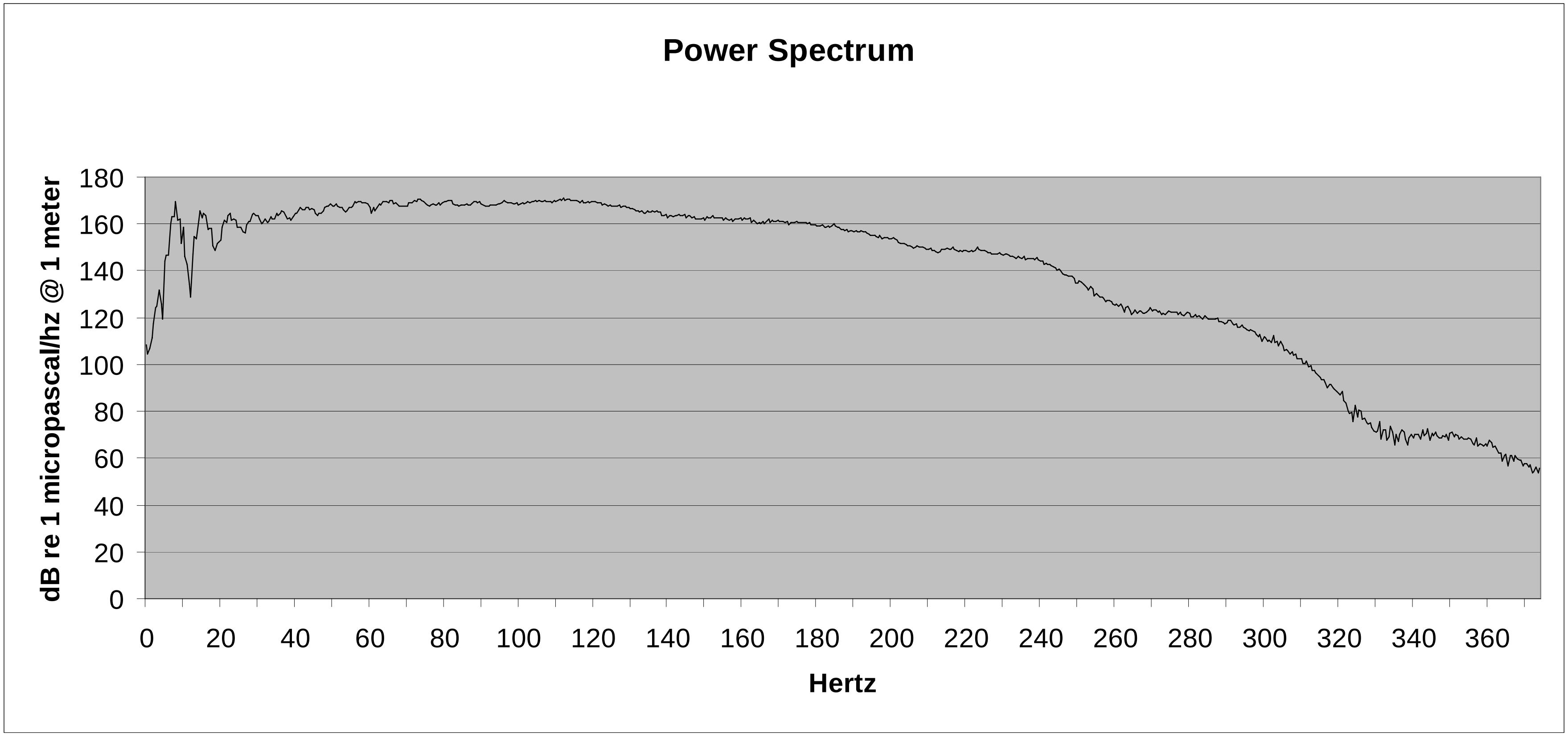
0-P Barm	3.45	P-P Barm	5.05	P/B Ratio =	16.41	Period =	141.00	Depth =	3.75	M	Power =	173.52	Db	

File 2.68: 300 cu in SeaScan Tri-Cluster ® array (# 3 & 4 only) @ 10 ft



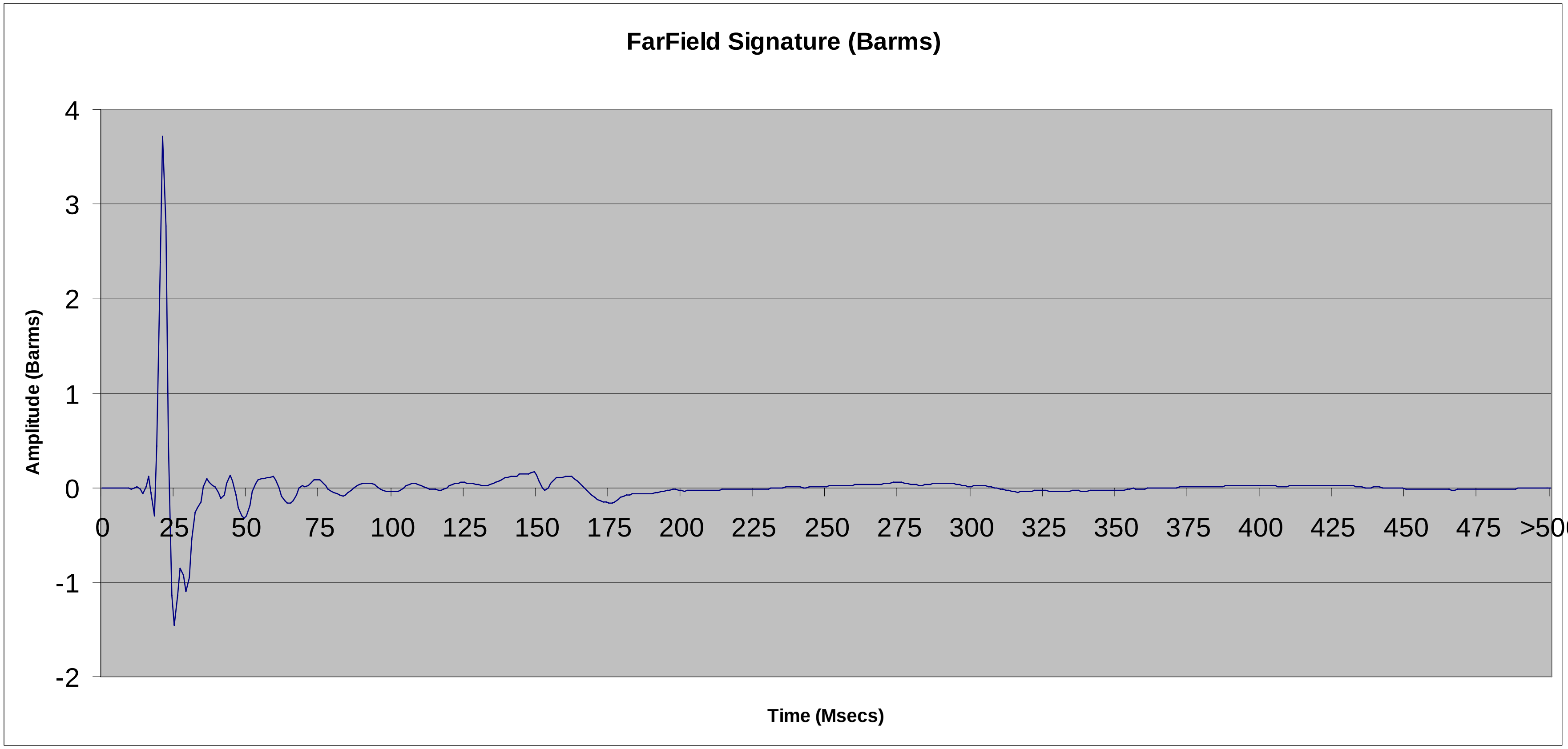
0-P Barm	4.02	P-P Barm	6.12	P/B Ratio =	17.62	Period =	127.25	Depth =	2.81	M	Power =	170.83	Db

File 2.68: 300 cu in SeaScan Tri-Cluster ® array (# 3 & 4 only) @ 10 ft



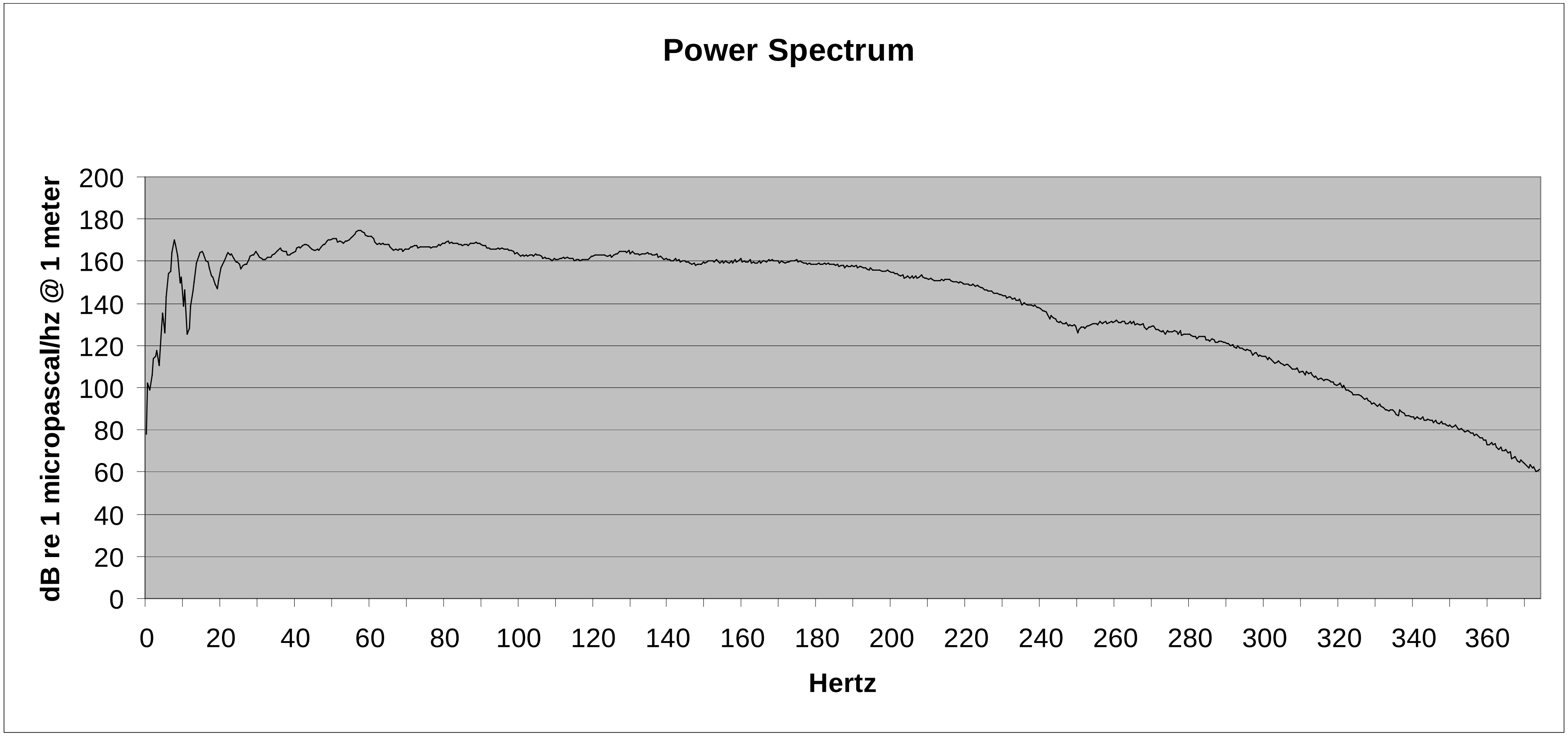
0-P Barm	4.02	P-P Barm	6.12	P/B Ratio =	17.62	Period =	127.25	Depth =	2.81	M	Power =	170.83	Db

File 2.69: 150 cu in SeaScan Tri-Cluster ® array (#5 only) @ 10 ft



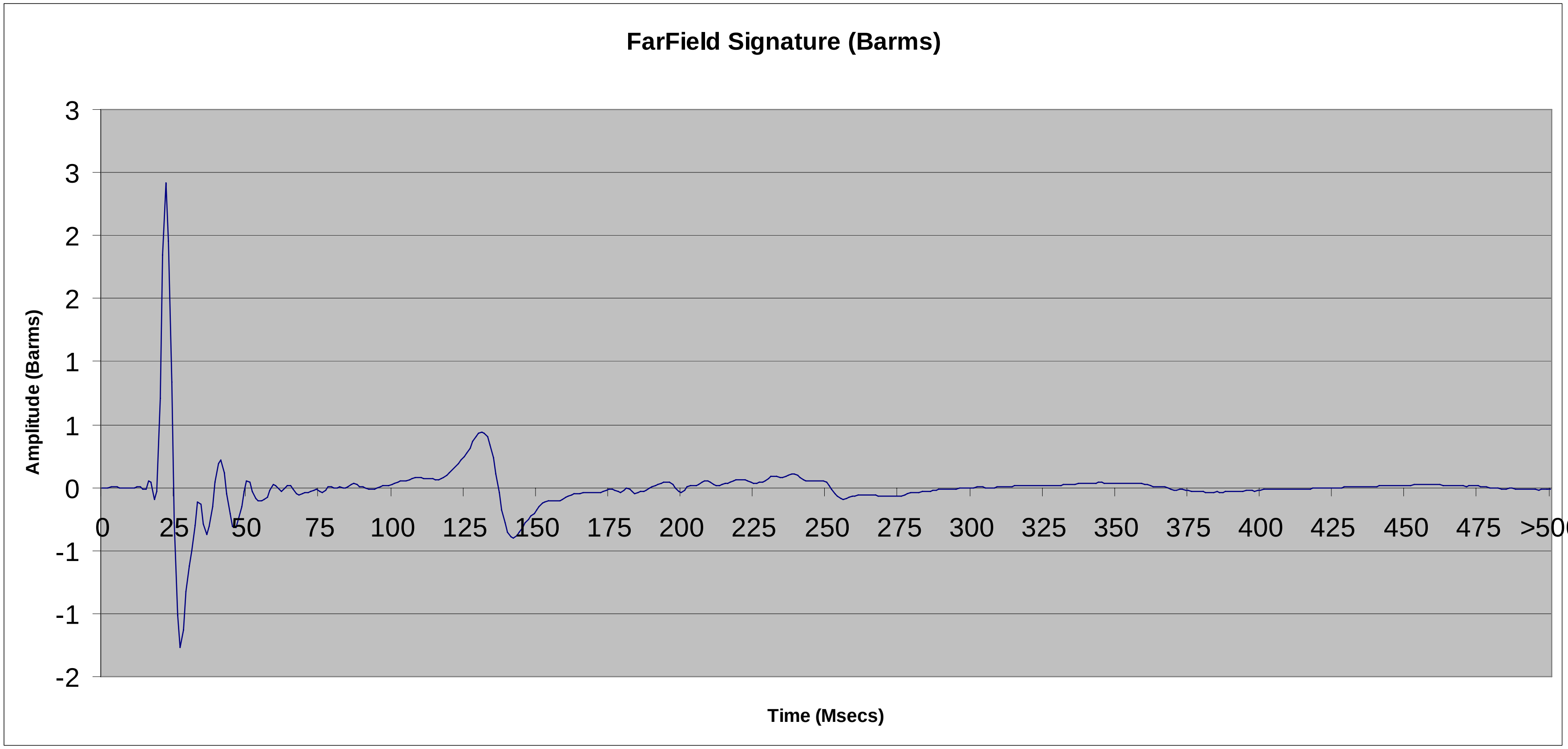
0-P Barm 3.72 P-P Barm 5.19 P/B Ratio = 11.23 Period = 127.75 Depth = 2.81 M Power = 174.84 Db

File 2.69: 150 cu in SeaScan Tri-Cluster ® array (#5 only) @ 10 ft



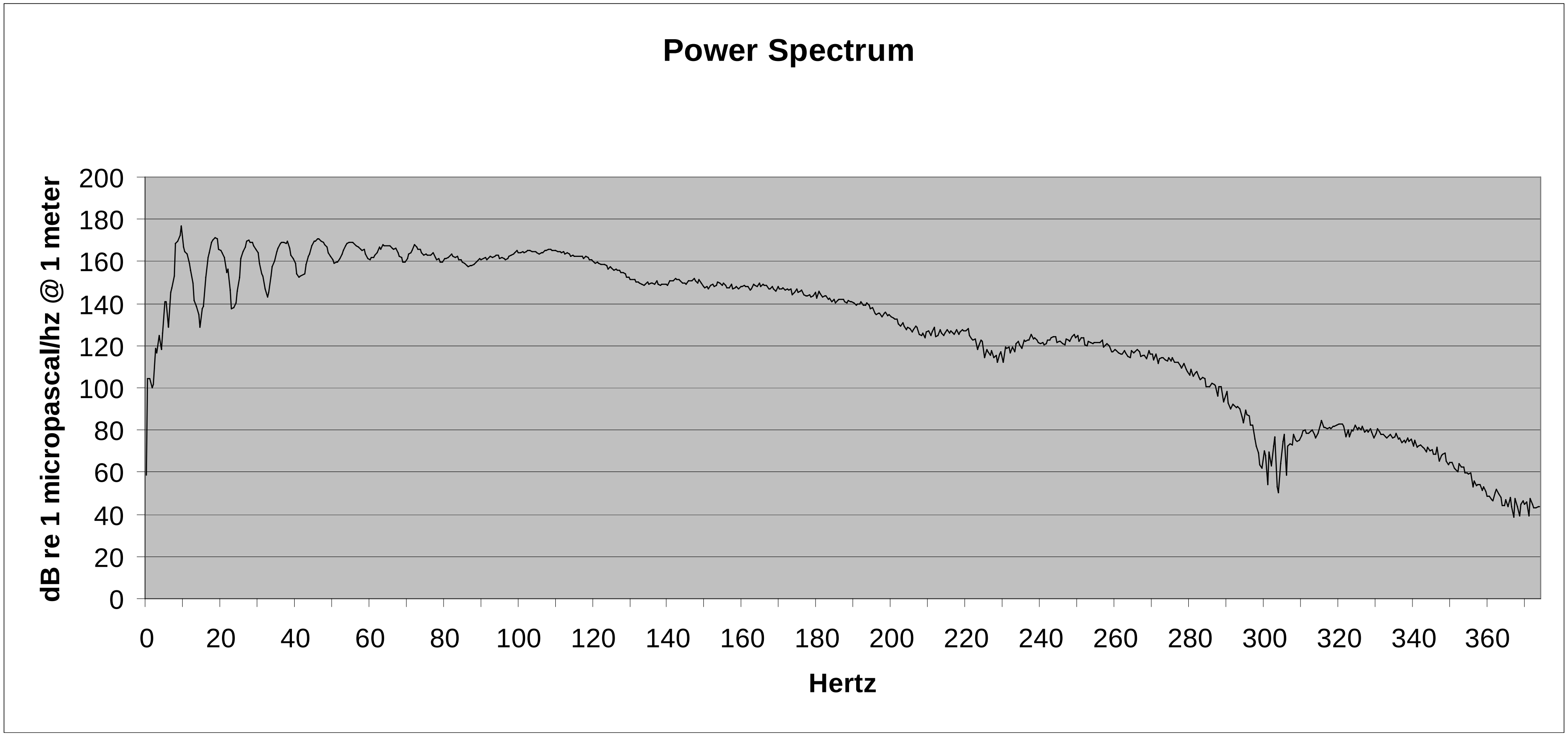
0-P Barm 3.72 P-P Barm 5.19 P/B Ratio = 11.23 Period = 127.75 Depth = 2.81 M Power = 174.84 Db

File 2.70: 150 cu in SeaScan Tri-Cluster ® array (#5 only) @ 10 ft



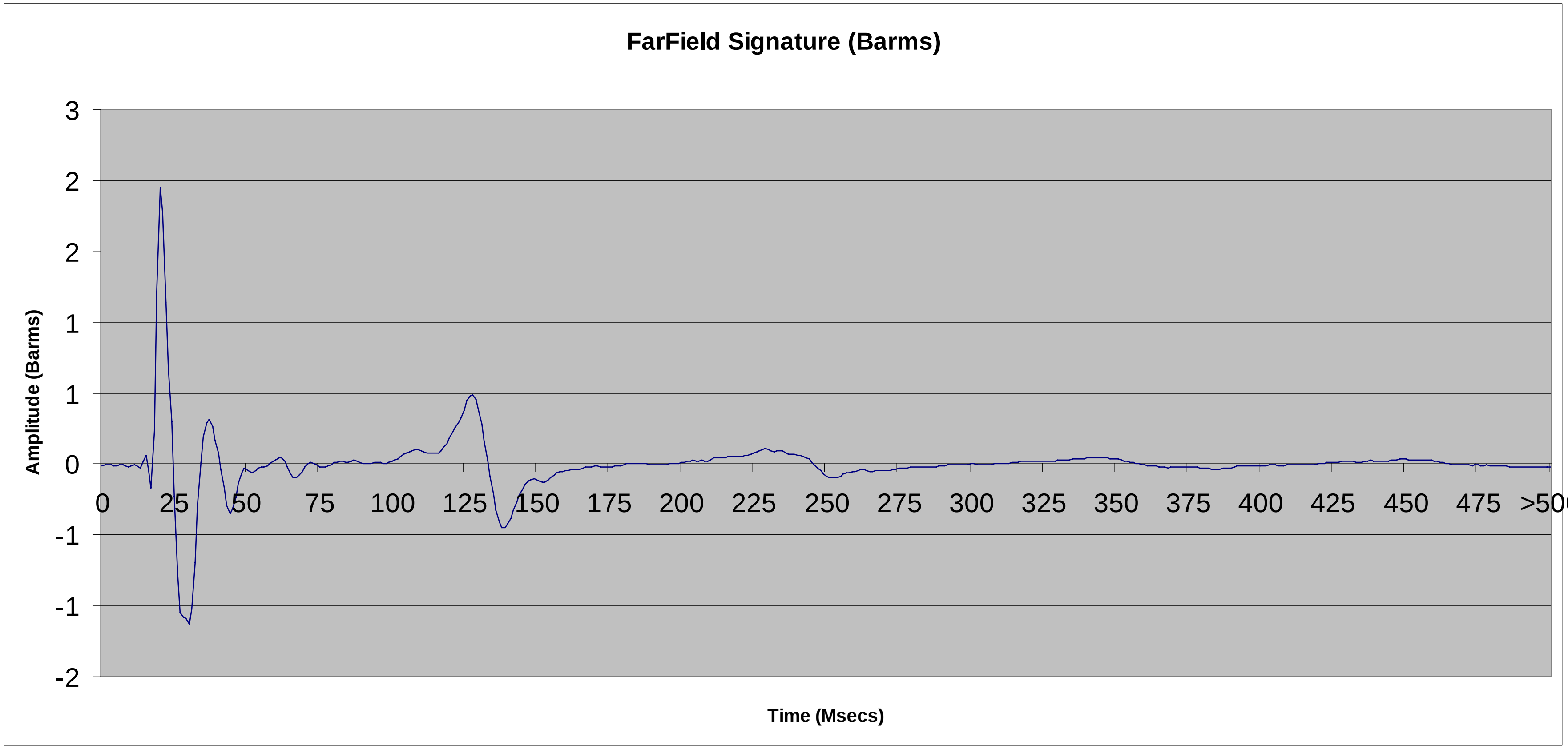
0-P Barm 2.42 P-P Barm 3.69 P/B Ratio = 4.42 Period = 109.00 Depth = 3.75 M Power = 176.73 Db

File 2.70: 150 cu in SeaScan Tri-Cluster ® array (#5 only) @ 10 ft



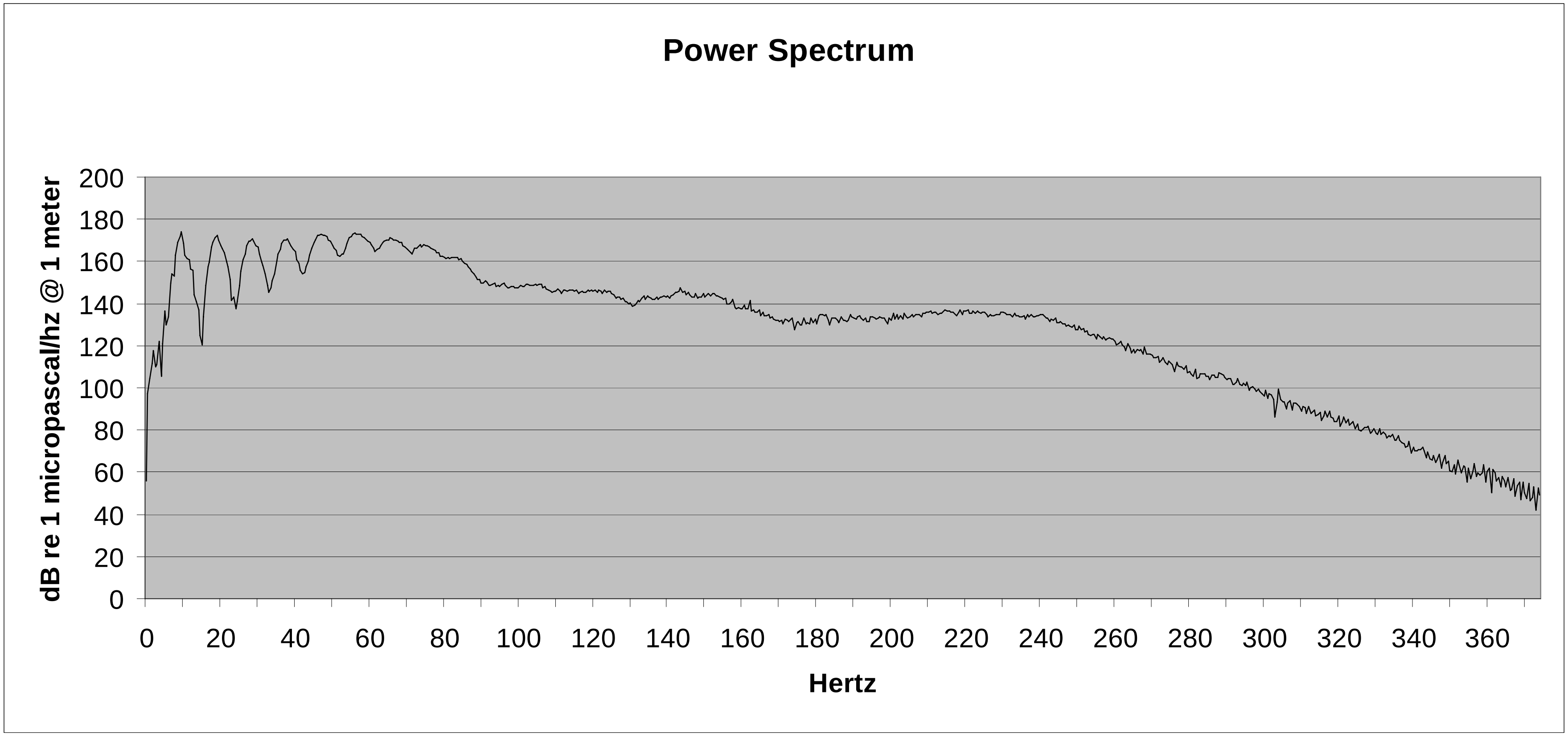
0-P Barm 2.42 P-P Barm 3.69 P/B Ratio = 4.42 Period = 109.00 Depth = 3.75 M Power = 176.73 Db

File 2.71: 150 cu in SeaScan Tri-Cluster ® array (#5 only) @ 10 ft



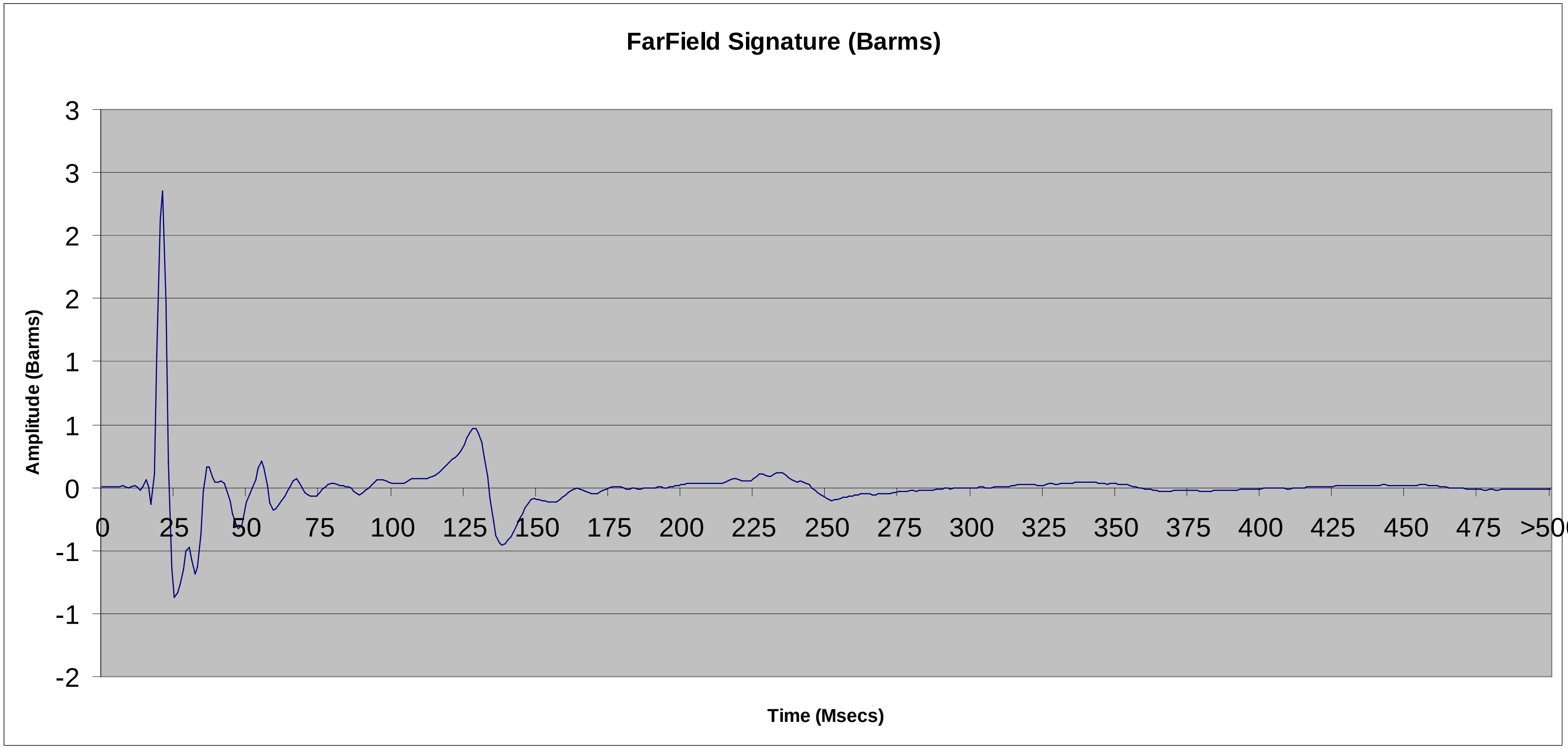
0-P Barm 1.99 P-P Barm 3.12 P/B Ratio = 3.31 Period = 107.25 Depth = 7.31 M Power = 174.01 Db

File 2.71: 150 cu in SeaScan Tri-Cluster ® array (#5 only) @ 10 ft



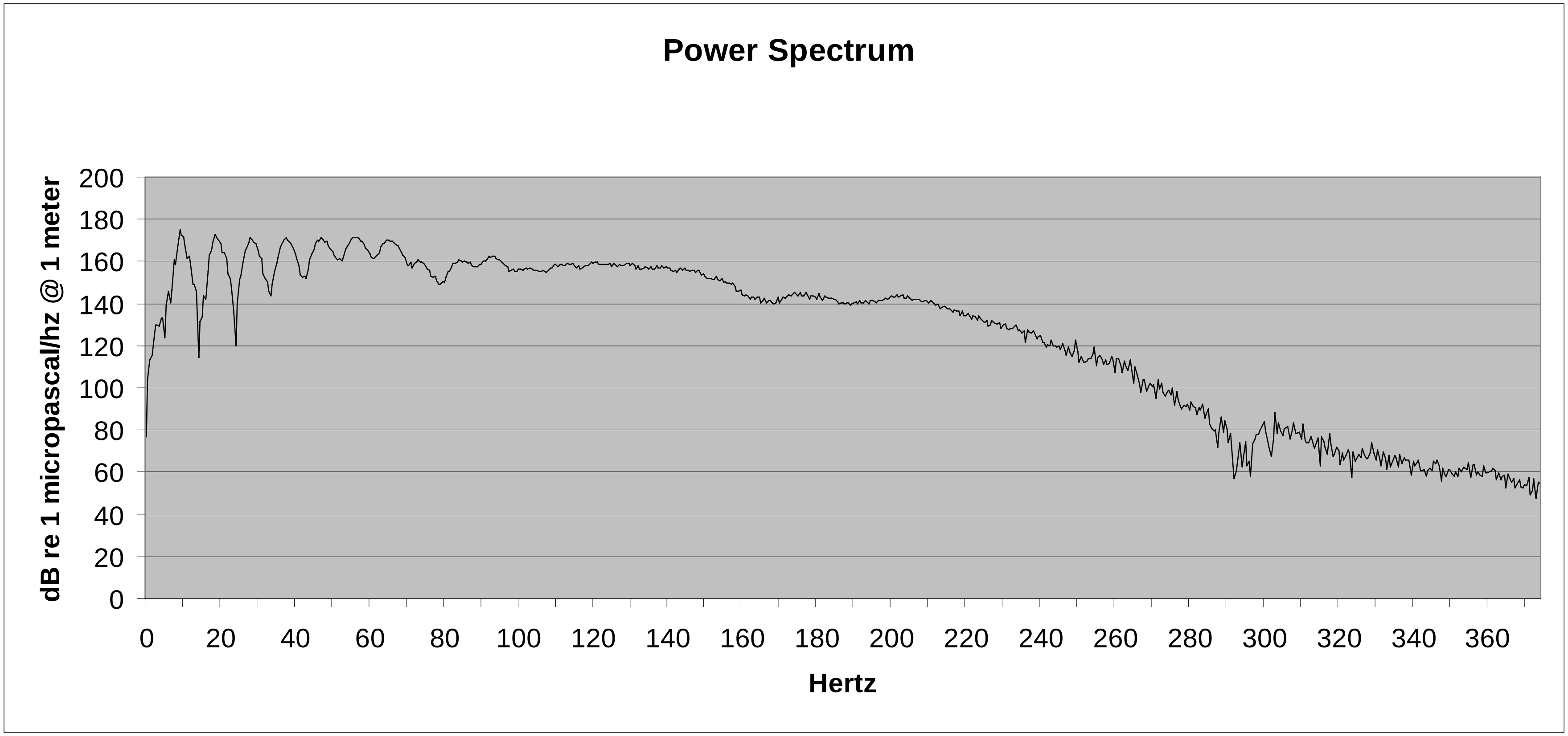
0-P Barm	1.99	P-P Barm	3.12	P/B Ratio =	3.31	Period =	107.25	Depth =	7.31	M	Power =	174.01	Db		

File 2.72: 150 cu in SeaScan Tri-Cluster ® array (#5 only) @ 10 ft



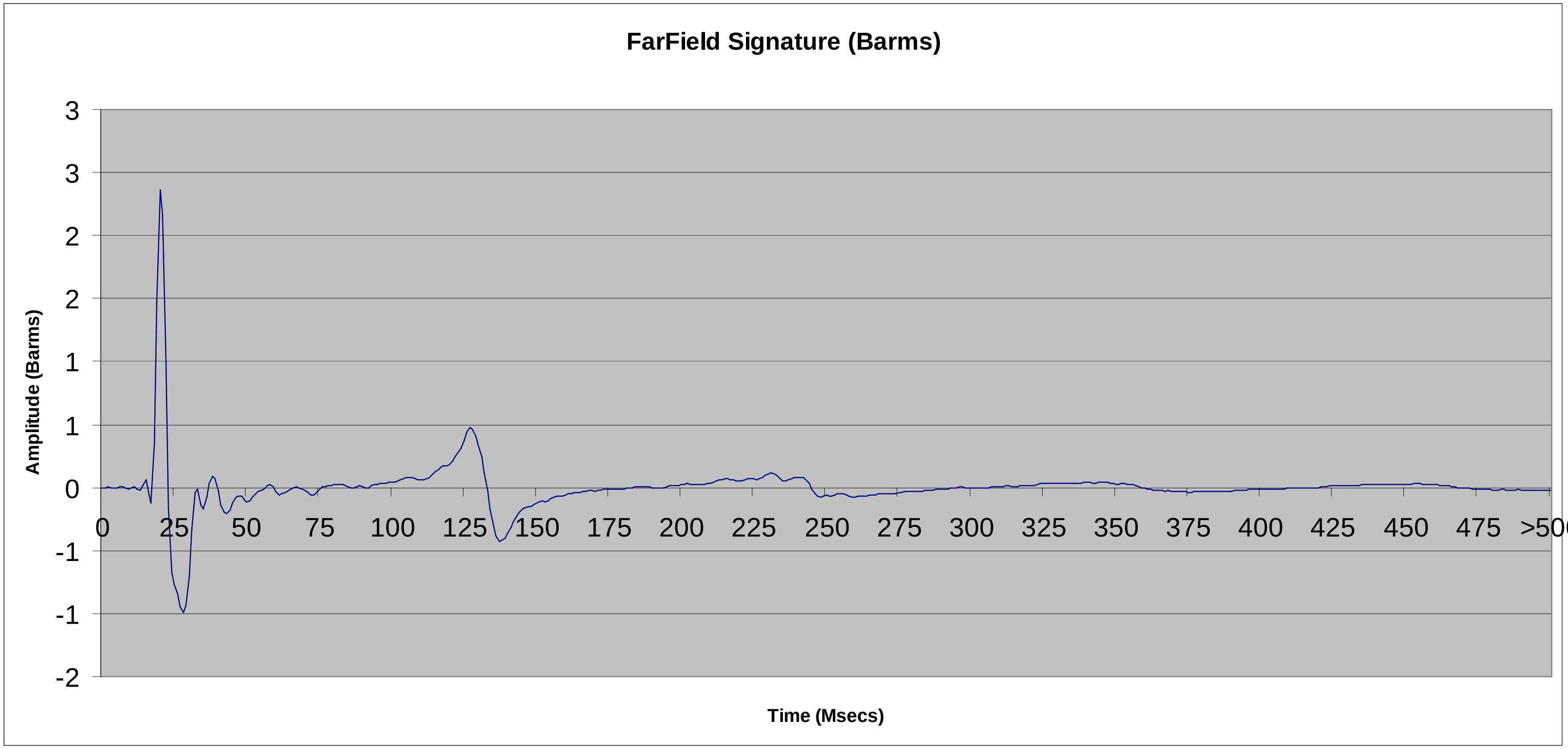
0-P Barm 2.41 P-P Barm 3.28 P/B Ratio = 3.53 Period = 107.75 Depth = 3.38 M Power = 175.04 Db

File 2.72: 150 cu in SeaScan Tri-Cluster ® array (#5 only) @ 10 ft



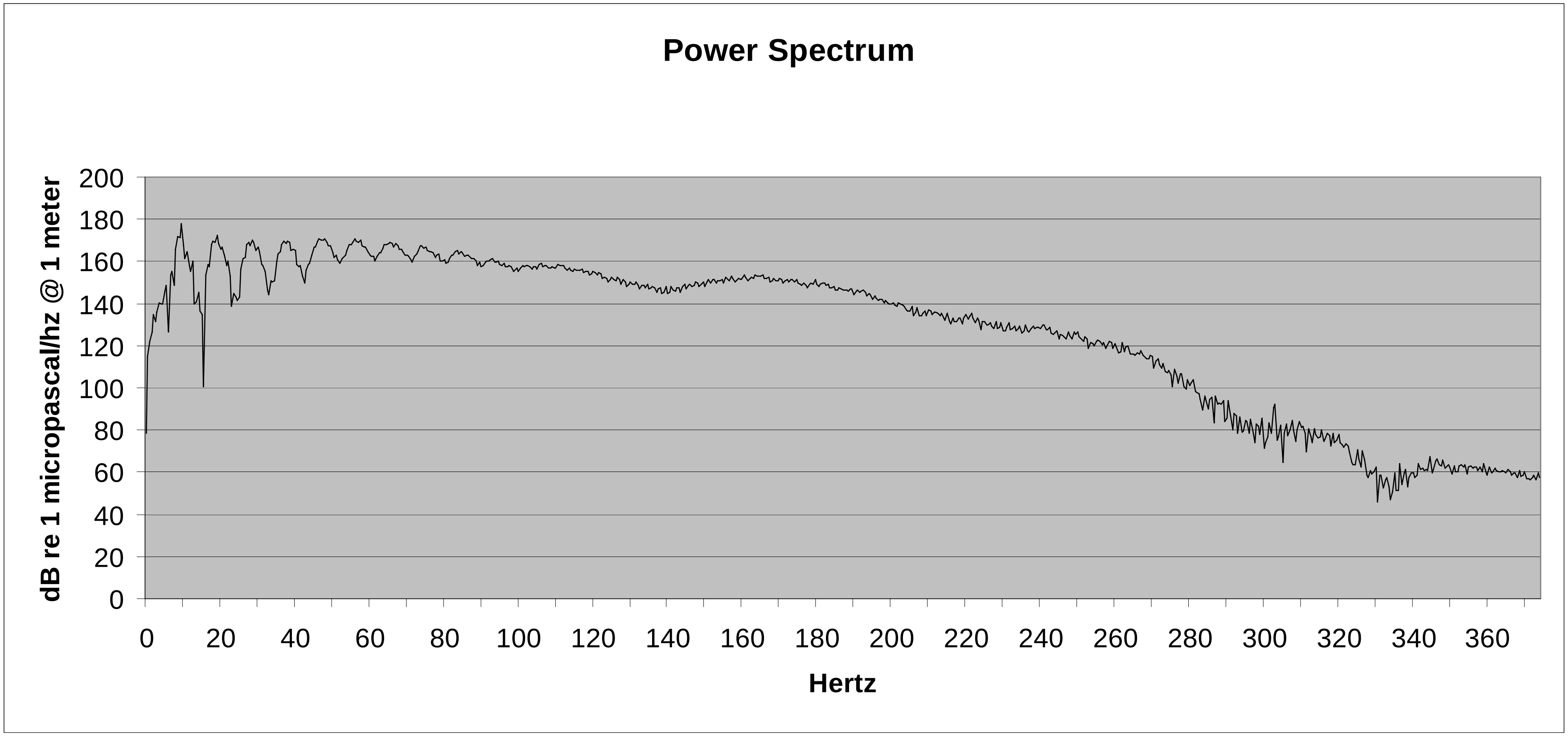
0-P Barm 2.41 P-P Barm 3.28 P/B Ratio = 3.53 Period = 107.75 Depth = 3.38 M Power = 175.04 Db

File 2.73: 150 cu in SeaScan Tri-Cluster ® array (#5 only) @ 10 ft



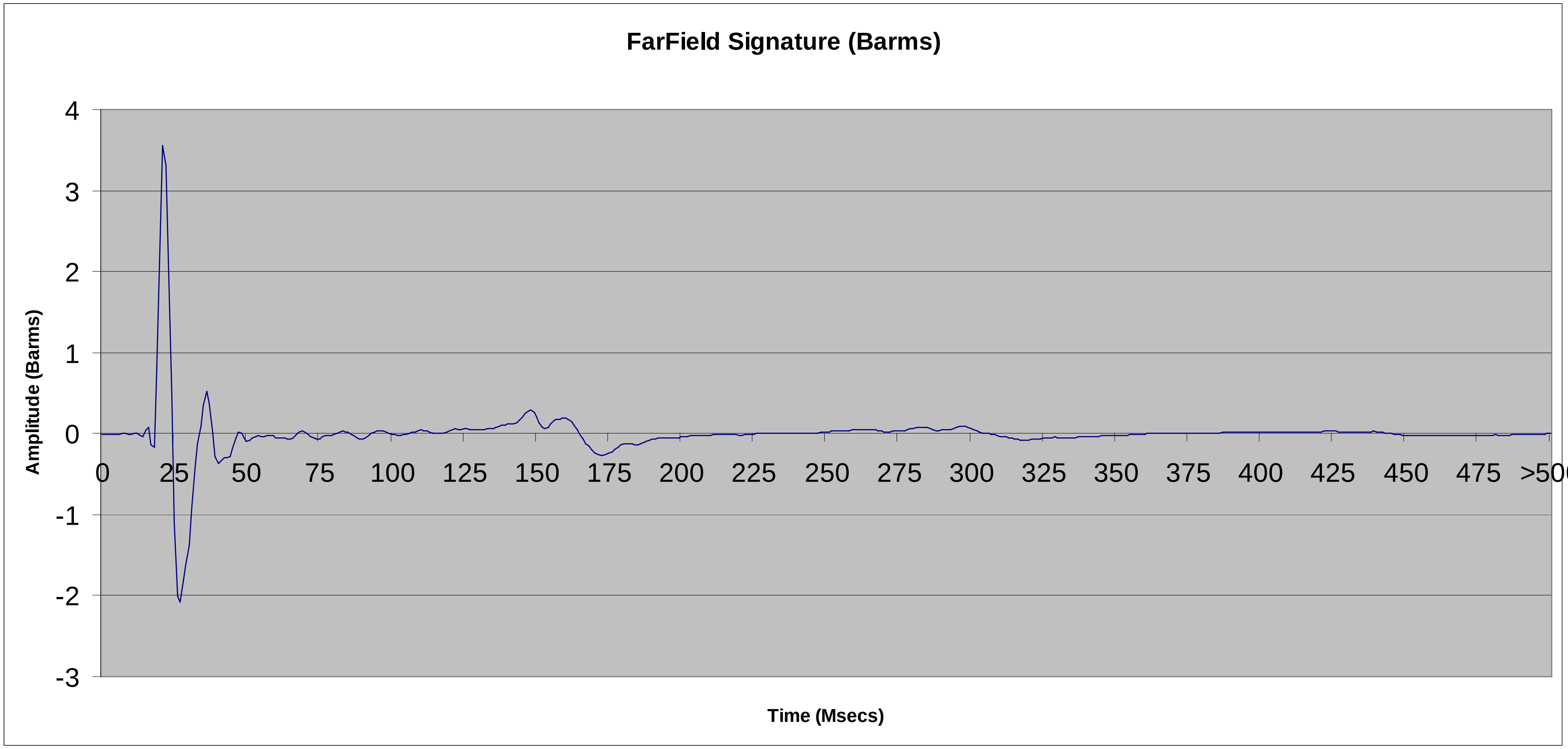
0-P Barm 2.43 P-P Barm 3.42 P/B Ratio = 3.78 Period = 107.00 Depth = 5.81 M Power = 177.94 Db

File 2.73: 150 cu in SeaScan Tri-Cluster ® array (#5 only) @ 10 ft



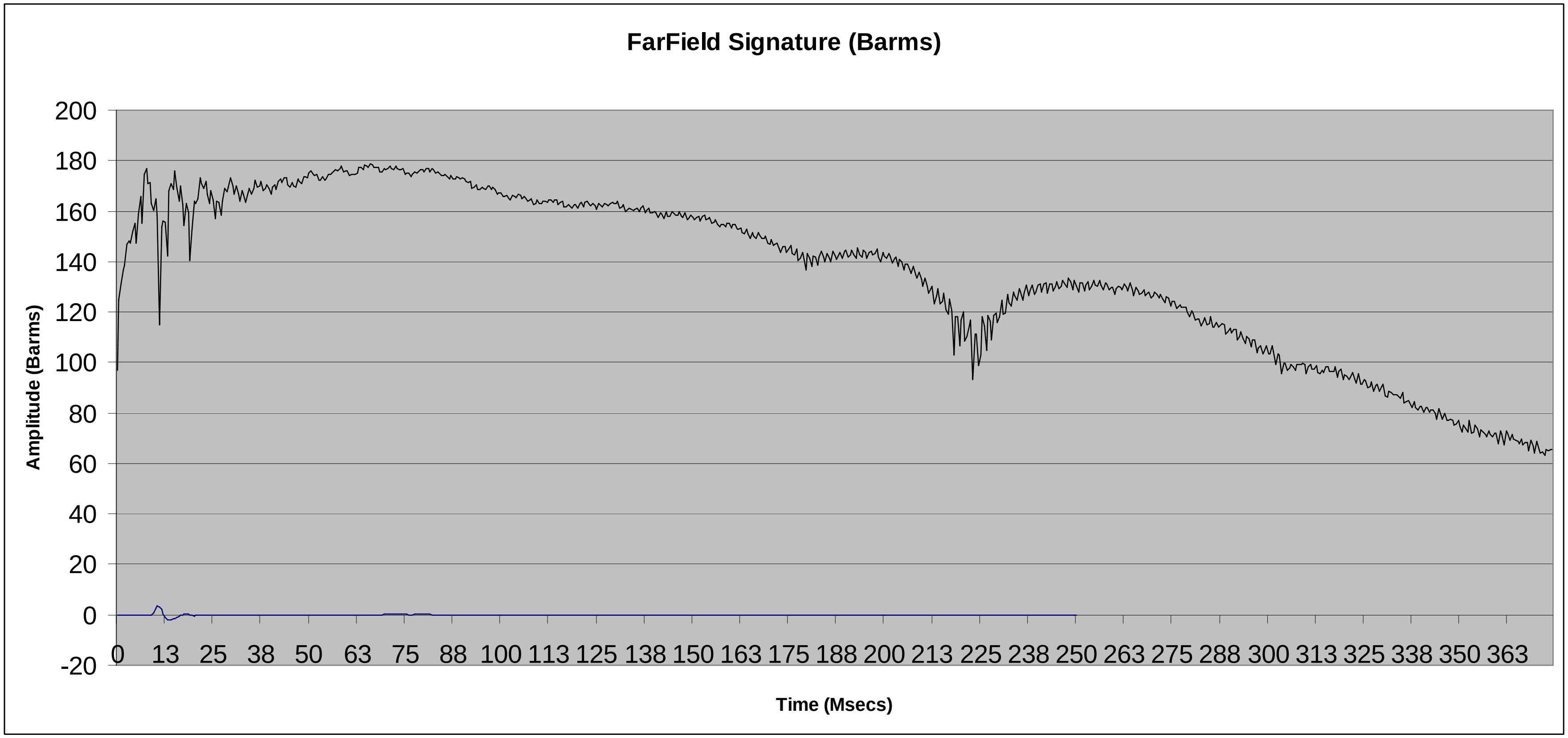
0-P Barm 2.43 P-P Barm 3.42 P/B Ratio = 3.78 Period = 107.00 Depth = 5.81 M Power = 177.94 Db

File 2.74: 300 cu in SeaScan Tri-Cluster ® array (#5 & 6) @ 10 ft



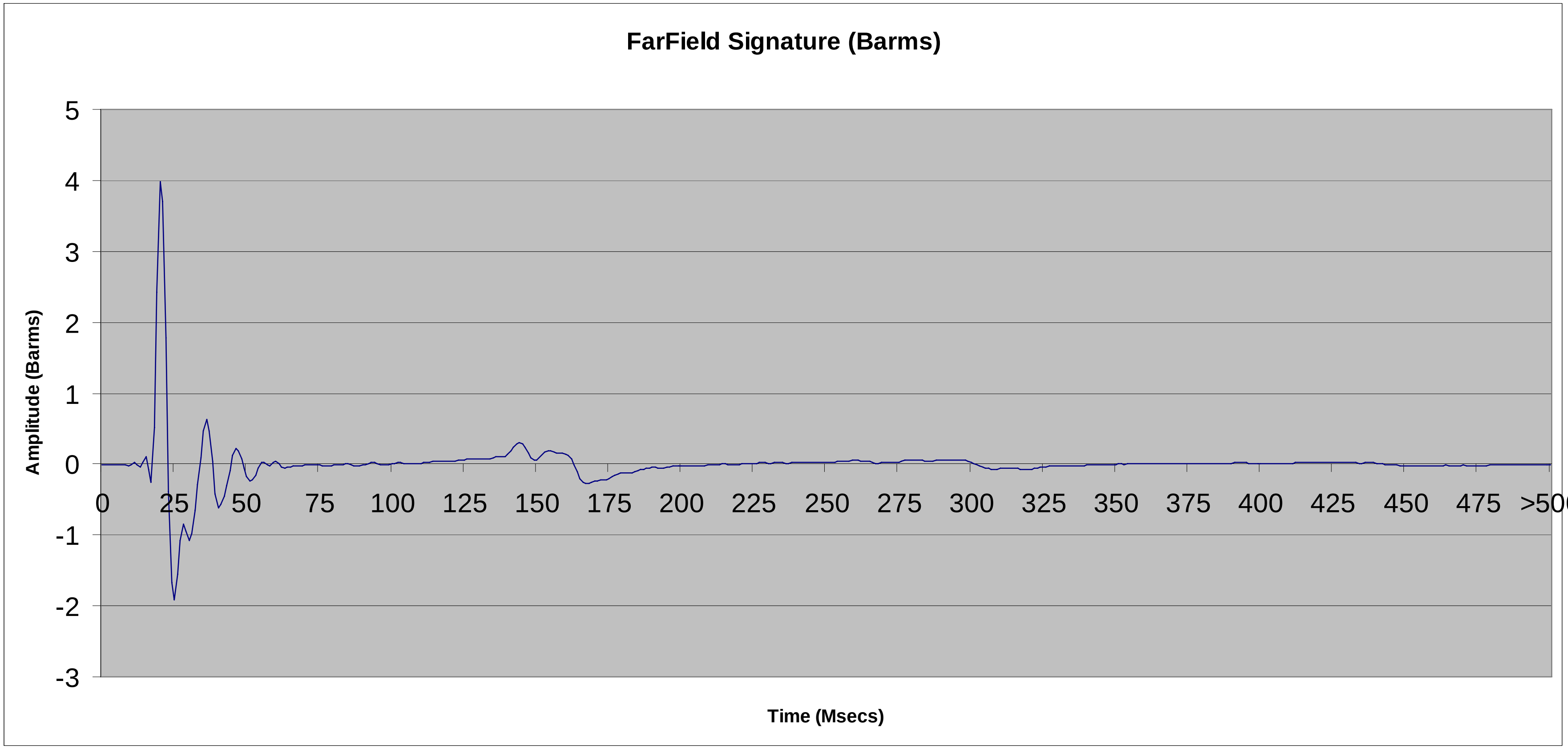
0-P Barm 3.62 P-P Barm 5.75 P/B Ratio = 10.27 Period = 126.75 Depth = 3.94 M Power = 178.70 Db

File 2.74: 300 cu in SeaScan Tri-Cluster ® array (#5 & 6) @ 10 ft



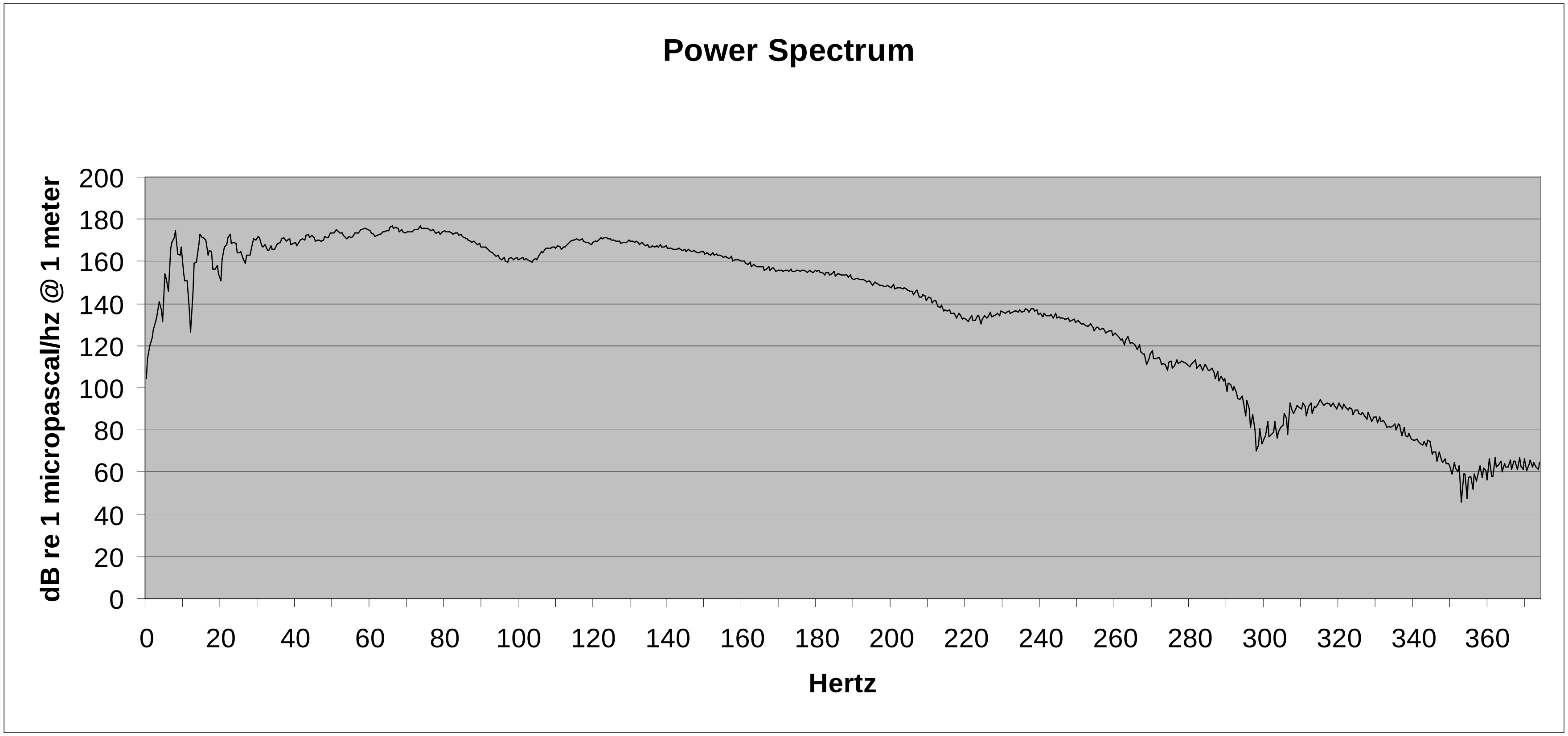
0-P Barm	3.62	P-P Barm	5.75	P/B Ratio =	10.27	Period =	126.75	Depth =	3.94	M	Power =	178.70	Db

File 2.75: 300 cu in SeaScan Tri-Cluster ® array (#5 & 6) @ 10 ft



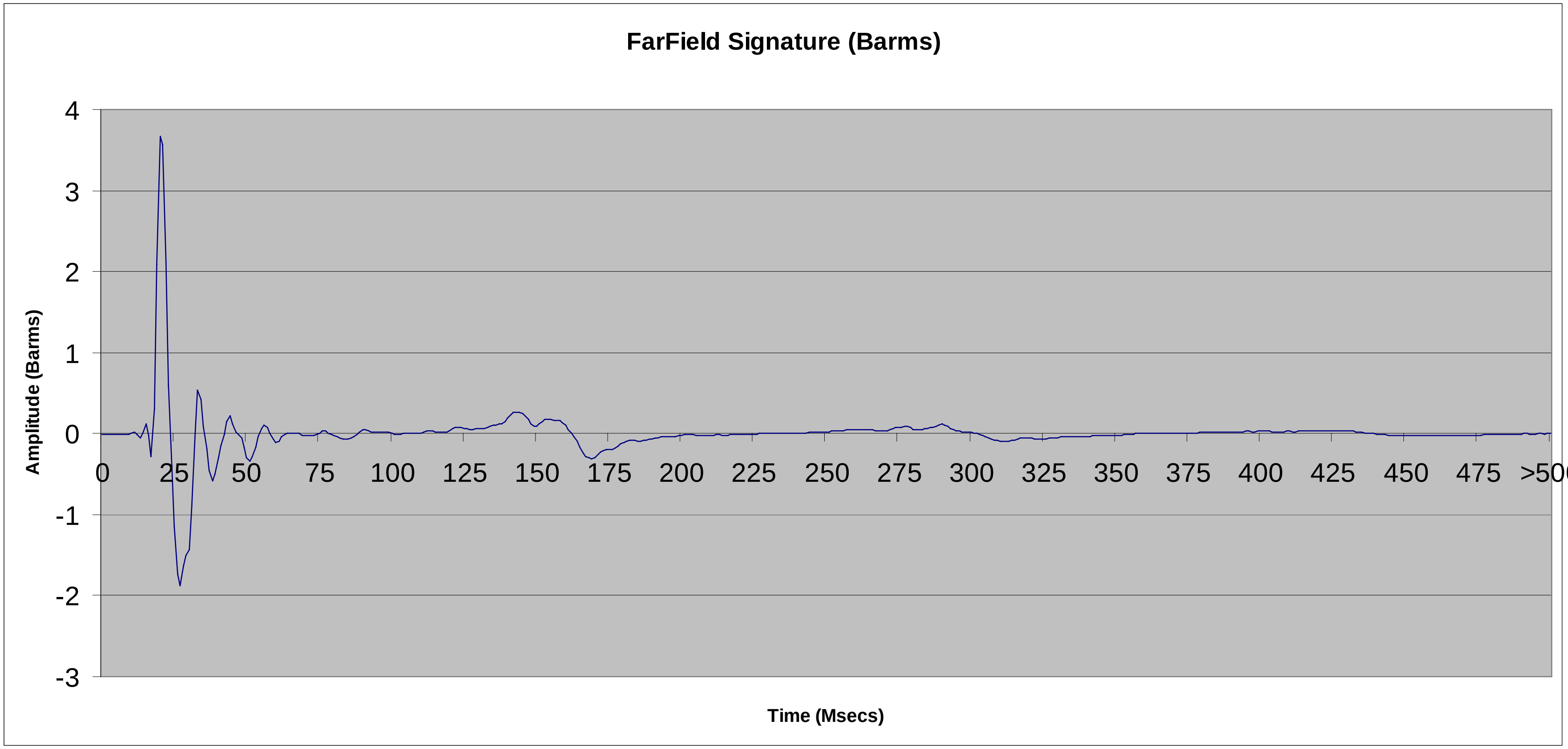
0-P Barm	4.11	P-P Barm	6.04	P/B Ratio =	10.35	Period =	123.75	Depth =	3.38	M	Power =	176.78	Db

File 2.75: 300 cu in SeaScan Tri-Cluster ® array (#5 & 6) @ 10 ft



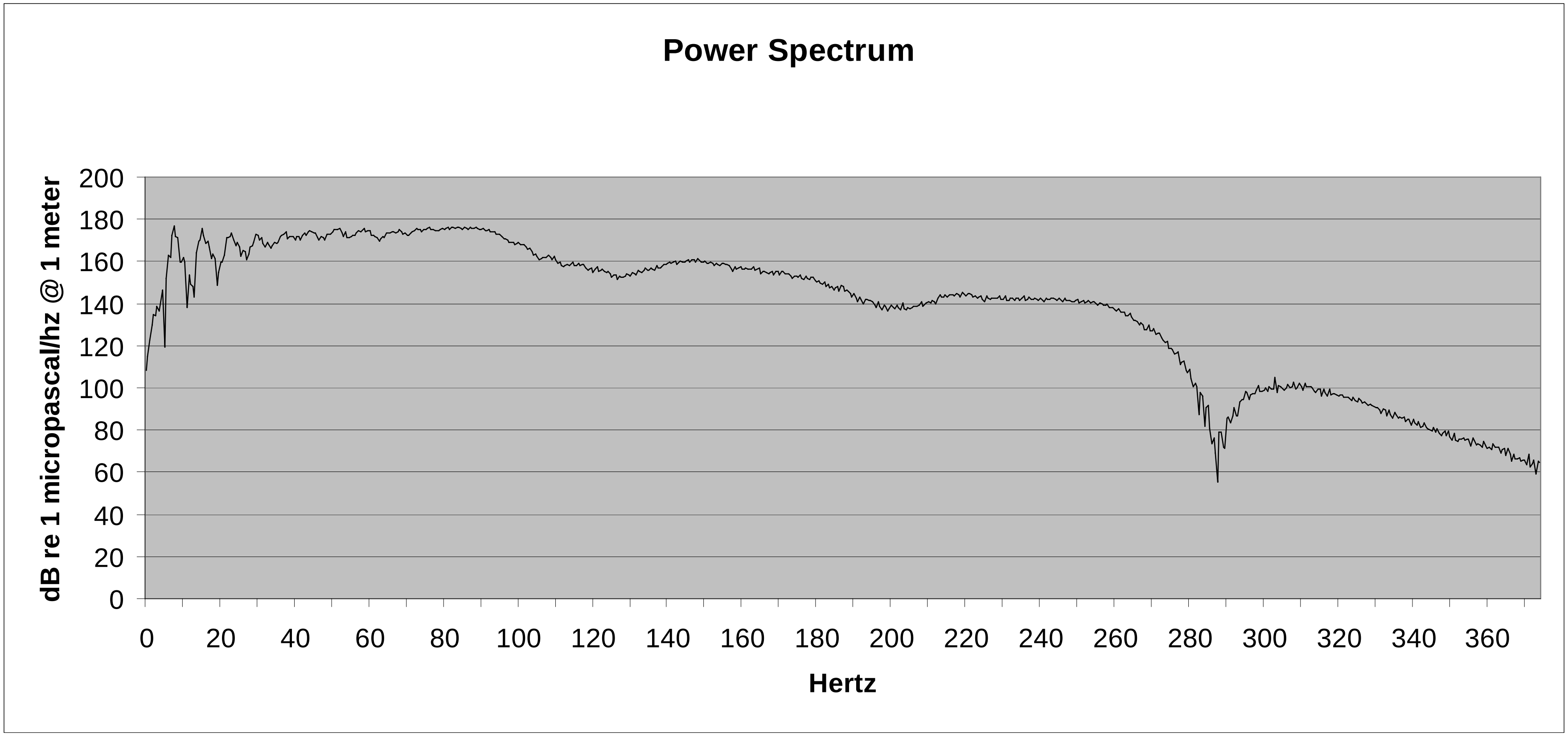
0-P Barm	4.11	P-P Barm	6.04	P/B Ratio =	10.35	Period =	123.75	Depth =	3.38	M	Power =	176.78	Db

File 2.76: 300 cu in SeaScan Tri-Cluster ® array (#5 & 6) @ 10 ft



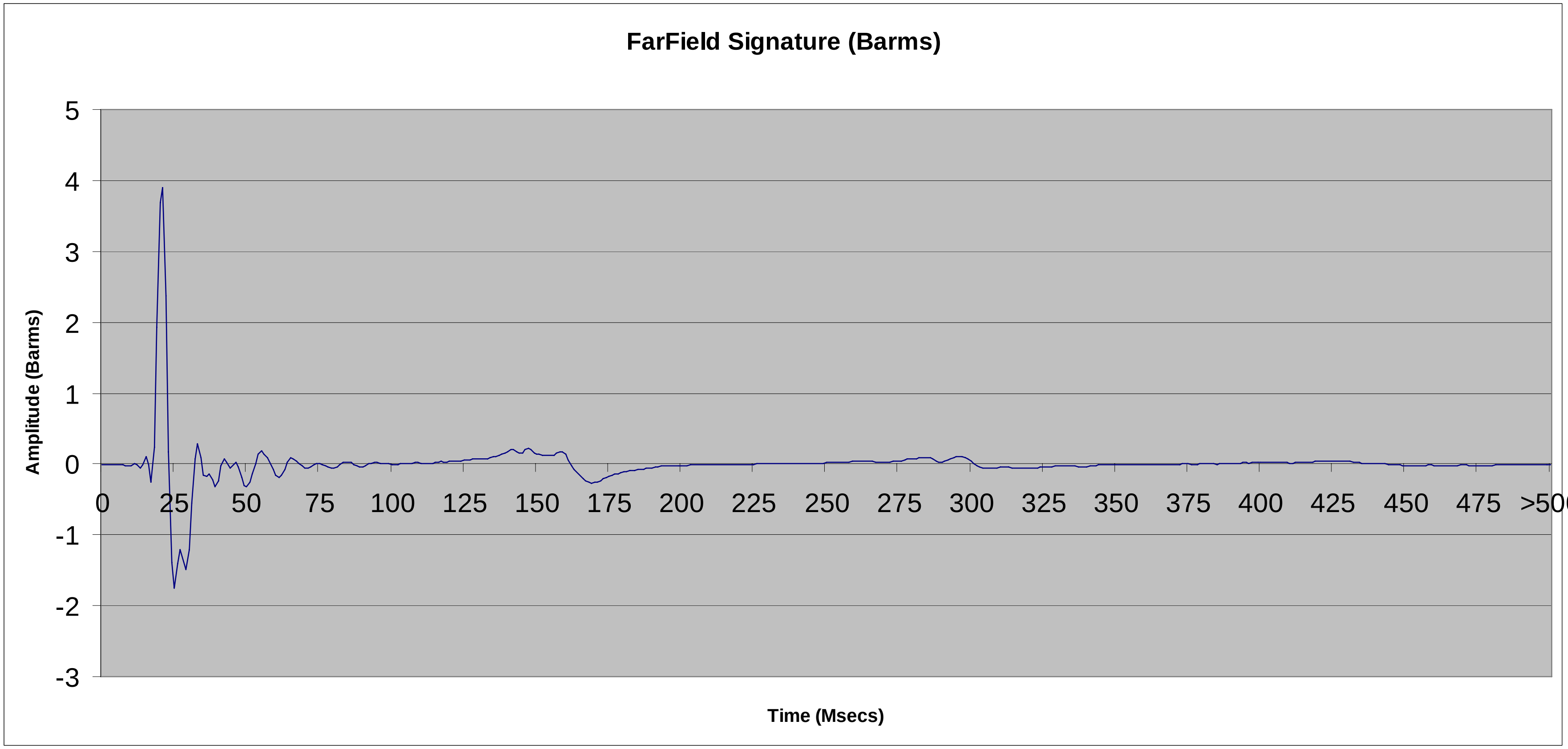
0-P Barm 3.85 P-P Barm 5.74 P/B Ratio = 10.07 Period = 122.00 Depth = 4.69 M Power = 176.81 Db

File 2.76: 300 cu in SeaScan Tri-Cluster ® array (#5 & 6) @ 10 ft



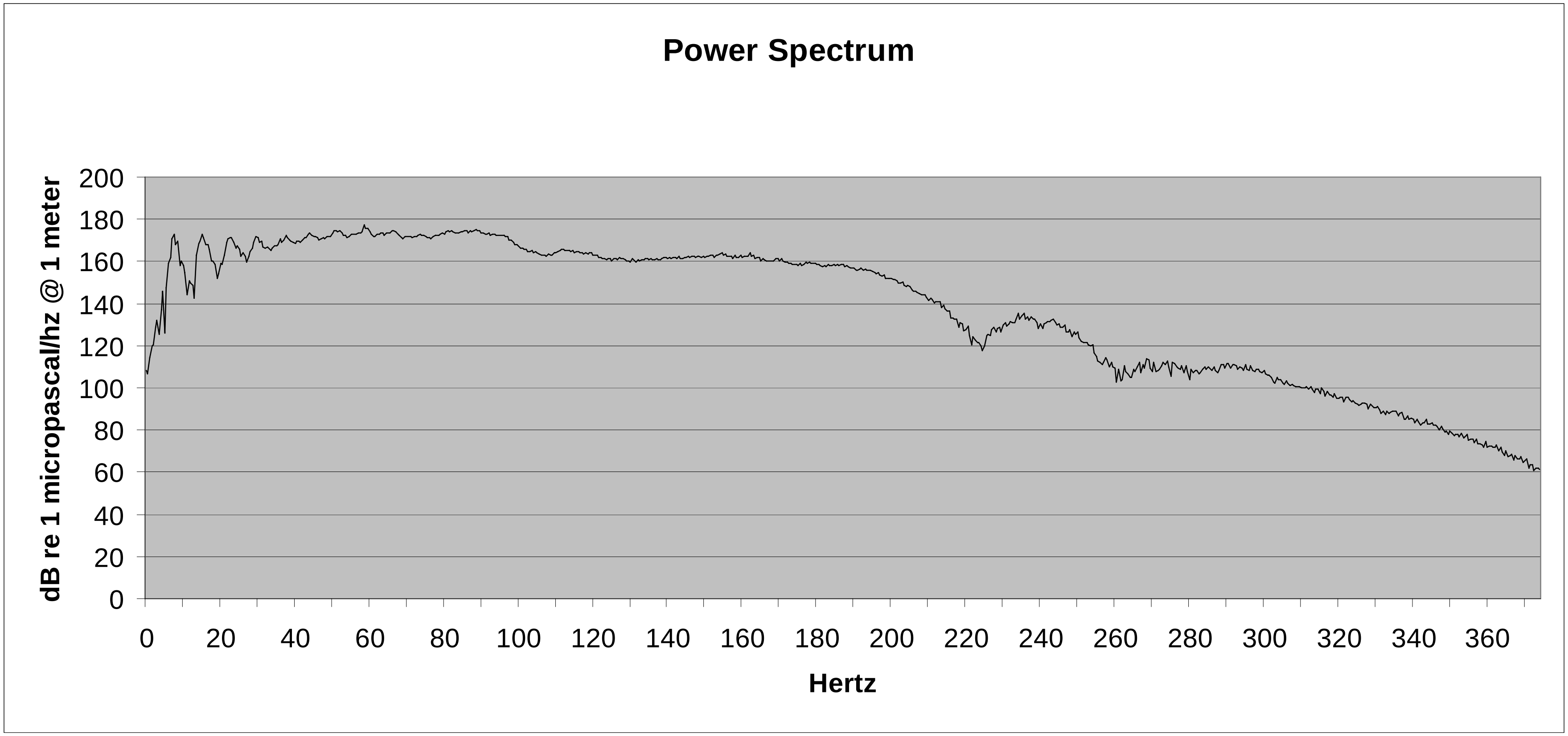
0-P Barm	3.85	P-P Barm	5.74	P/B Ratio =	10.07	Period =	122.00	Depth =	4.69	M	Power =	176.81	Db

File 2.77: 300 cu in SeaScan Tri-Cluster ® array (#5 & 6) @ 10 ft



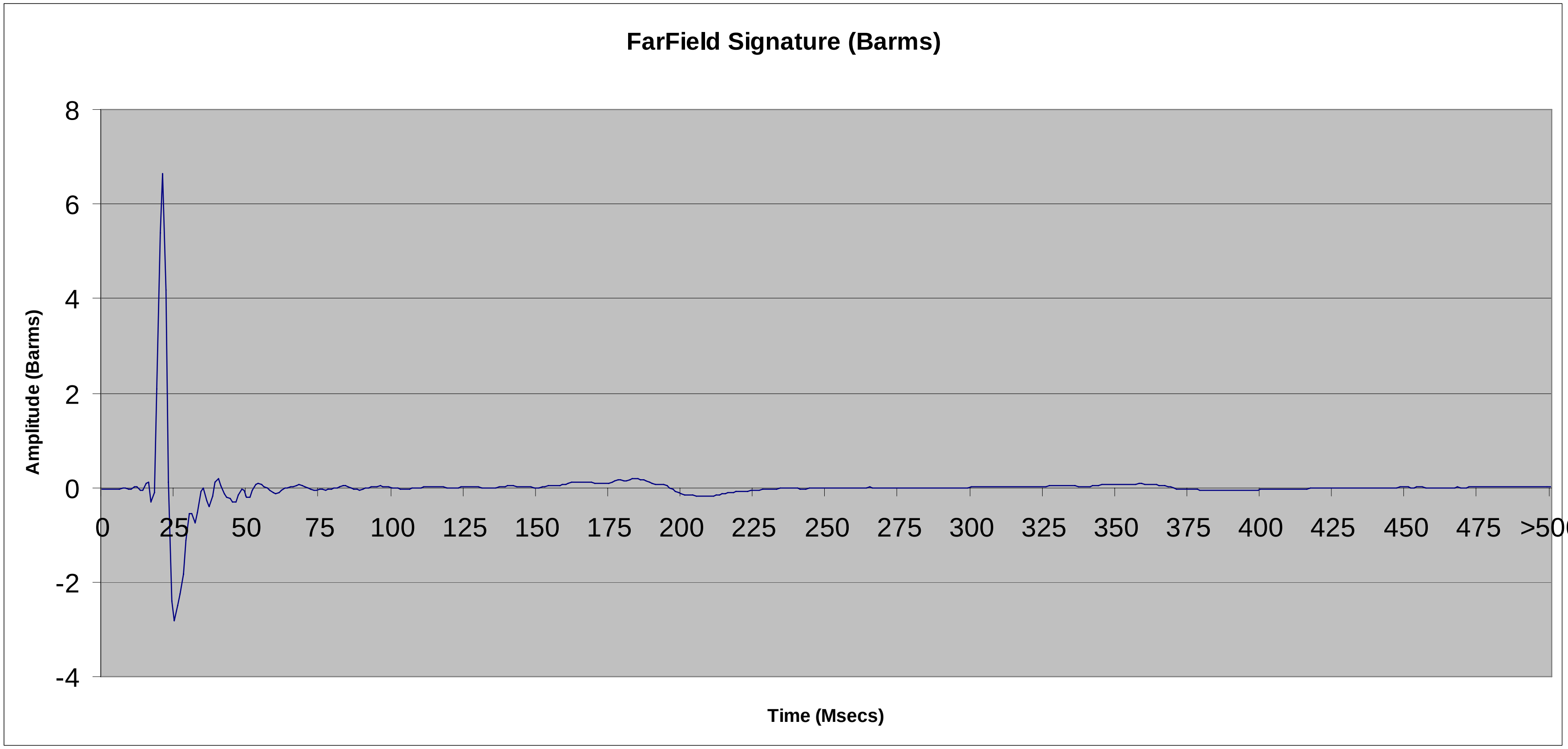
0-P Barm 4.03 P-P Barm 5.80 P/B Ratio = 10.83 Period = 126.50 Depth = 3.19 M Power = 177.16 Db

File 2.77: 300 cu in SeaScan Tri-Cluster ® array (#5 & 6) @ 10 ft



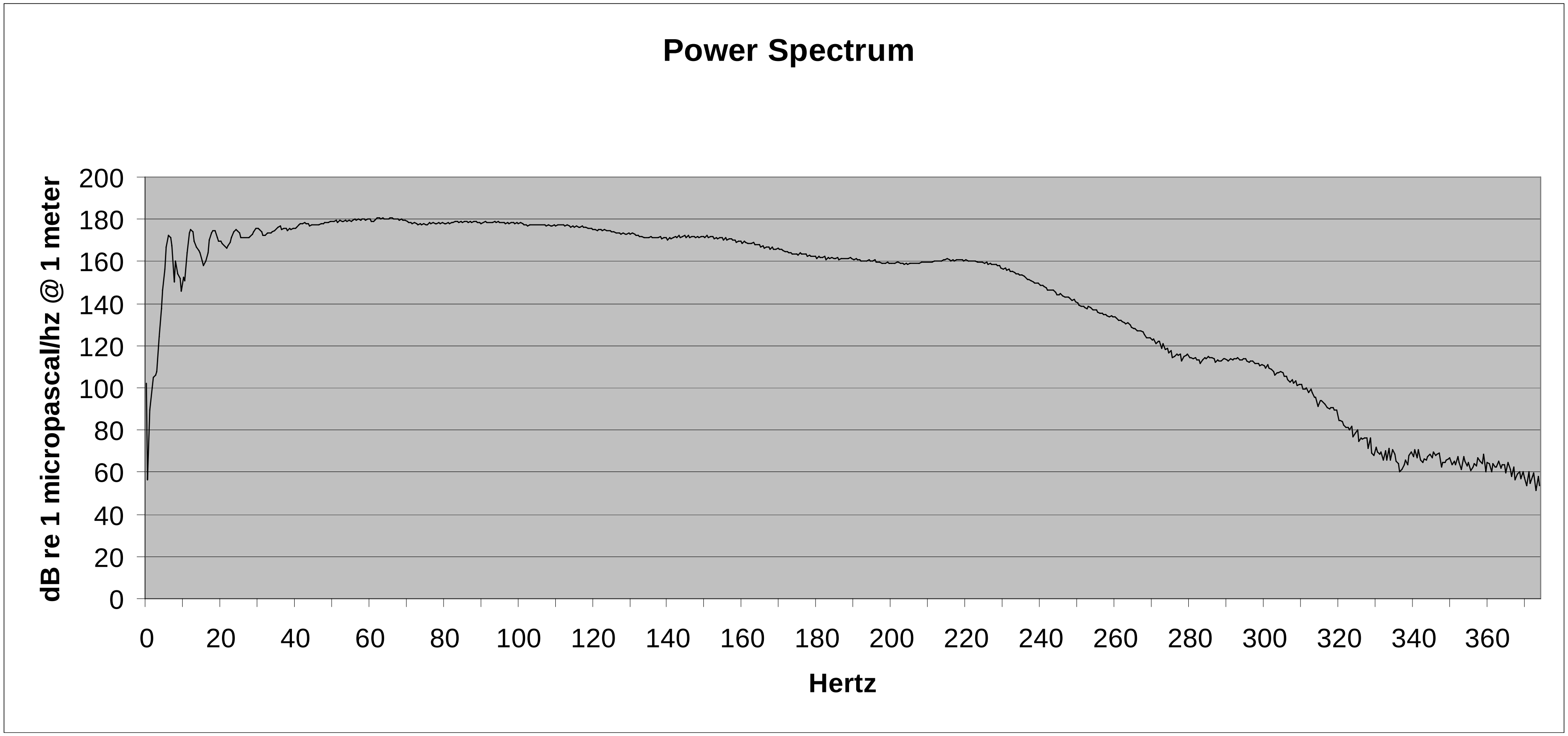
0-P Barm	4.03	P-P Barm	5.80	P/B Ratio =	10.83	Period =	126.50	Depth =	3.19	M	Power =	177.16	Db

File 2.78: 600 cu in SeaScan Tri-Cluster ® array (#3,4,5,6 only) @ 10 ft



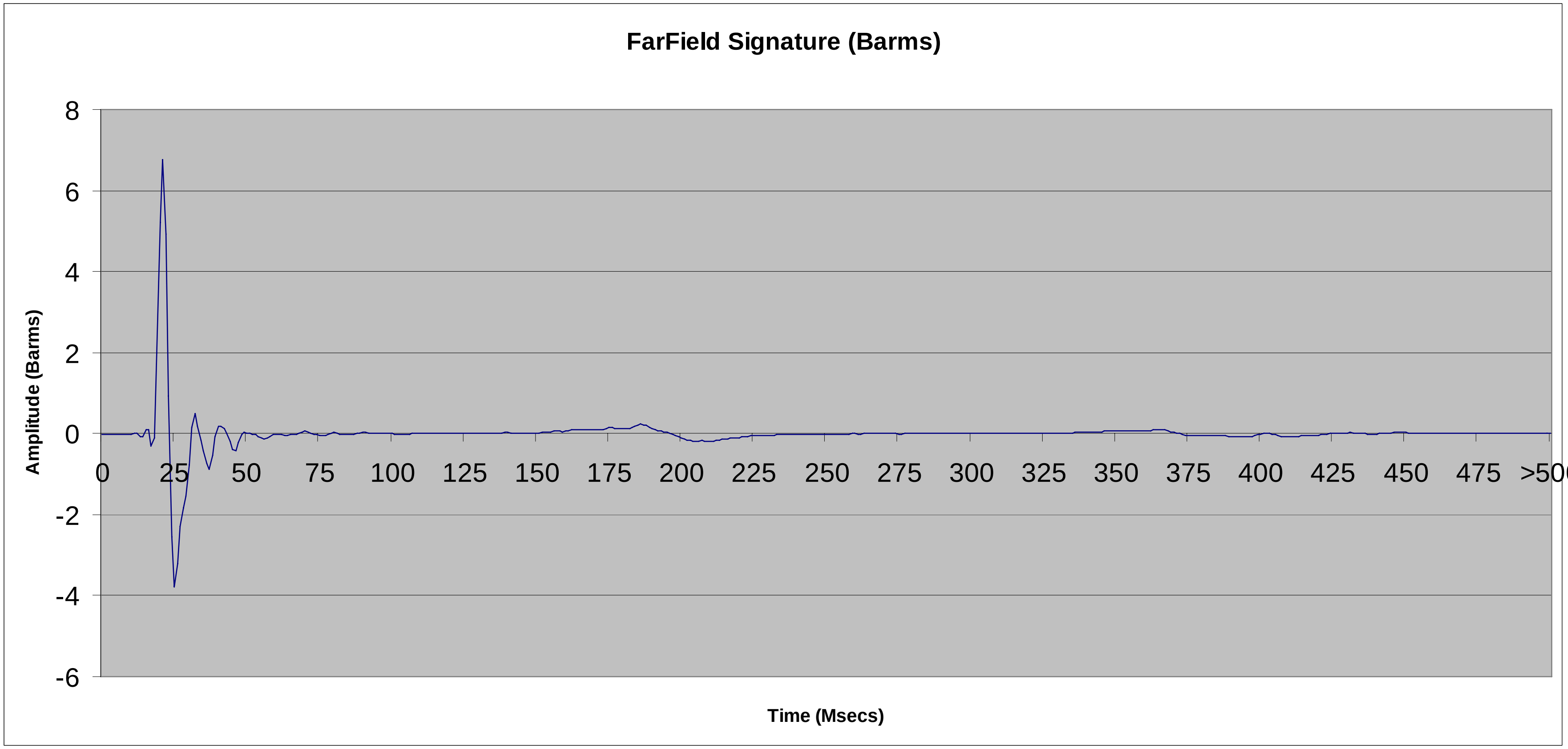
0-P Barm	6.68	P-P Barm	9.52	P/B Ratio =	22.65	Period =	163.50	Depth =	3.00	M	Power =	180.85 Db

File 2.78: 600 cu in SeaScan Tri-Cluster ® array (#3,4,5,6 only) @ 10 ft



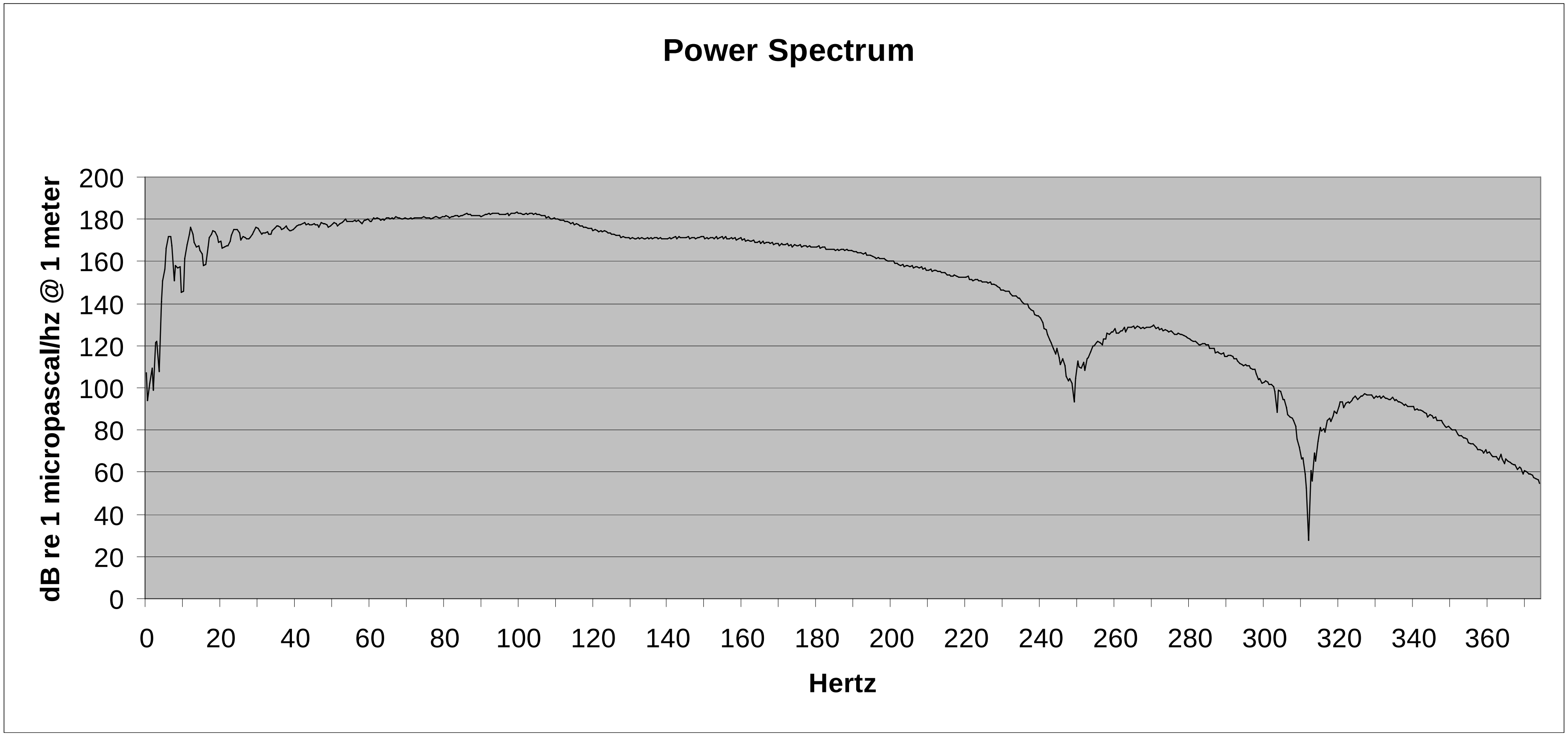
0-P Barm 6.68 P-P Barm 9.52 P/B Ratio = 22.65 Period = 163.50 Depth = 3.00 M Power = 180.85 Db

File 2.79: 600 cu in SeaScan Tri-Cluster ® array (#3,4,5,6 only) @ 10 ft



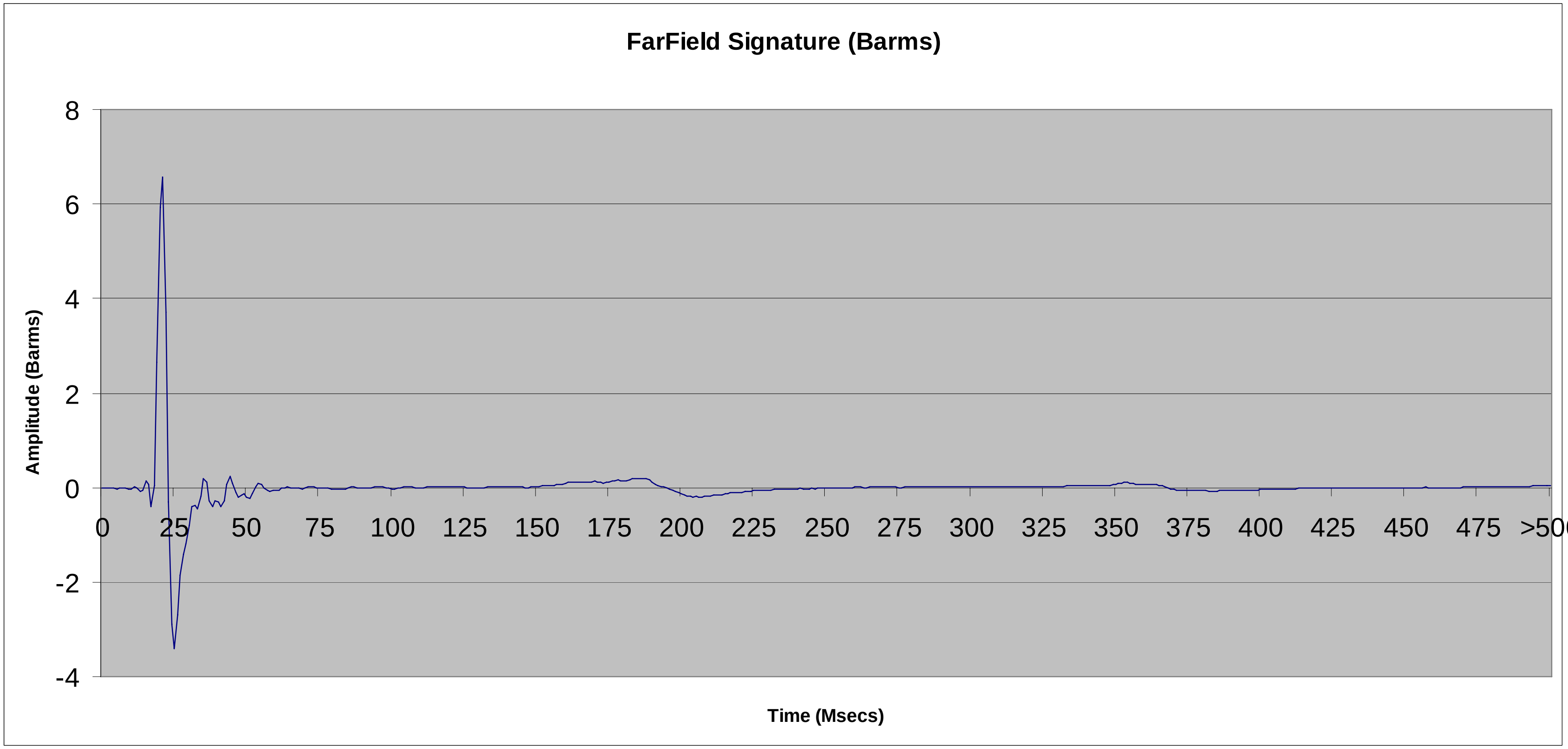
0-P Barm	6.75	P-P Barm	10.55	P/B Ratio =	25.13	Period =	165.25	Depth =	3.00	M	Power =	183.18	Db

File 2.79: 600 cu in SeaScan Tri-Cluster ® array (#3,4,5,6 only) @ 10 ft



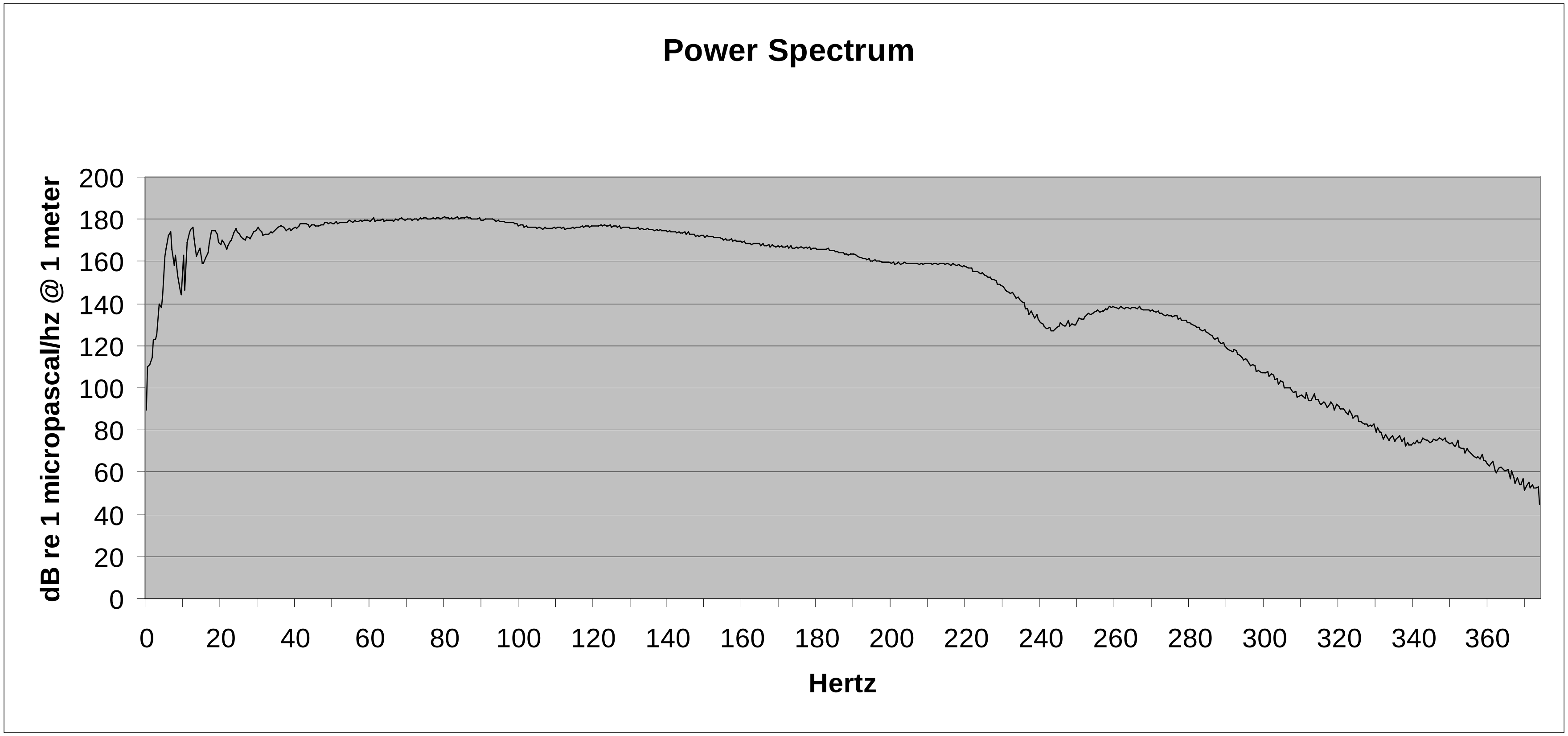
0-P Barm	6.75	P-P Barm	10.55	P/B Ratio =	25.13	Period =	165.25	Depth =	3.00	M	Power =	183.18	Db

File 2.80: 600 cu in SeaScan Tri-Cluster ® array (#3,4,5,6 only) @ 10 ft



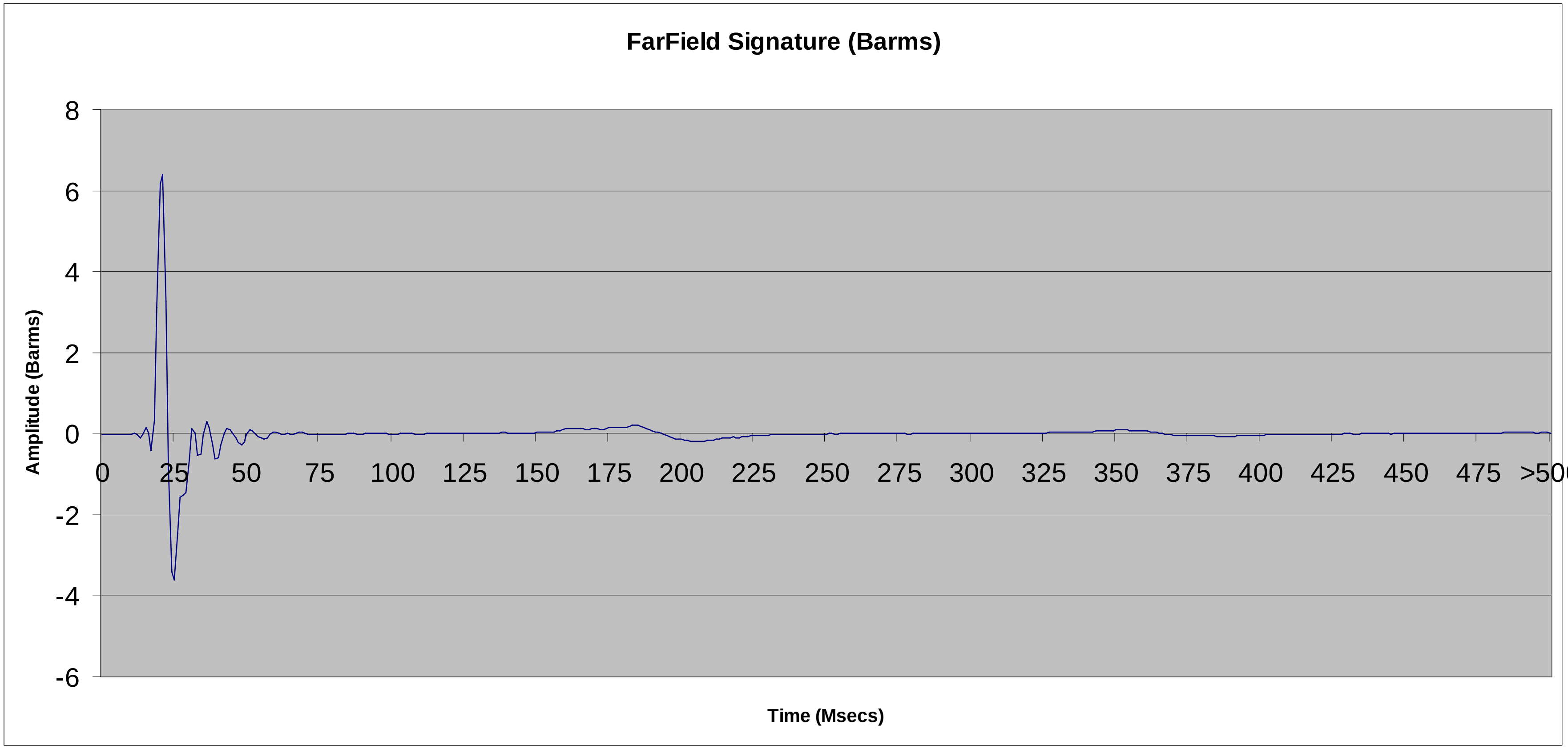
0-P Barm	6.78	P-P Barm	10.22	P/B Ratio =	24.21	Period =	162.75	Depth =	3.00	M	Power =	181.11	Db

File 2.80: 600 cu in SeaScan Tri-Cluster ® array (#3,4,5,6 only) @ 10 ft



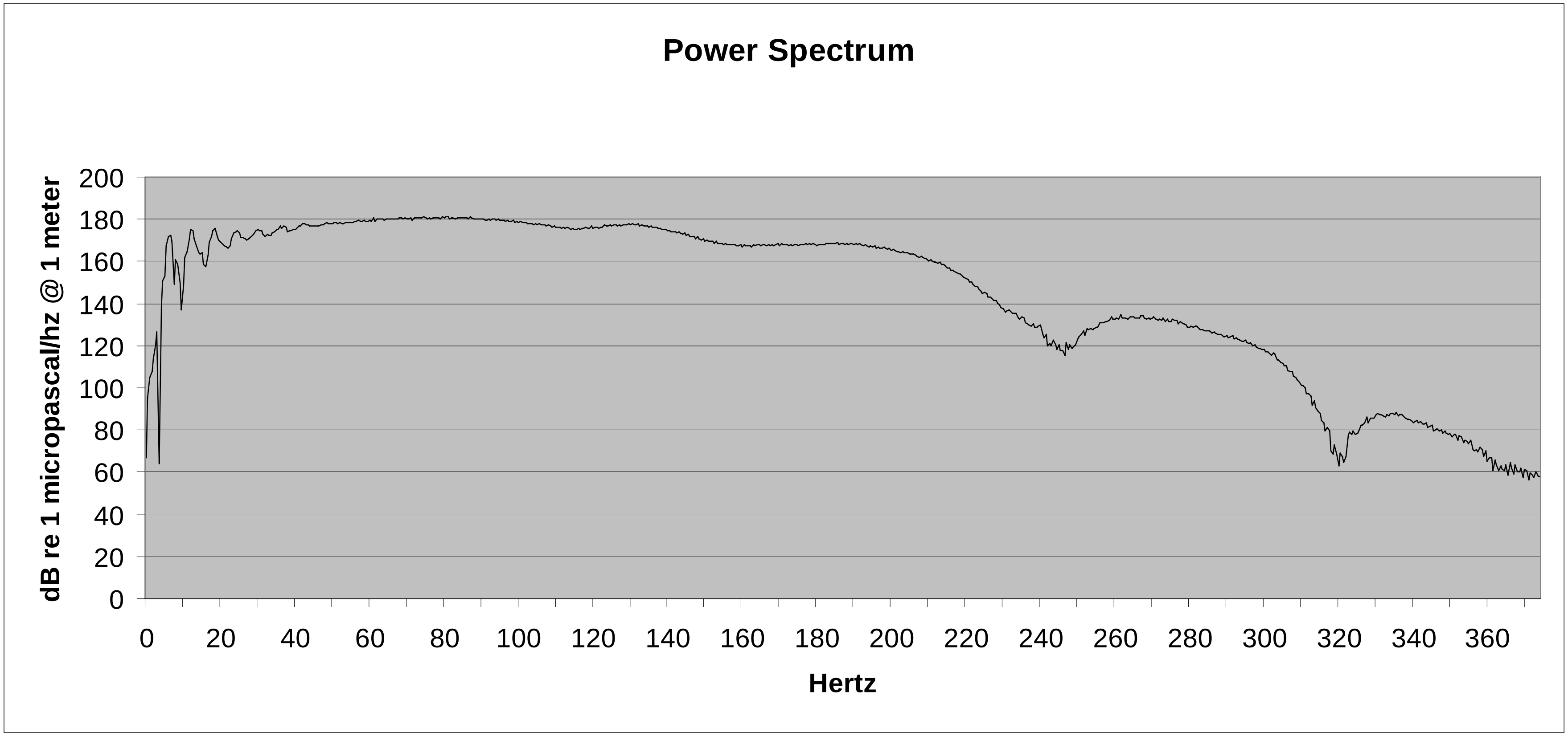
0-P Barm	6.78	P-P Barm	10.22	P/B Ratio =	24.21	Period =	162.75	Depth =	3.00	M	Power =	181.11	Db

File 2.81: 600 cu in SeaScan Tri-Cluster ® array (#3,4,5,6 only) @ 10 ft



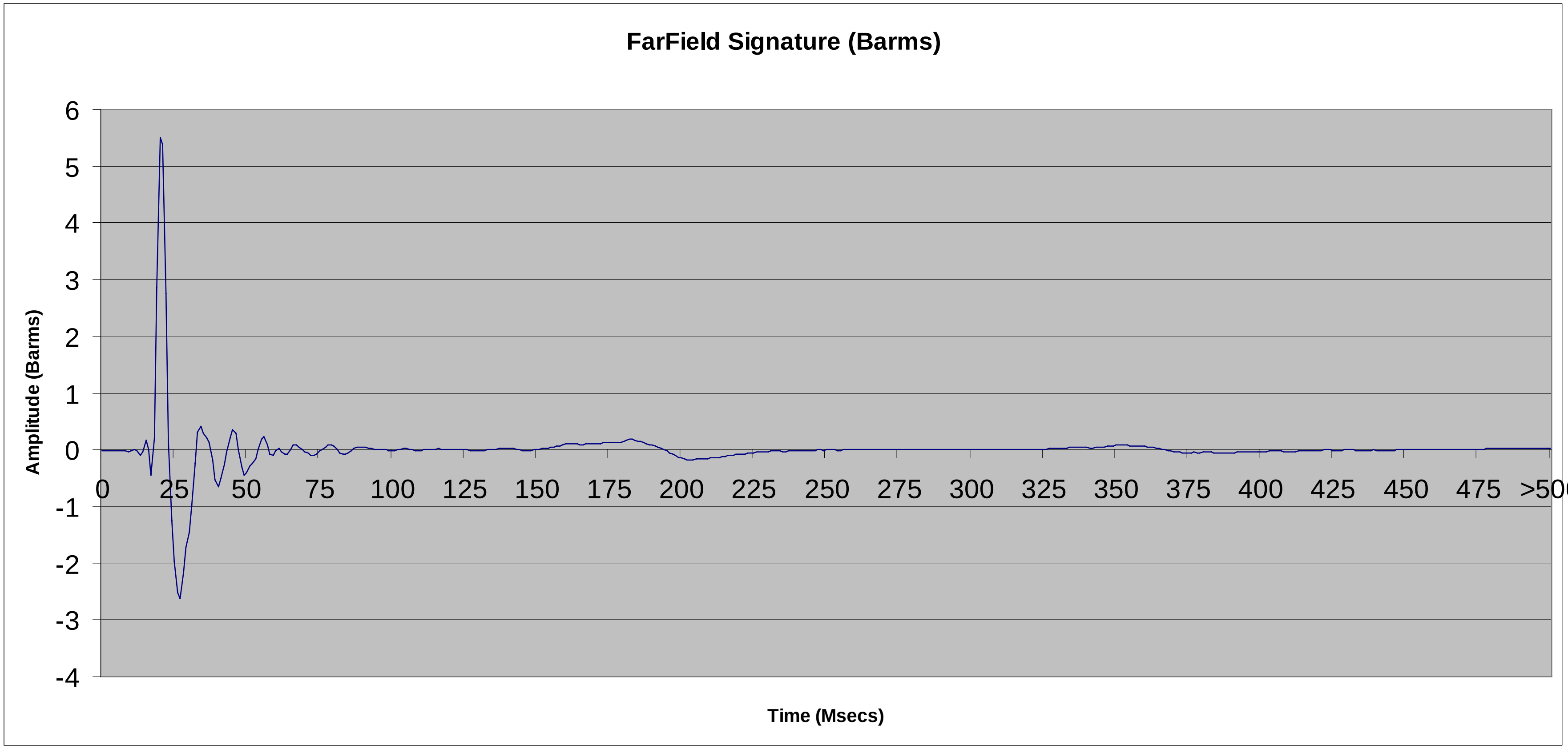
0-P Barm	6.75	P-P Barm	10.54	P/B Ratio =	25.78	Period =	163.50	Depth =	3.00	M	Power =	181.02	Db

File 2.81: 600 cu in SeaScan Tri-Cluster ® array (#3,4,5,6 only) @ 10 ft



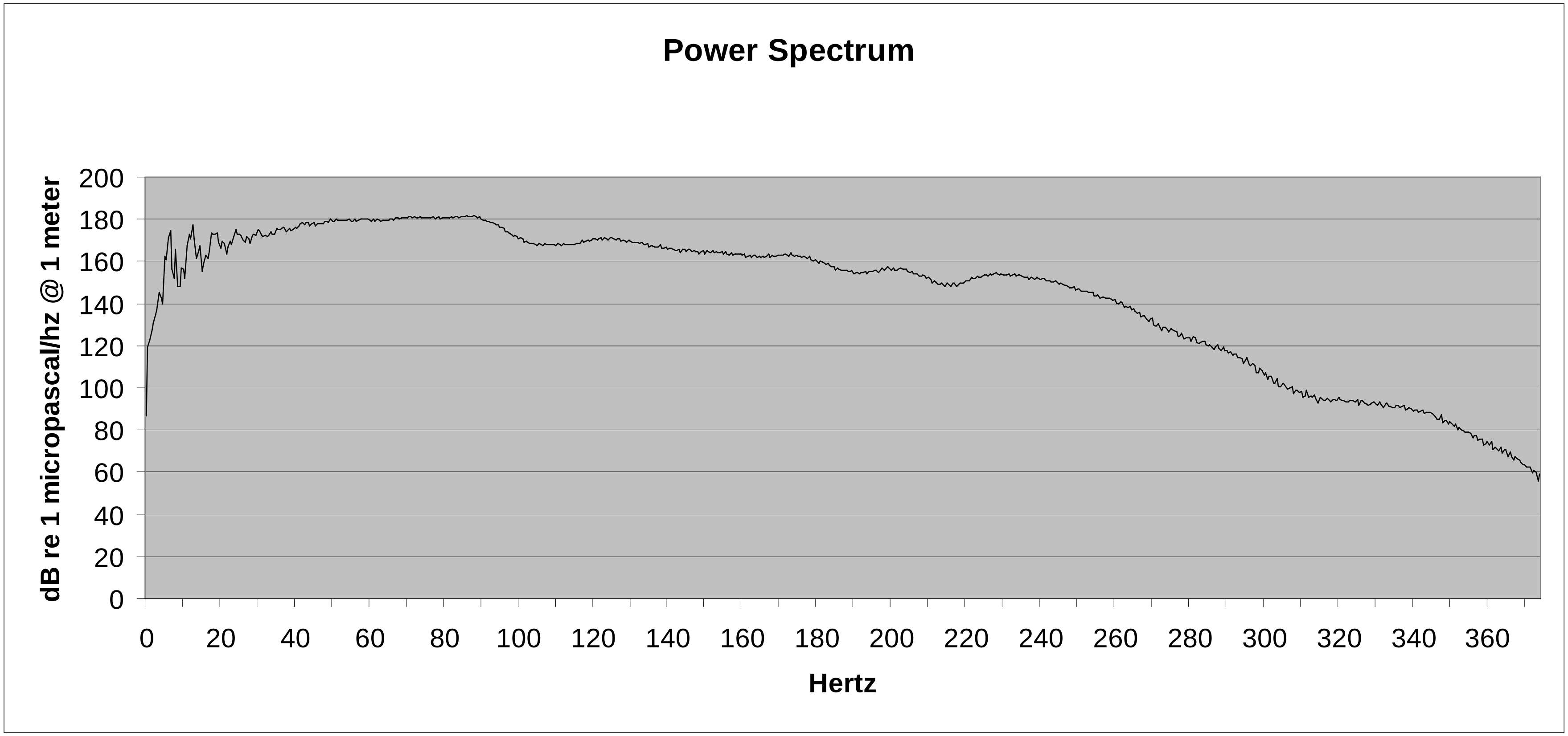
0-P Barm	6.75	P-P Barm	10.54	P/B Ratio =	25.78	Period =	163.50	Depth =	3.00	M	Power =	181.02	Db

File 2.82: 600 cu in SeaScan Tri-Cluster ® array (#3,4,5,6 only) @ 10 ft



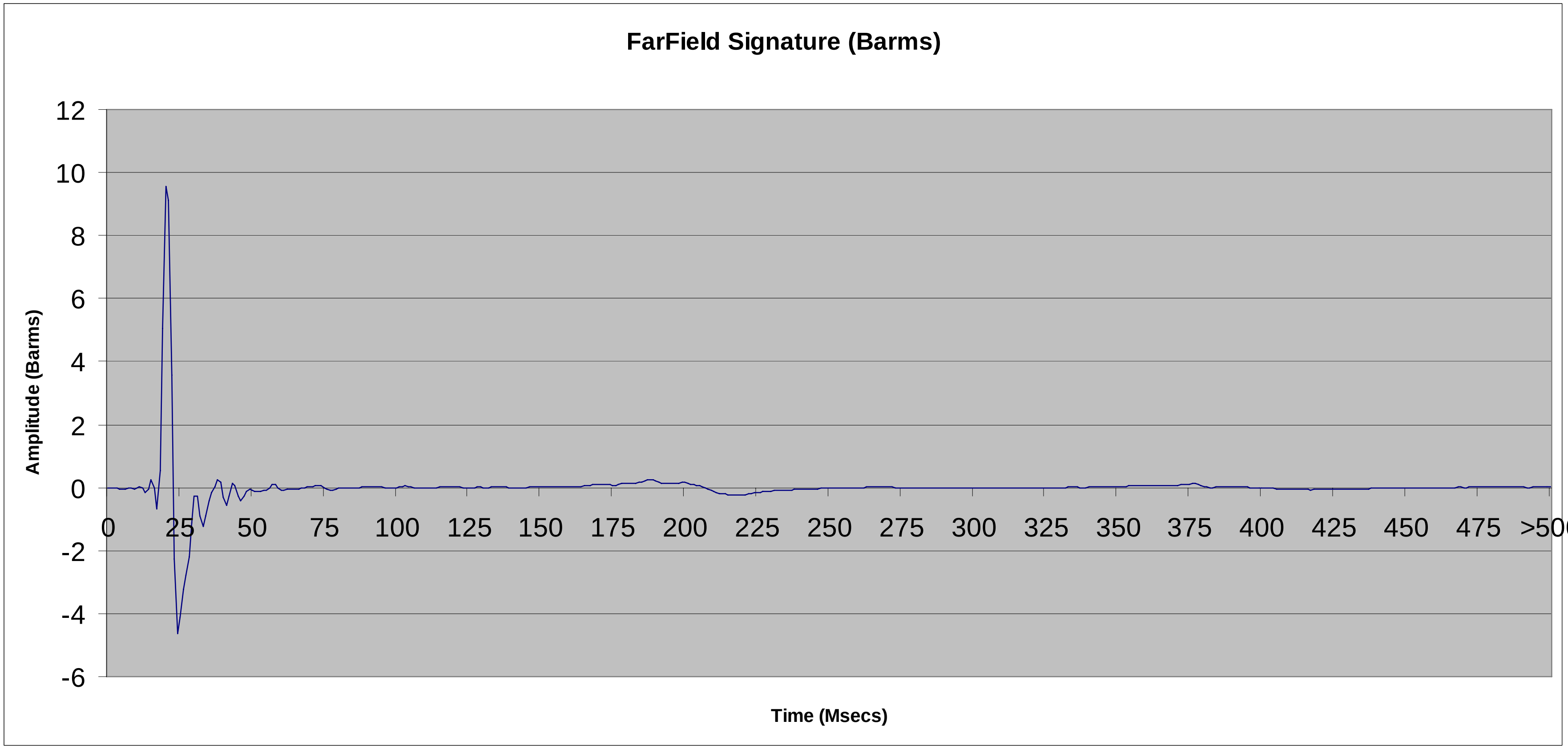
0-P Barm	5.87	P-P Barm	8.53	P/B Ratio =	17.63	Period =	35.25	Depth =	4.69	M	Power =	181.65	Db

File 2.82: 600 cu in SeaScan Tri-Cluster ® array (#3,4,5,6 only) @ 10 ft



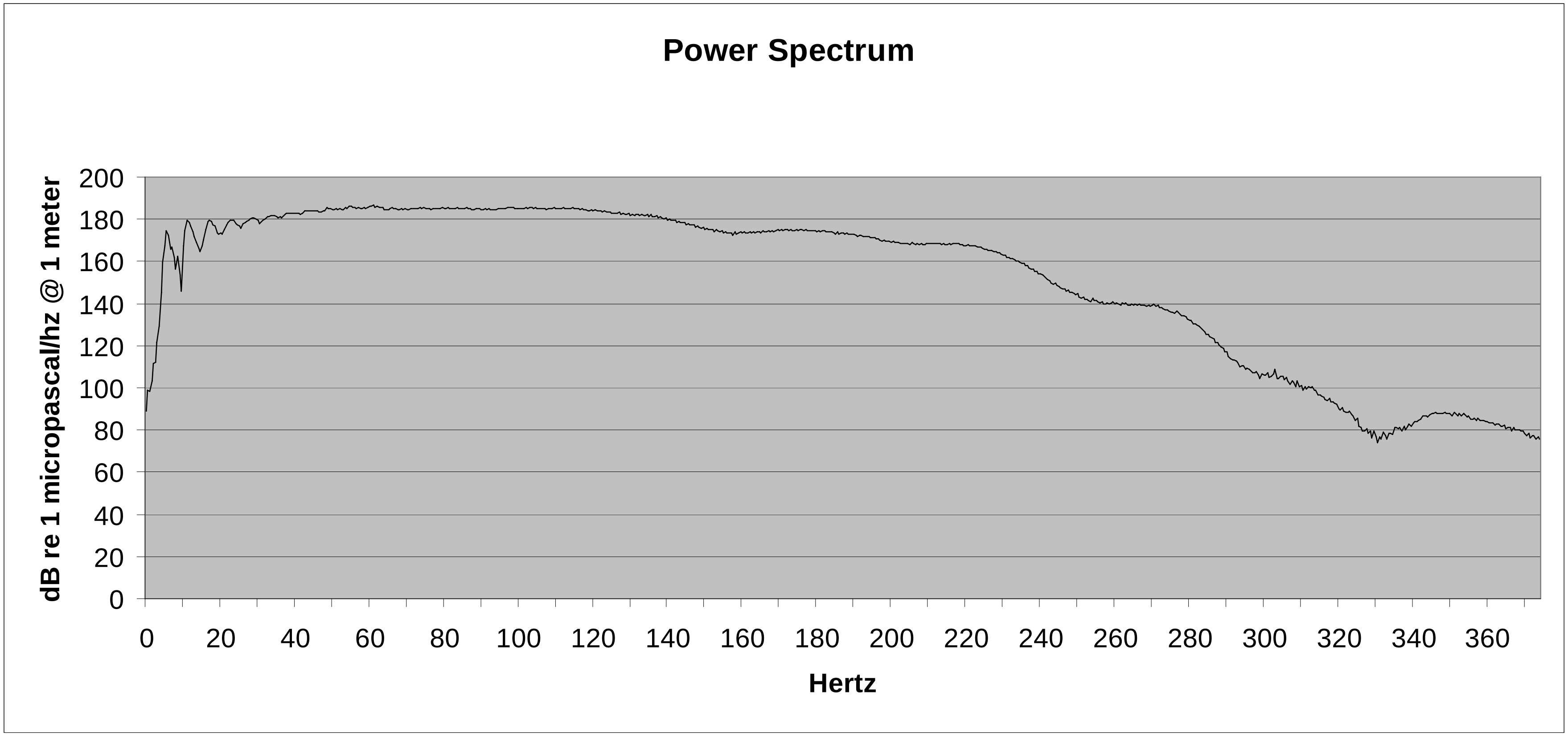
0-P Barm	5.87	P-P Barm	8.53	P/B Ratio =	17.63	Period =	35.25	Depth =	4.69	M	Power =	181.65	Db

File 2.83: 900 cu in SeaScan Tri-Cluster ® array (#1,2,3,4,5,6 only) @ 10 ft



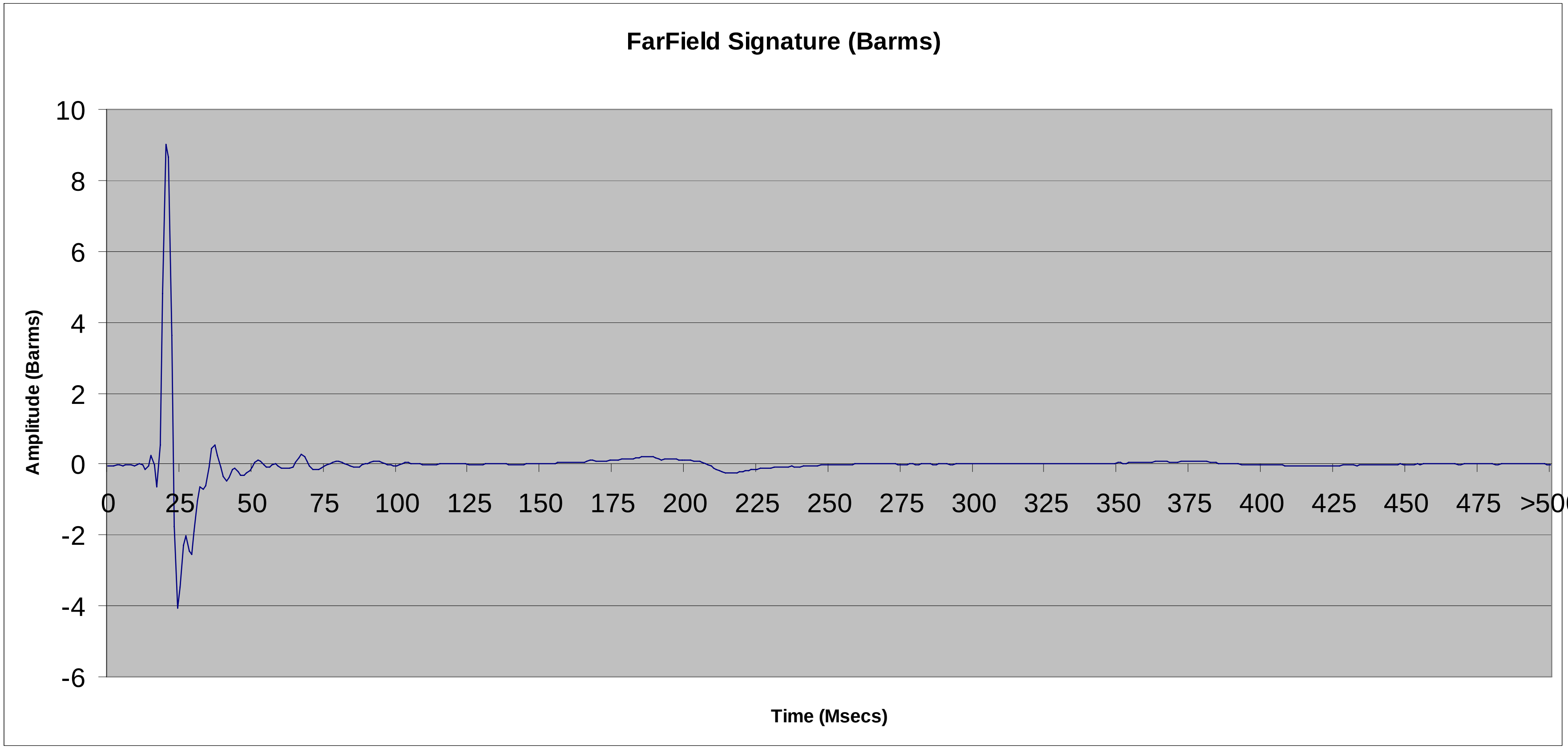
0-P Barm	10.12	P-P Barm	14.79	P/B Ratio =	30.00	Period =	168.25	Depth =	2.81	M	Power =	186.55	Db

File 2.83: 900 cu in SeaScan Tri-Cluster ® array (#1,2,3,4,5,6 only) @ 10 ft



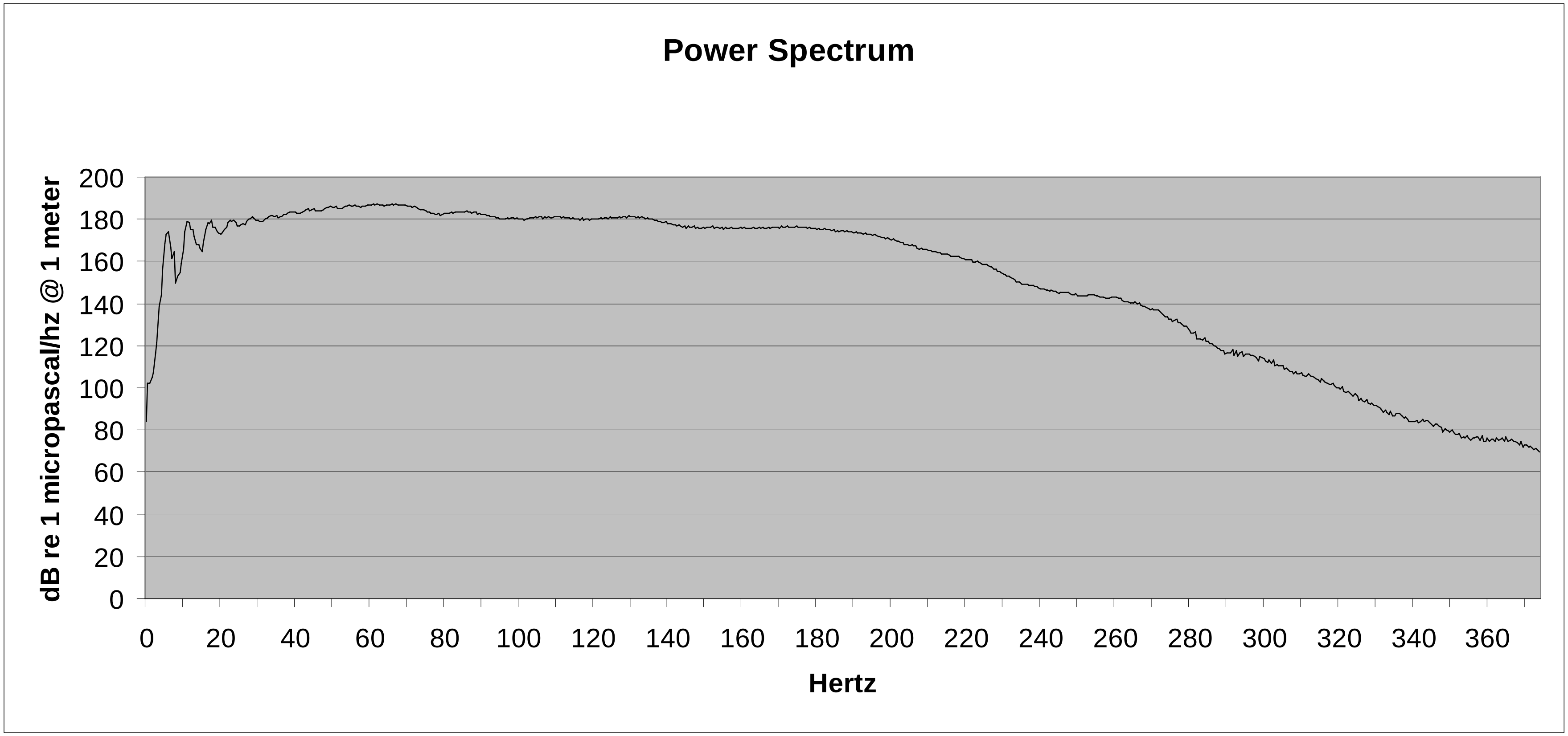
0-P Barm 10.12 P-P Barm 14.79 P/B Ratio = 30.00 Period = 168.25 Depth = 2.81 M Power = 186.55 Db

File 2.84: 900 cu in SeaScan Tri-Cluster ® array (#1,2,3,4,5,6 only) @ 10 ft



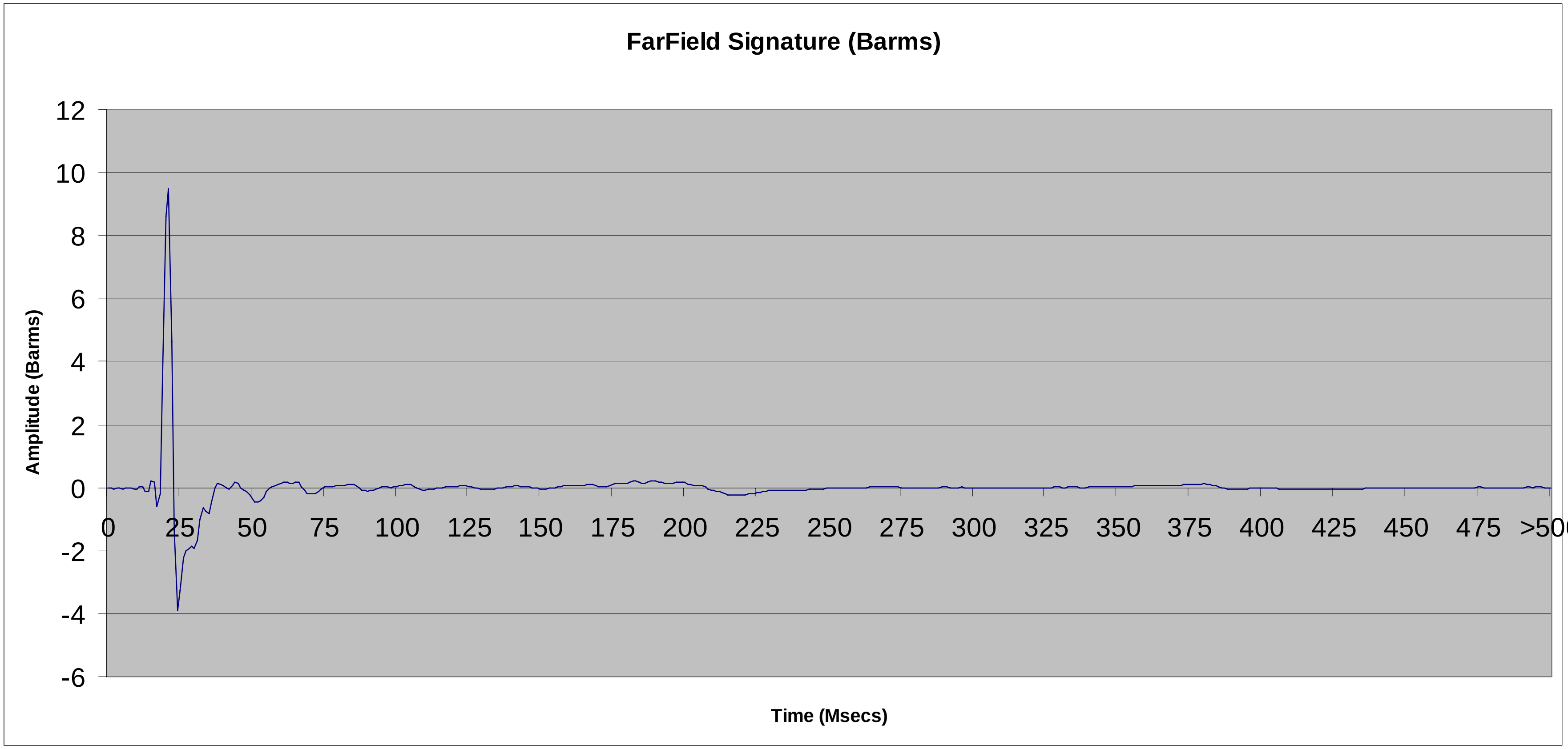
0-P Barm	9.56	P-P Barm	13.65	P/B Ratio =	25.98	Period =	46.75	Depth =	2.81	M	Power =	187.50	Db

File 2.84: 900 cu in SeaScan Tri-Cluster ® array (#1,2,3,4,5,6 only) @ 10 ft



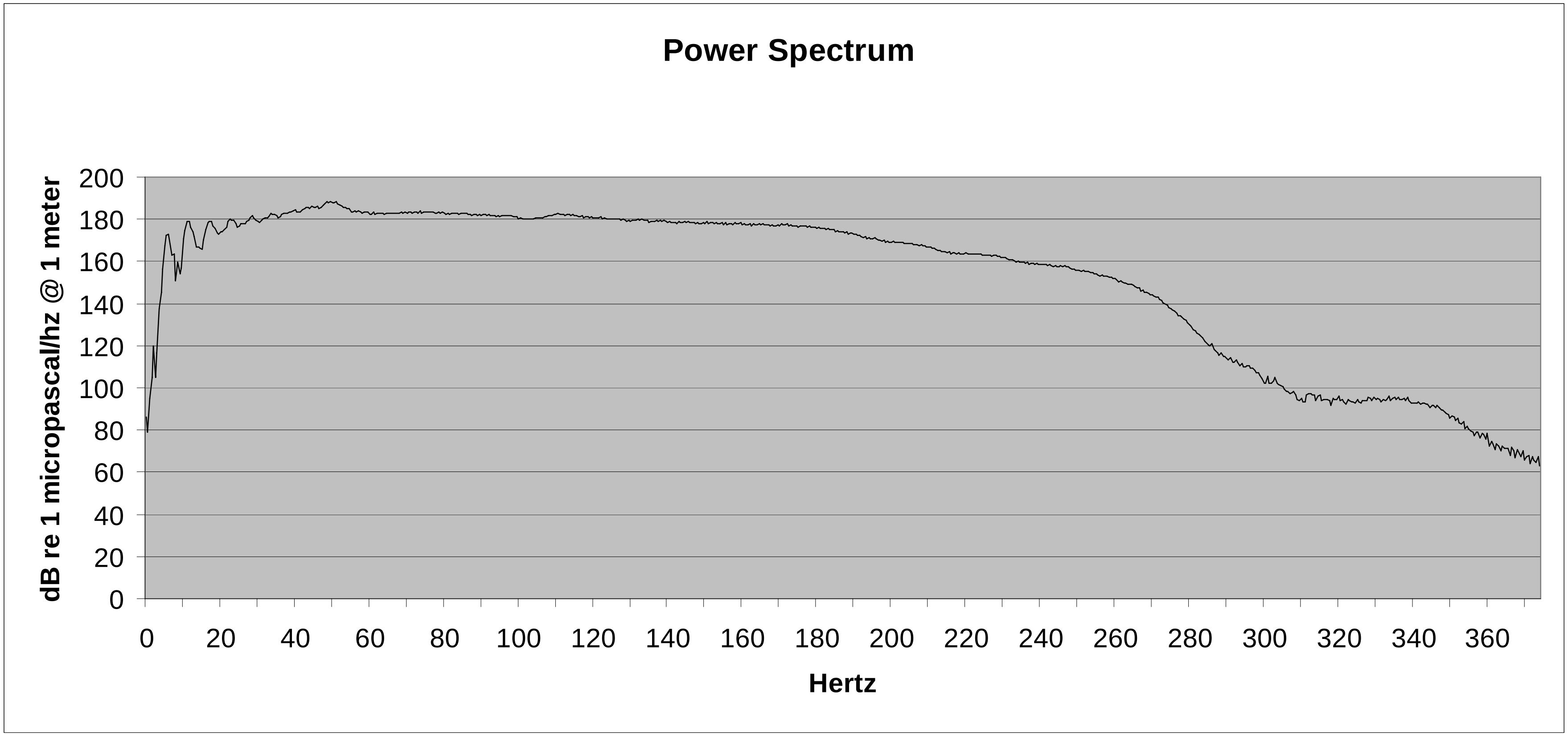
0-P Barm 9.56 P-P Barm 13.65 P/B Ratio = 25.98 Period = 46.75 Depth = 2.81 M Power = 187.50 Db

File 2.85: 900 cu in SeaScan Tri-Cluster ® array (#1,2,3,4,5,6 only) @ 10 ft



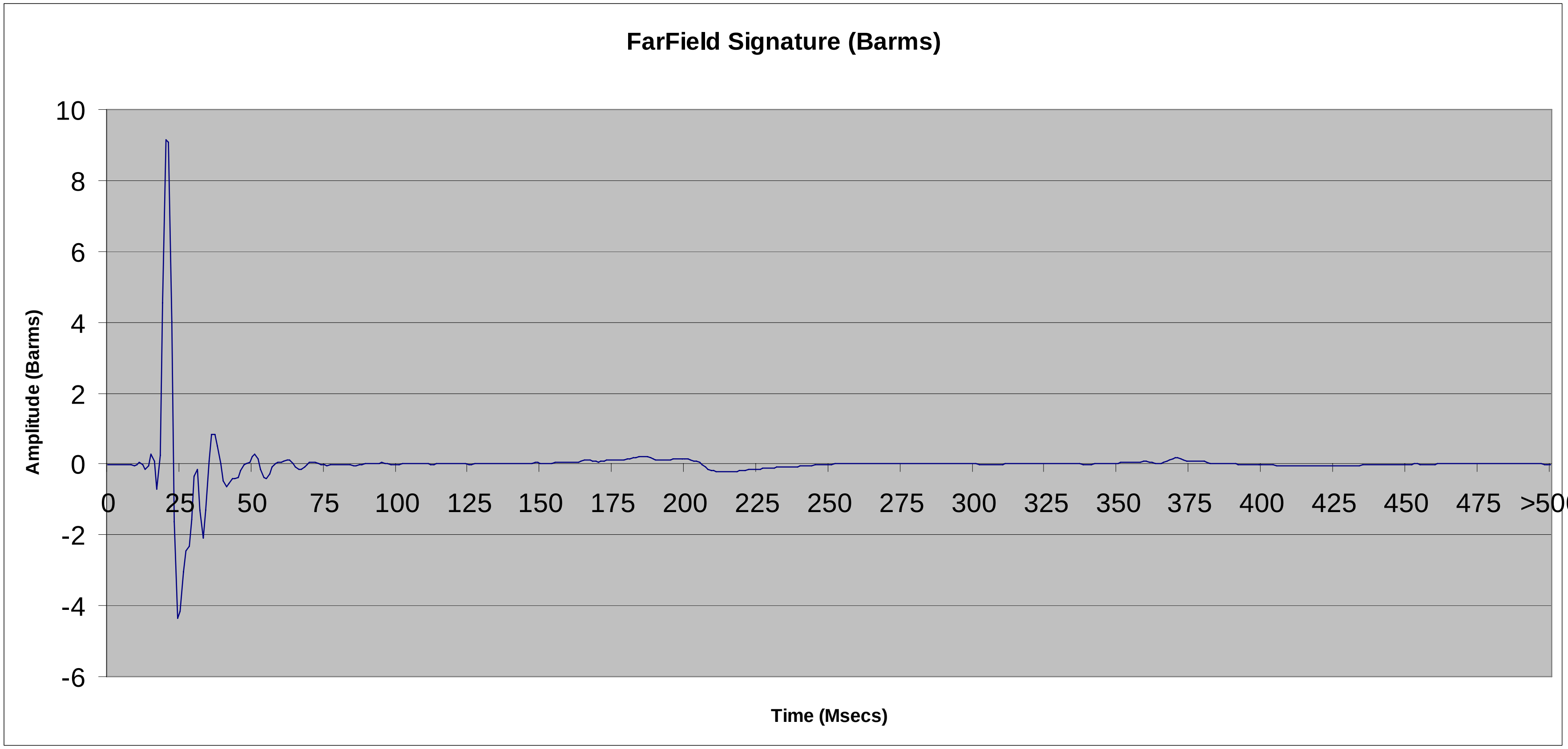
0-P Barm 9.85 P-P Barm 13.79 P/B Ratio = 20.42 Period = 161.75 Depth = 2.63 M Power = 188.26 Db

File 2.85: 900 cu in SeaScan Tri-Cluster ® array (#1,2,3,4,5,6 only) @ 10 ft



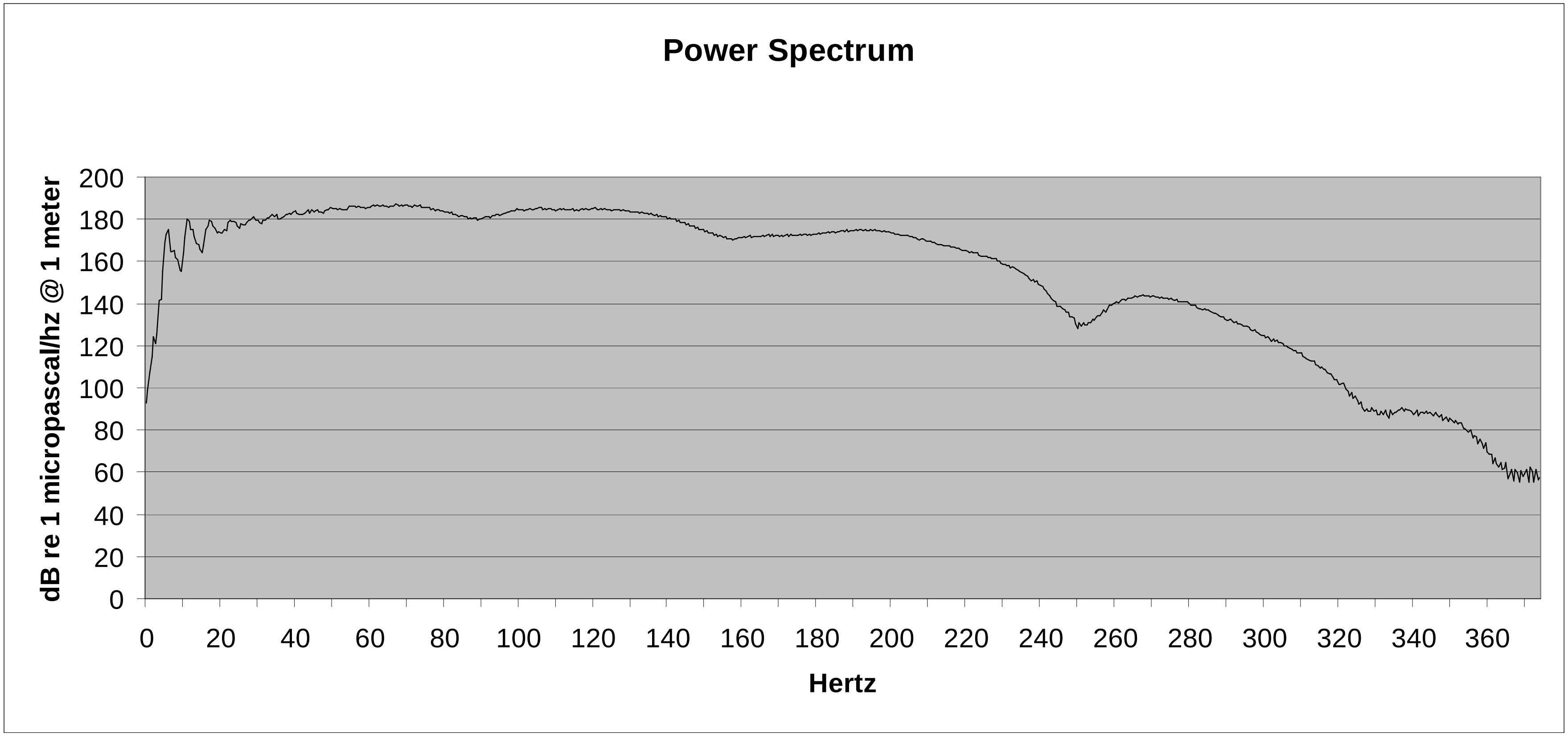
0-P Barm	9.85	P-P Barm	13.79	P/B Ratio =	20.42	Period =	161.75	Depth =	2.63	M	Power =	188.26	Db

File 2.86: 900 cu in SeaScan Tri-Cluster ® array (#1,2,3,4,5,6 only) @ 10 ft



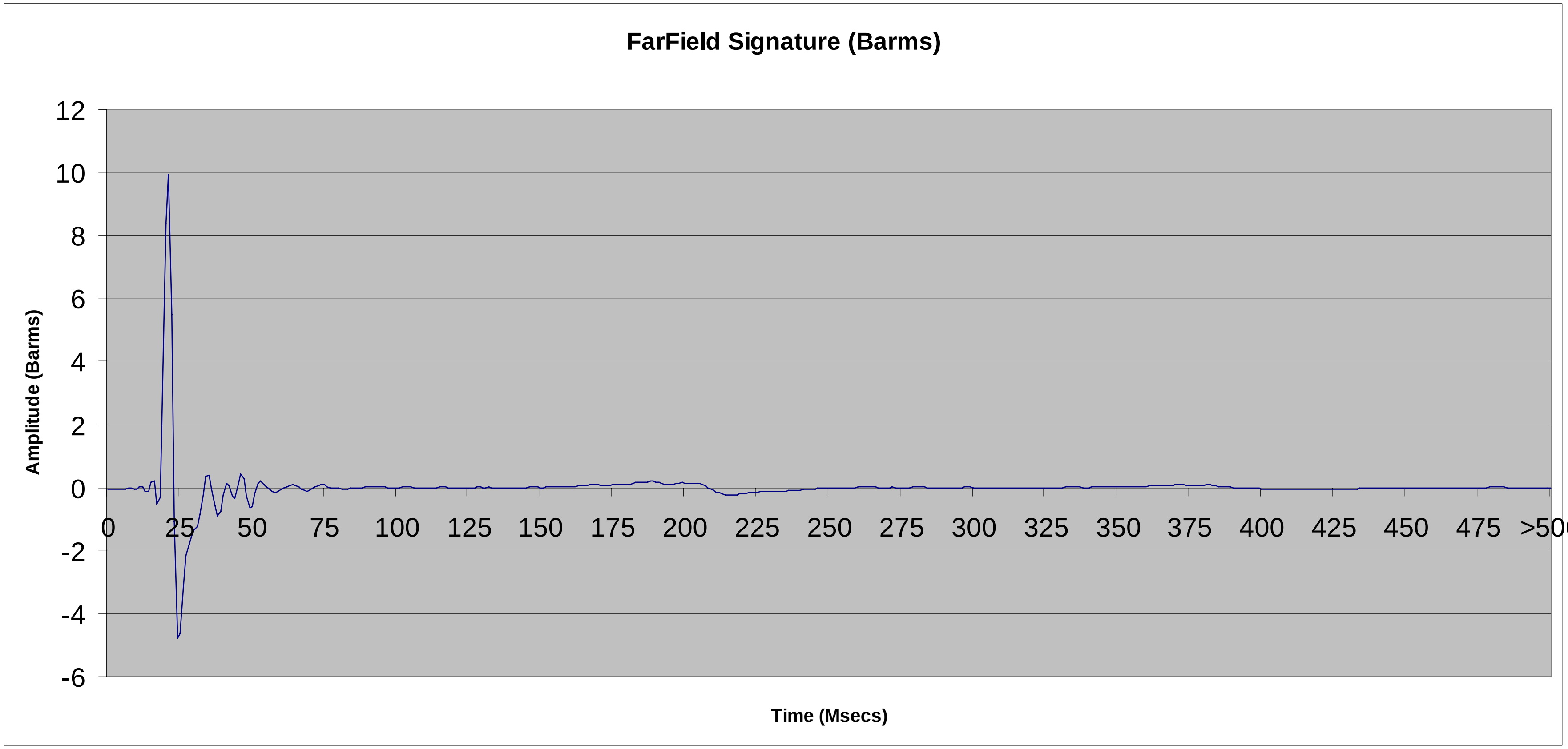
0-P Barm	9.87	P-P Barm	14.39	P/B Ratio =	20.41	Period =	30.25	Depth =	3.00	M	Power =	187.34	Db

File 2.86: 900 cu in SeaScan Tri-Cluster ® array (#1,2,3,4,5,6 only) @ 10 ft



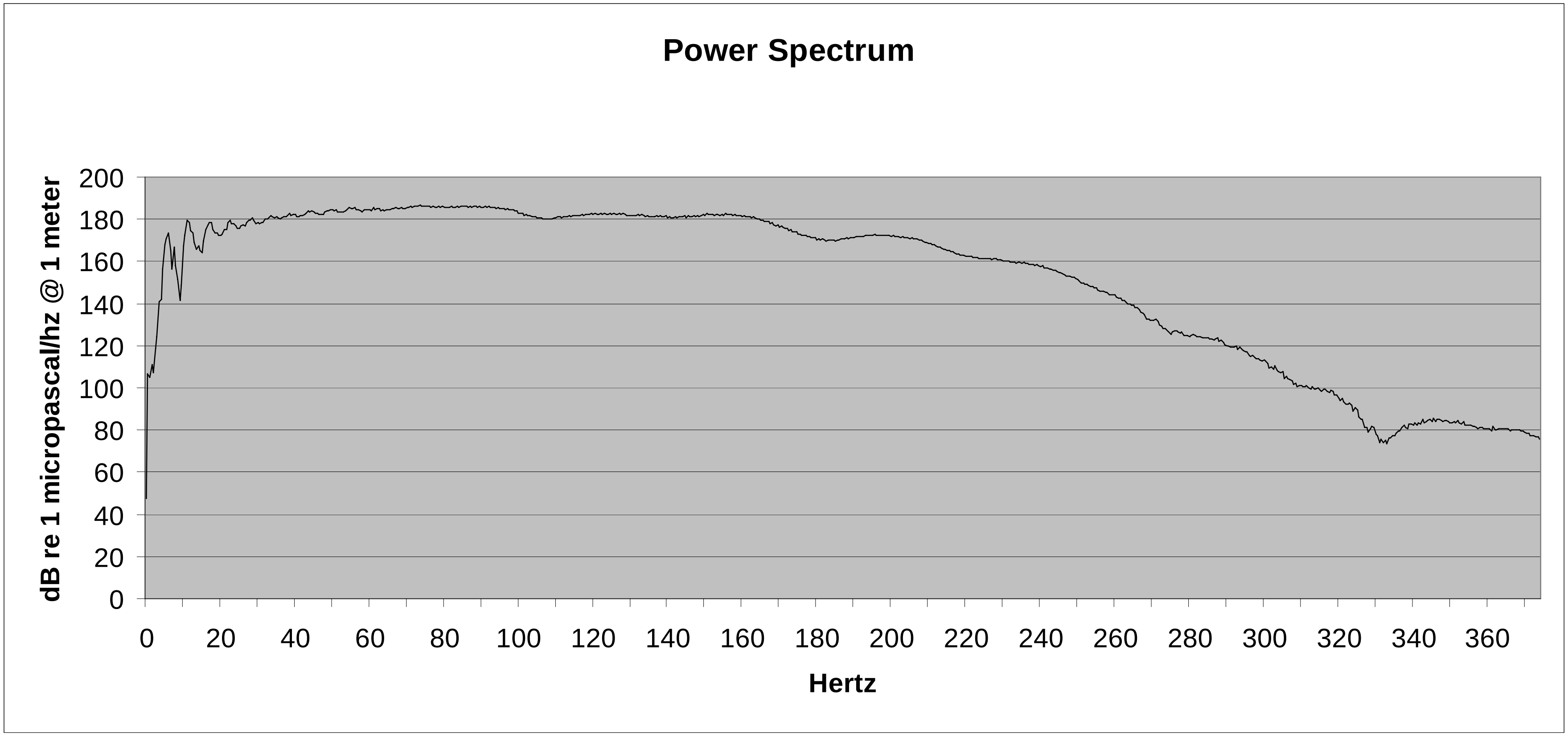
0-P Barm	9.87	P-P Barm	14.39	P/B Ratio =	20.41	Period =	30.25	Depth =	3.00	M	Power =	187.34	Db

File 2.87: 900 cu in SeaScan Tri-Cluster ® array (#1,2,3,4,5,6 only) @ 10 ft



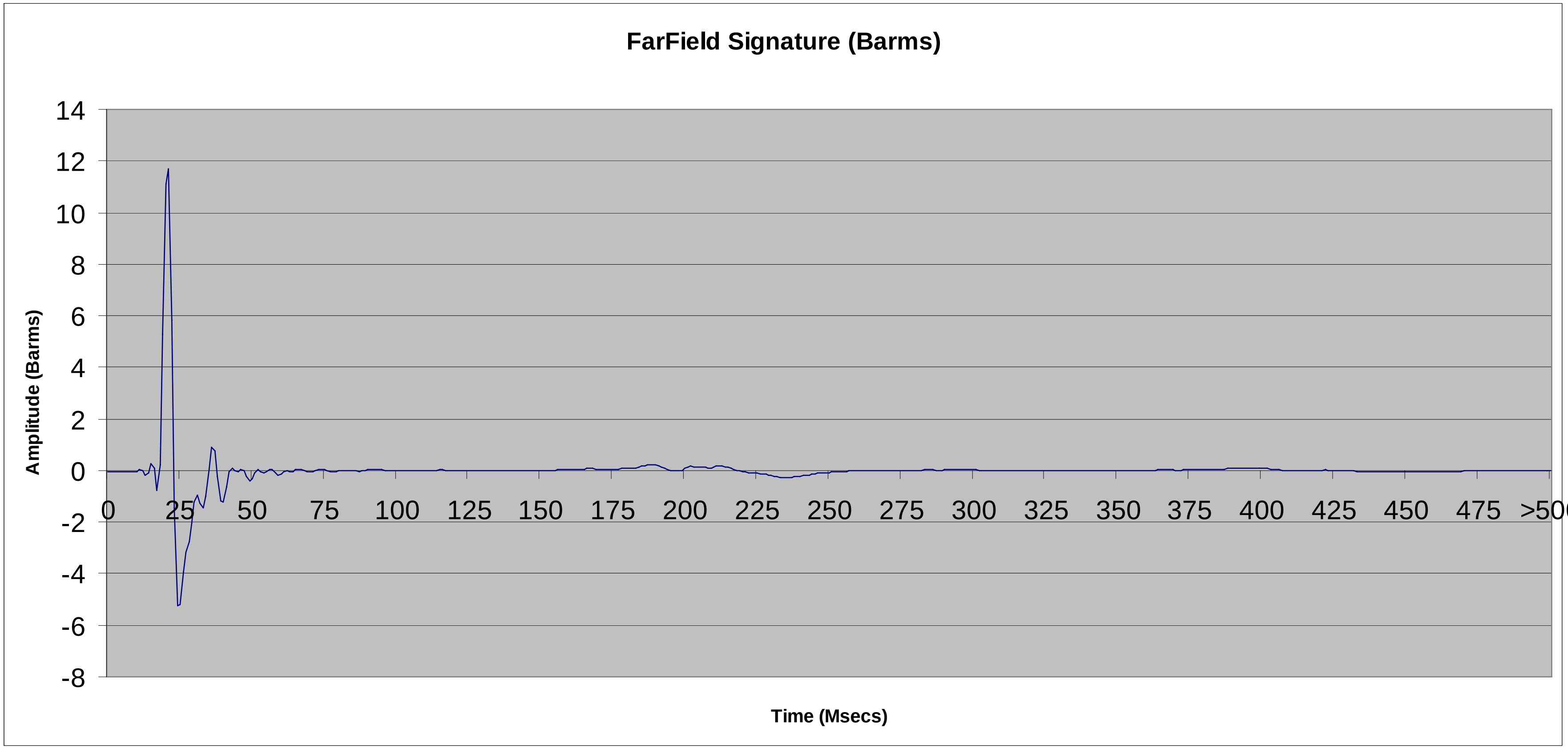
0-P Barm 10.12 P-P Barm 15.20 P/B Ratio = 17.82 Period = 32.00 Depth = 2.81 M Power = 186.66 Db

File 2.87: 900 cu in SeaScan Tri-Cluster ® array (#1,2,3,4,5,6 only) @ 10 ft



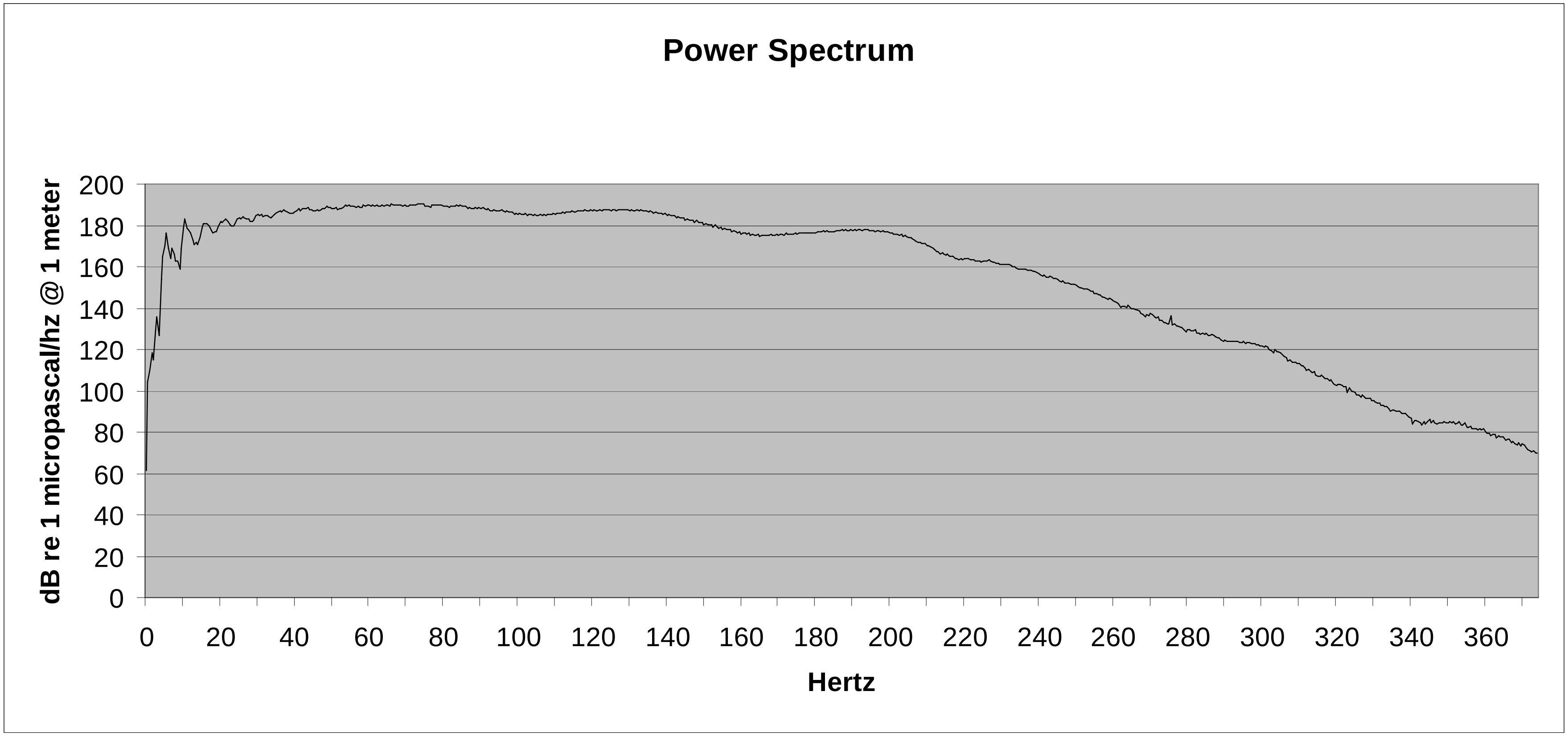
0-P Barm	10.12	P-P Barm	15.20	P/B Ratio =	17.82	Period =	32.00	Depth =	2.81	M	Power =	186.66	Db

File 2.88: 1200 cu in Single Tri-Cluster ® Tri-Cluster array @ 10 ft



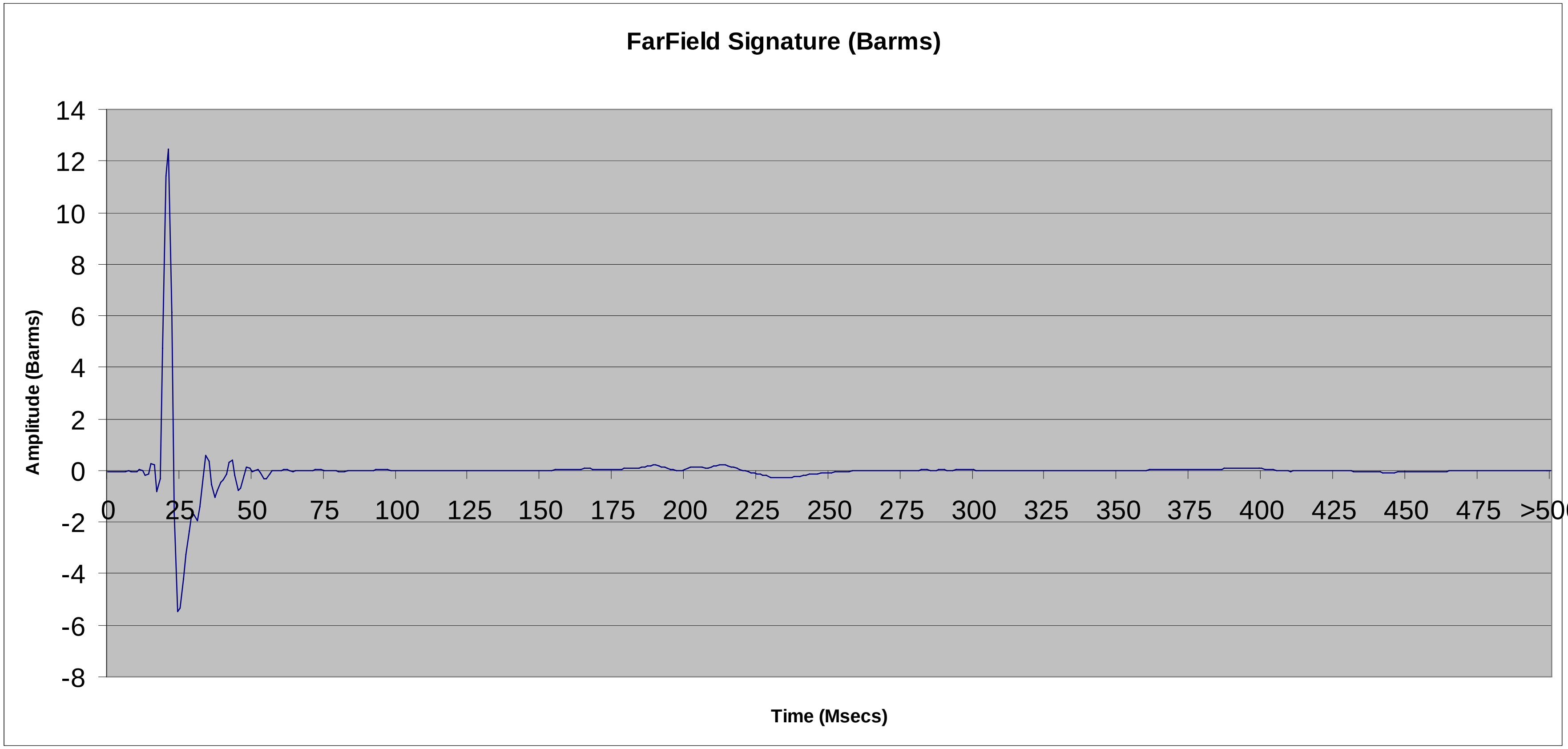
0-P Barm	12.33	P-P Barm	17.88	P/B Ratio =	30.51	Period =	167.50	Depth =	3.00	M	Power =	190.46	Db

File 2.88: 1200 cu in Single Tri-Cluster ® Tri-Cluster array @ 10 ft



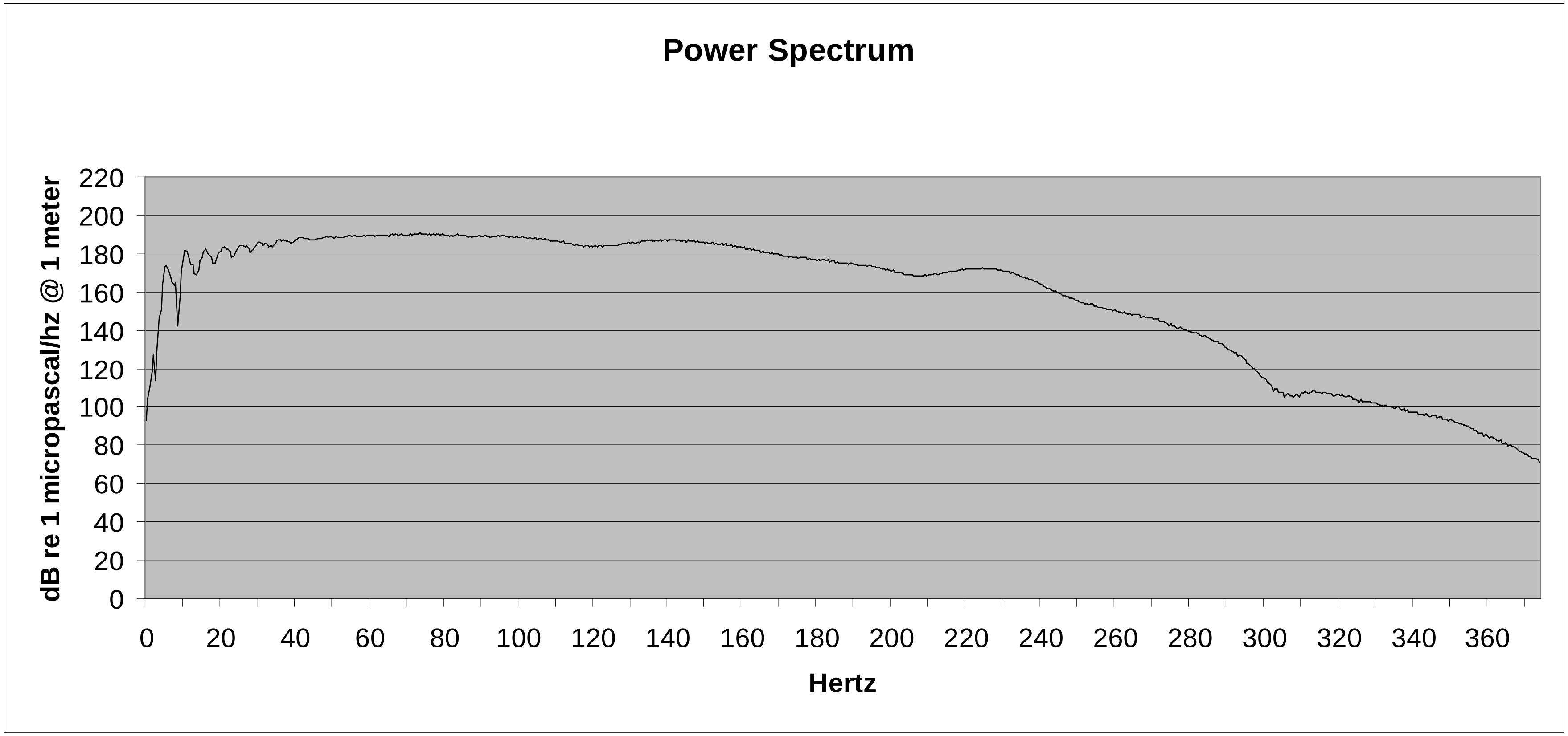
0-P Barm 12.33 P-P Barm 17.88 P/B Ratio = 30.51 Period = 167.50 Depth = 3.00 M Power = 190.46 Db

File 2.89: 1200 cu in Single Tri-Cluster ® Tri-Cluster array @ 10 ft



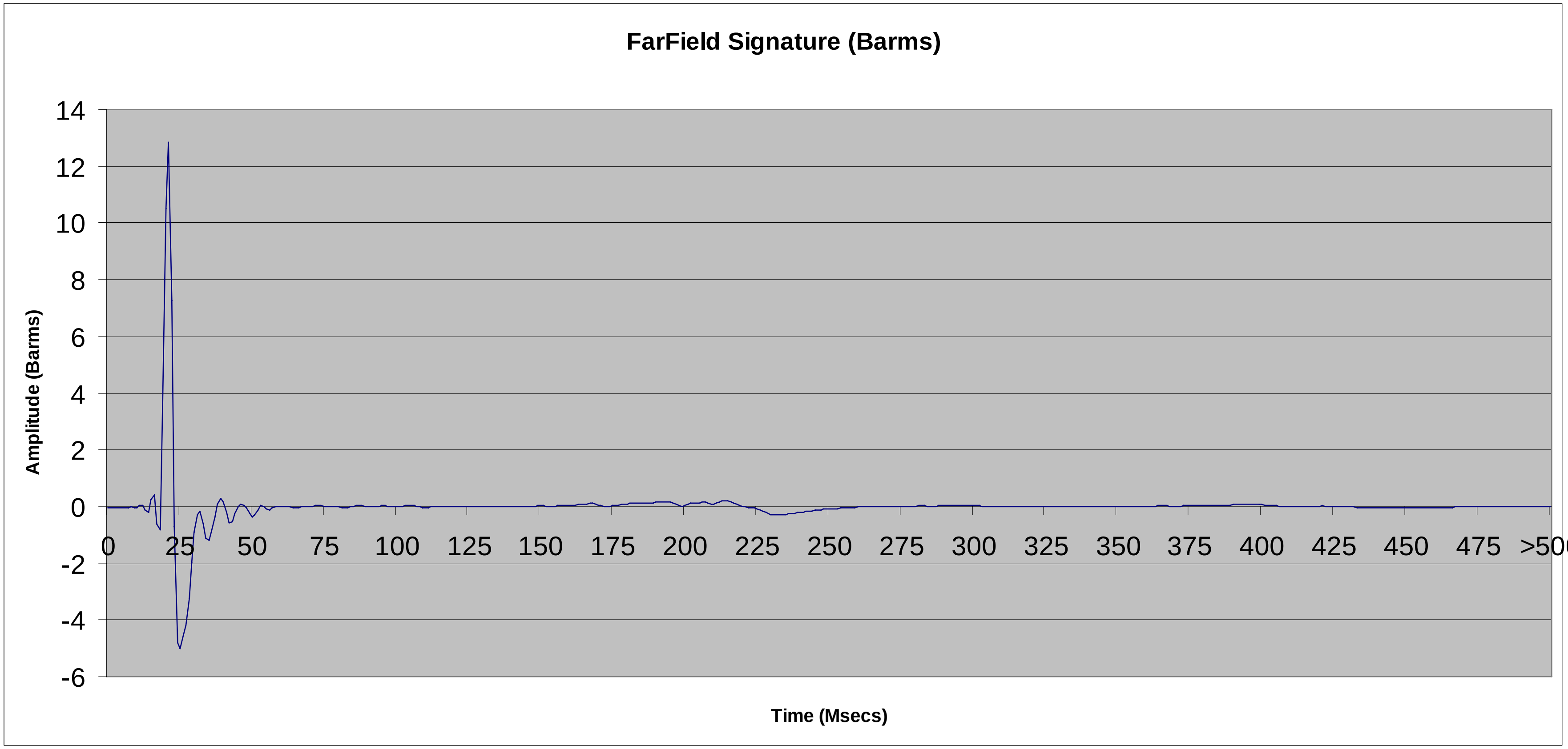
0-P Barm	13.00	P-P Barm	18.69	P/B Ratio =	33.10	Period =	192.00	Depth =	2.81	M	Power =	190.72	Db

File 2.89: 1200 cu in Single Tri-Cluster ® Tri-Cluster array @ 10 ft



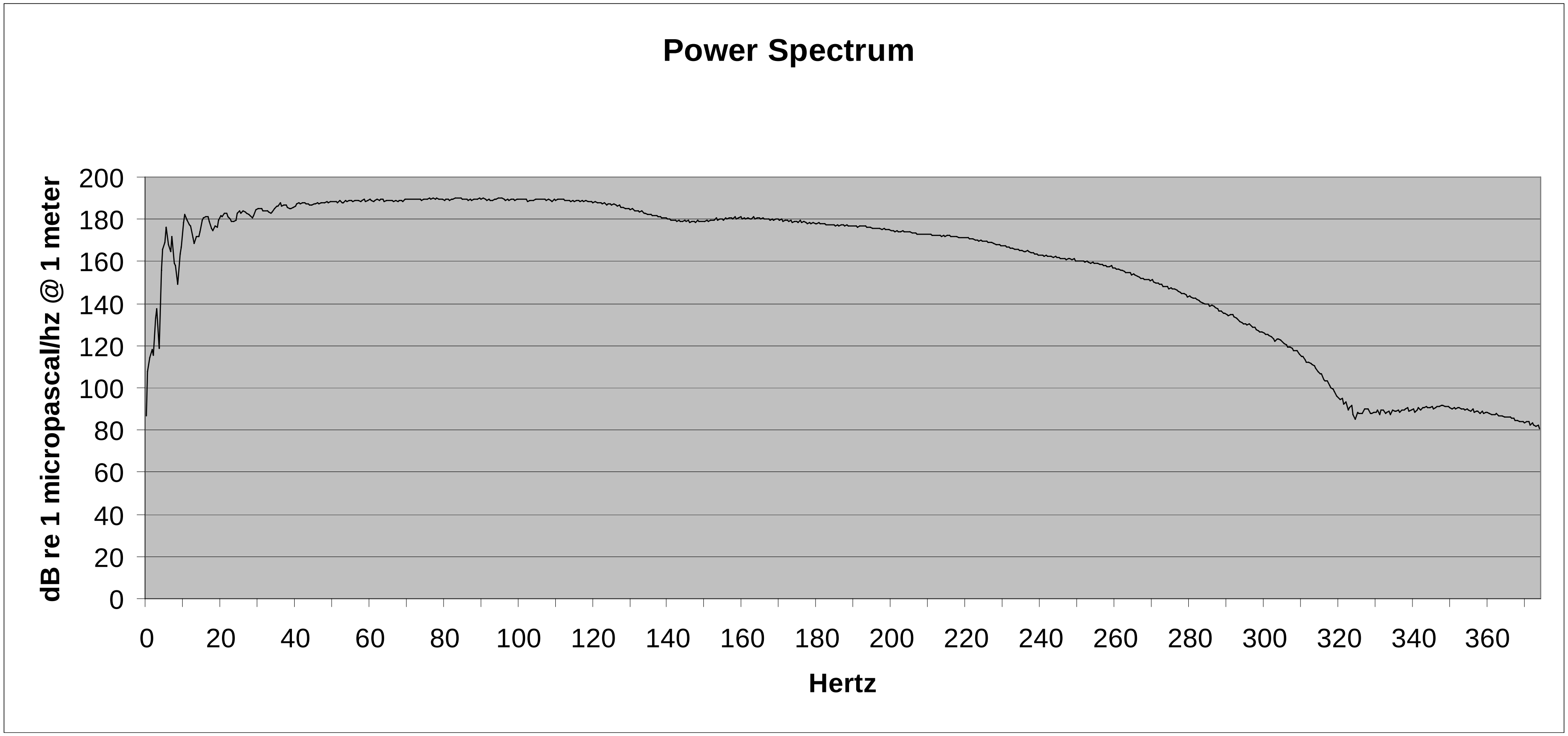
0-P Barm 13.00 P-P Barm 18.69 P/B Ratio = 33.10 Period = 192.00 Depth = 2.81 M Power = 190.72 Db

File 2.90: 1200 cu in Single Tri-Cluster ® Tri-Cluster array @ 10 ft



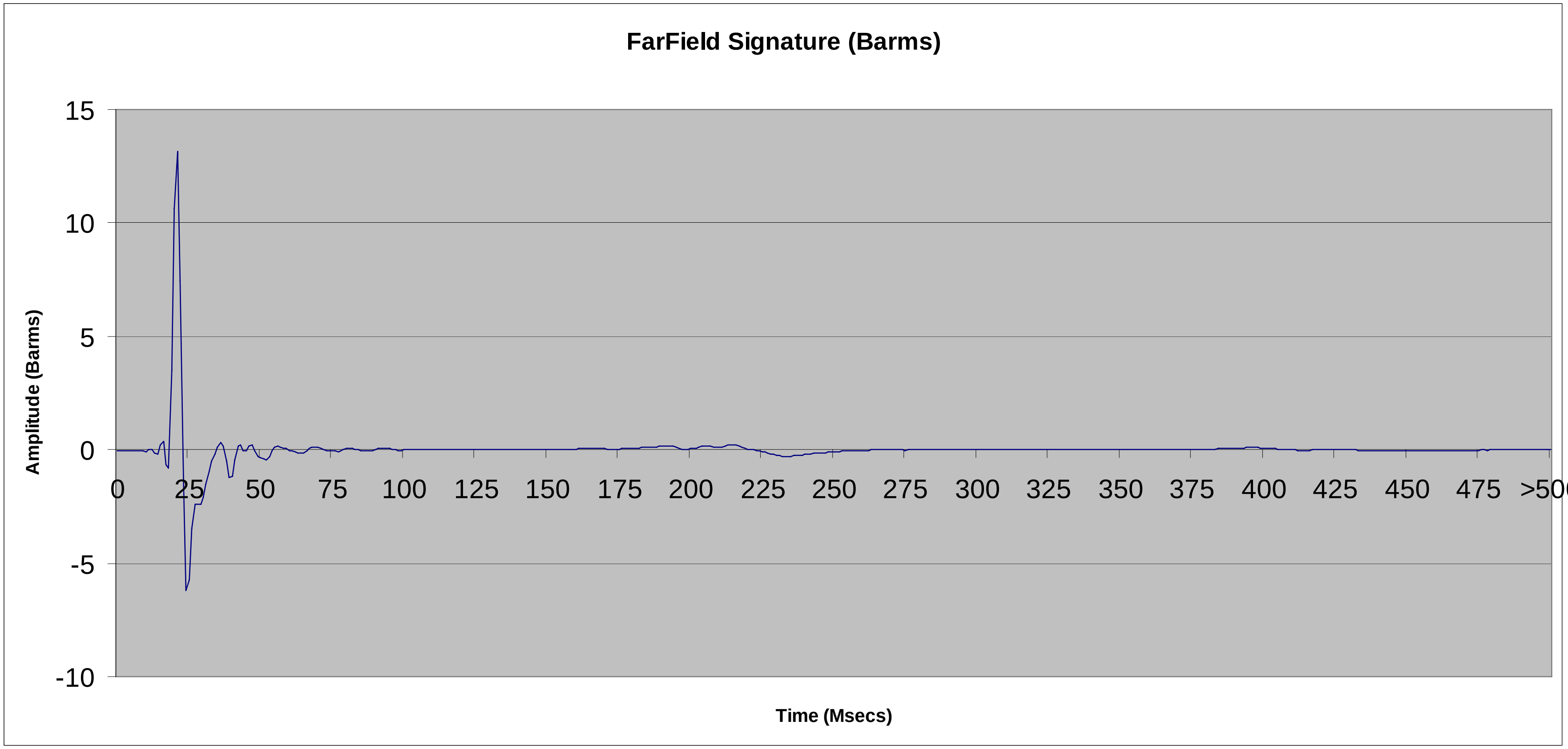
0-P Barm	13.04	P-P Barm	18.22	P/B Ratio =	30.32	Period =	193.50	Depth =	2.81	M	Power =	190.12	Db

File 2.90: 1200 cu in Single Tri-Cluster ® Tri-Cluster array @ 10 ft



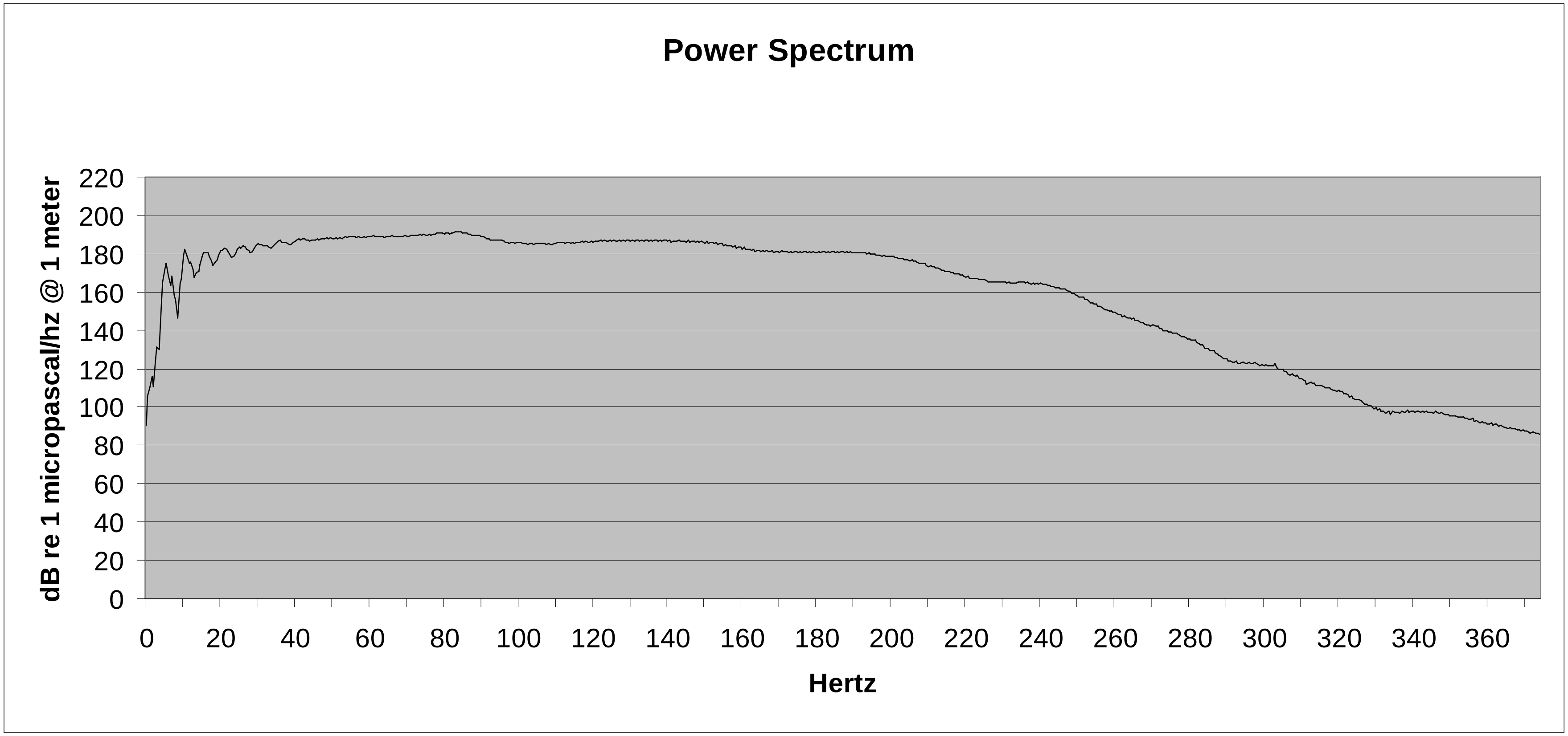
0-P Barm 13.04 P-P Barm 18.22 P/B Ratio = 30.32 Period = 193.50 Depth = 2.81 M Power = 190.12 Db

File 2.91: 1200 cu in Single Tri-Cluster ® Tri-Cluster array @ 10 ft



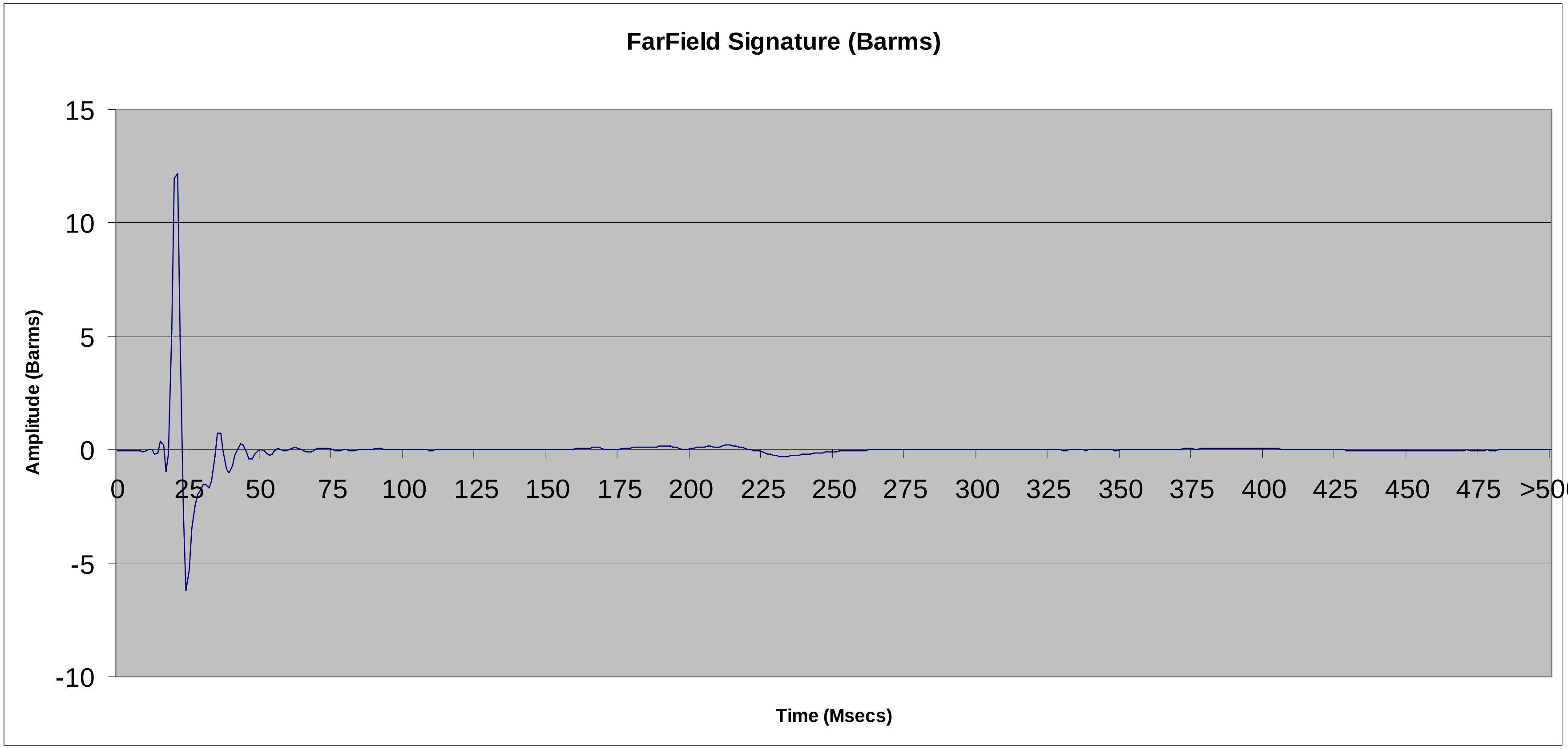
0-P Barm 13.30 P-P Barm 19.78 P/B Ratio = 30.06 Period = 193.25 Depth = 2.63 M Power = 191.58 Db

File 2.91: 1200 cu in Single Tri-Cluster ® Tri-Cluster array @ 10 ft



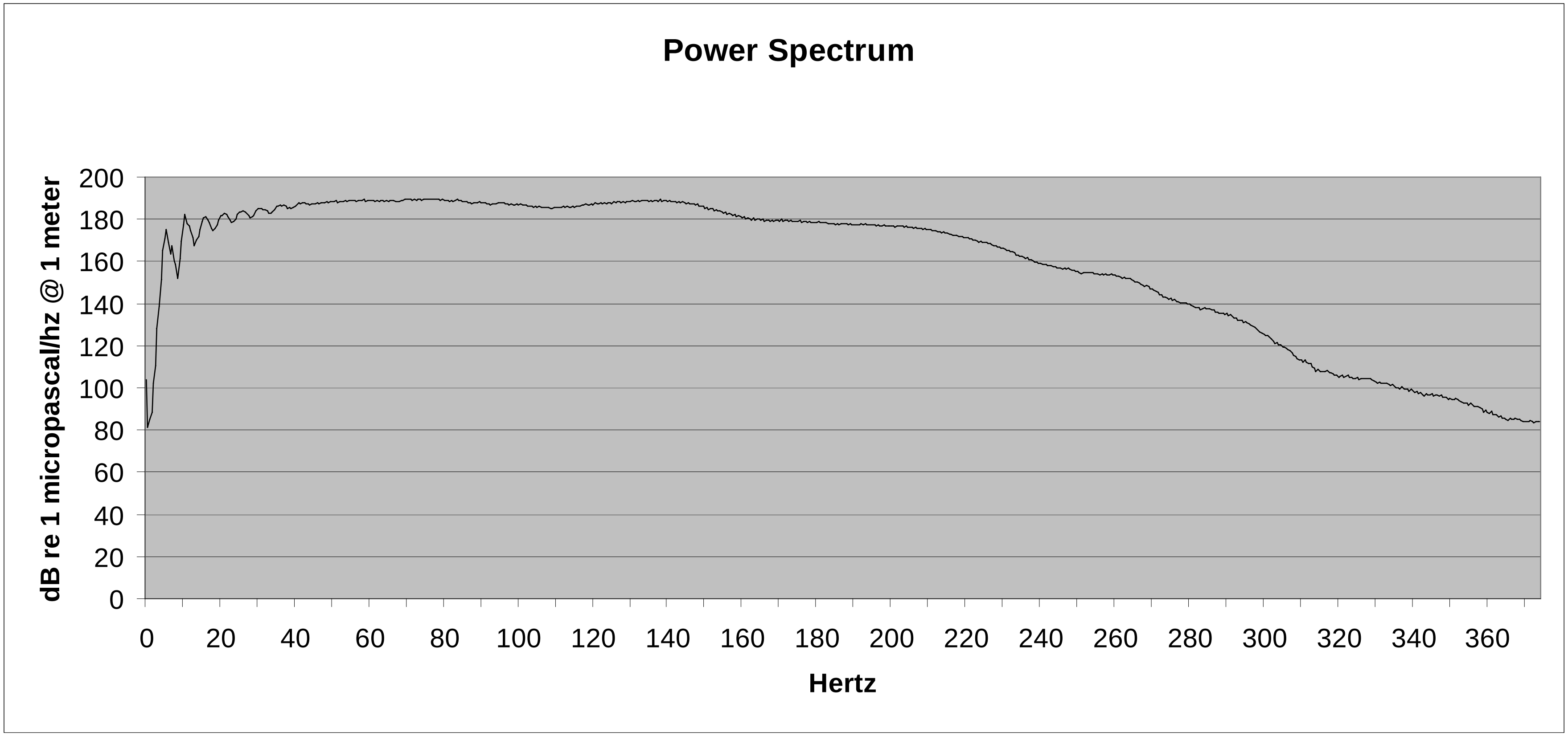
0-P Barm	13.30	P-P Barm	19.78	P/B Ratio =	30.06	Period =	193.25	Depth =	2.63	M	Power =	191.58	Db

File 2.92: 1200 cu in Single Tri-Cluster ® Tri-Cluster array @ 10 ft



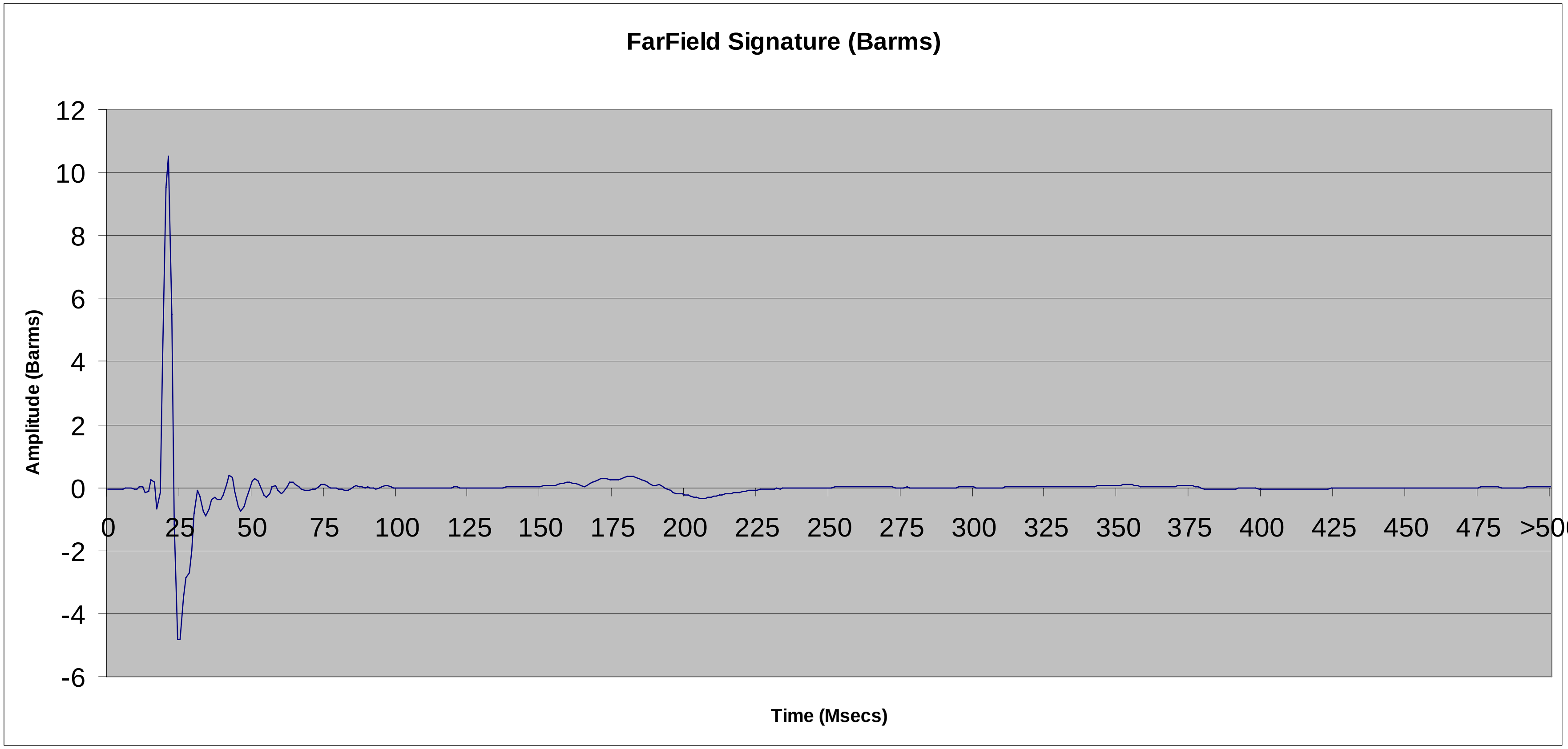
0-P Barm	13.19	P-P Barm	19.42	P/B Ratio =	37.08	Period =	192.50	Depth =	2.81	M	Power =	189.76	Db

File 2.92: 1200 cu in Single Tri-Cluster ® Tri-Cluster array @ 10 ft



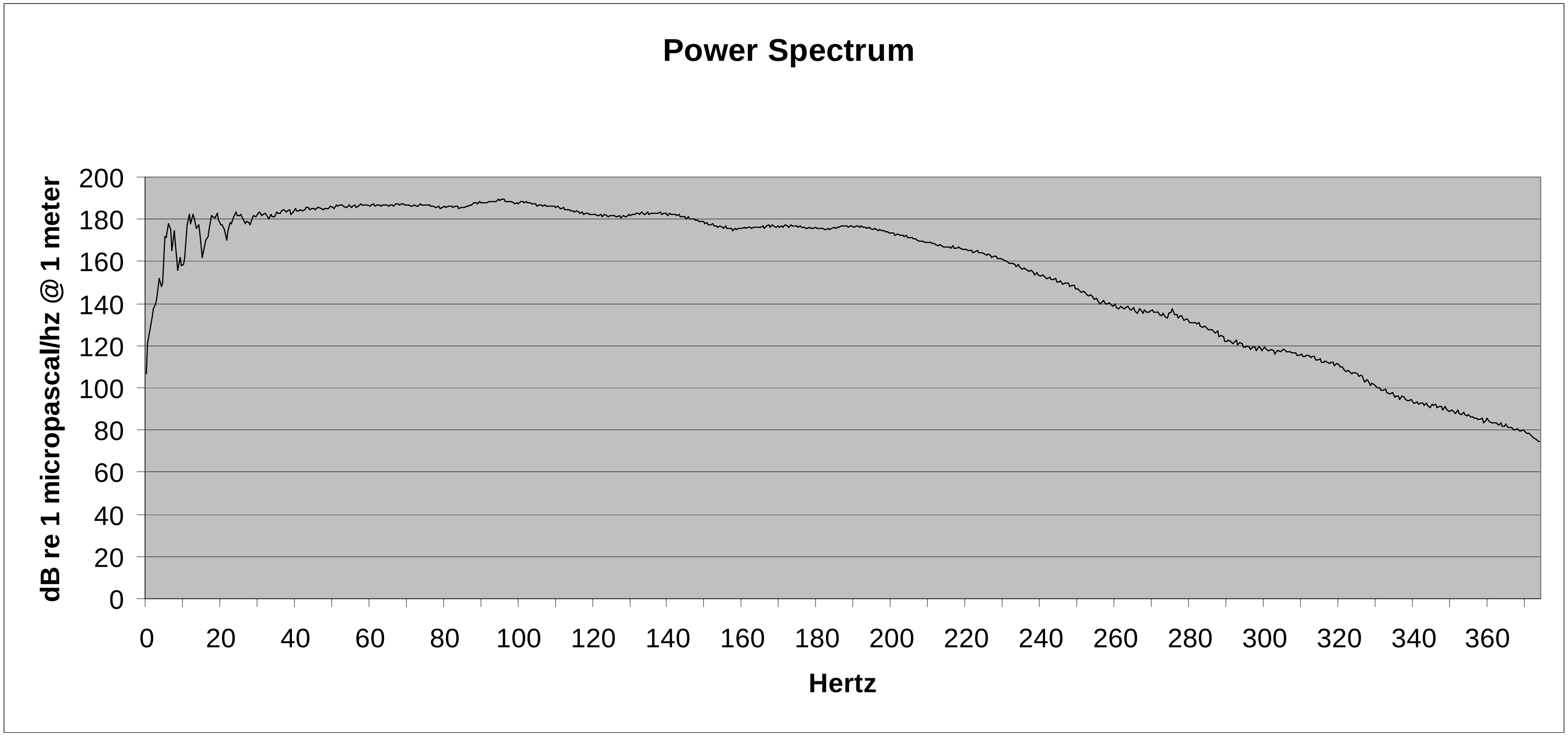
0-P Barm 13.19 P-P Barm 19.42 P/B Ratio = 37.08 Period = 192.50 Depth = 2.81 M Power = 189.76 Db

File 2.93: 900 cu in SeaScan Tri-Cluster ® array (#1,2,5,6,7,8 only) @ 10 ft



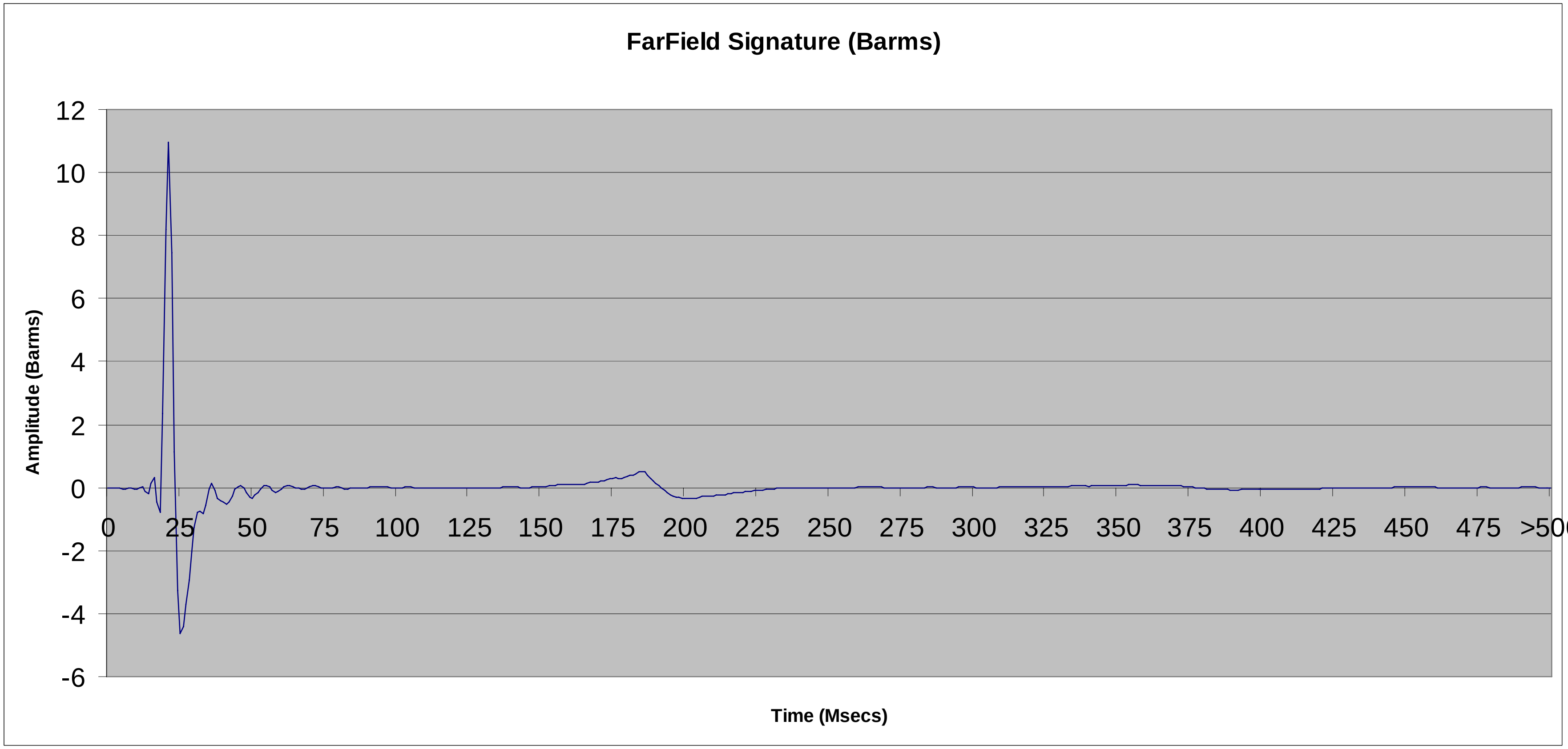
0-P Barm	10.90	P-P Barm	16.06	P/B Ratio =	22.66	Period =	160.00	Depth =	2.81	M	Power =	189.51	Db

File 2.93: 900 cu in SeaScan Tri-Cluster ® array (#1,2,5,6,7,8 only) @ 10 ft



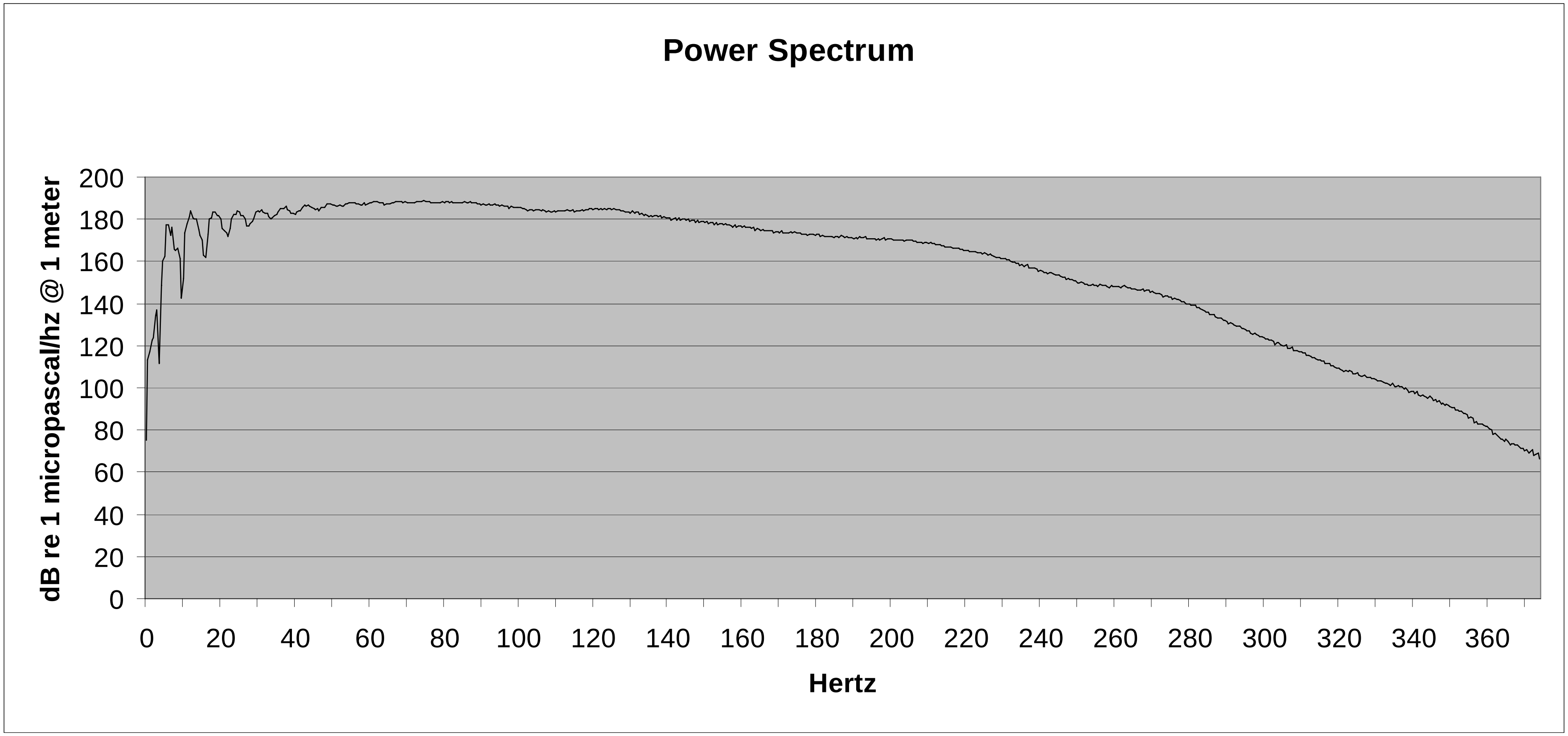
0-P Barm 10.90 P-P Barm 16.06 P/B Ratio = 22.66 Period = 160.00 Depth = 2.81 M Power = 189.51 Db

File 2.94: 900 cu in SeaScan Tri-Cluster ® array (#1,2,5,6,7,8 only) @ 10 ft



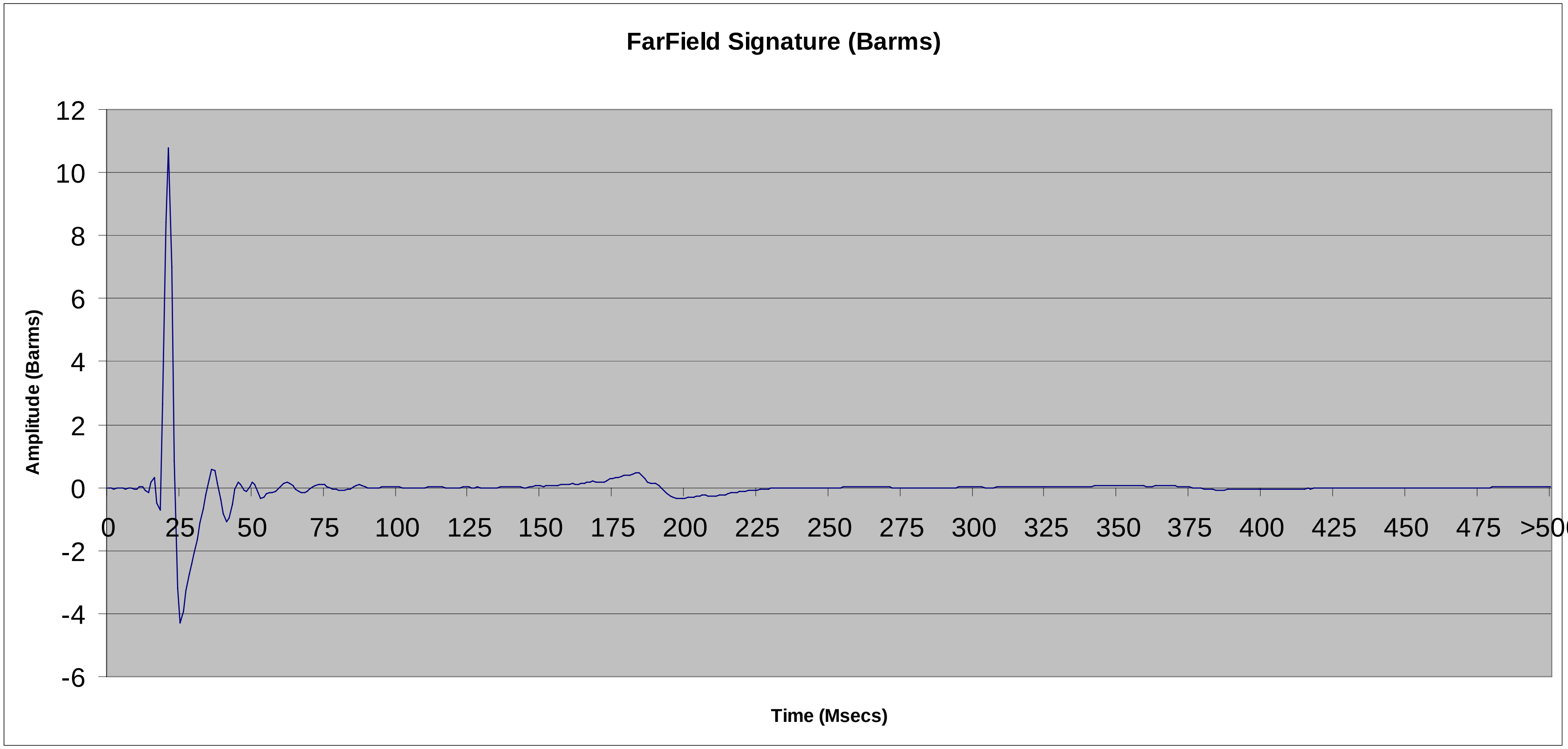
0-P Barm	10.96	P-P Barm	15.62	P/B Ratio =	18.18	Period =	164.00	Depth =	3.19	M	Power =	188.90	Db

File 2.94: 900 cu in SeaScan Tri-Cluster ® array (#1,2,5,6,7,8 only) @ 10 ft



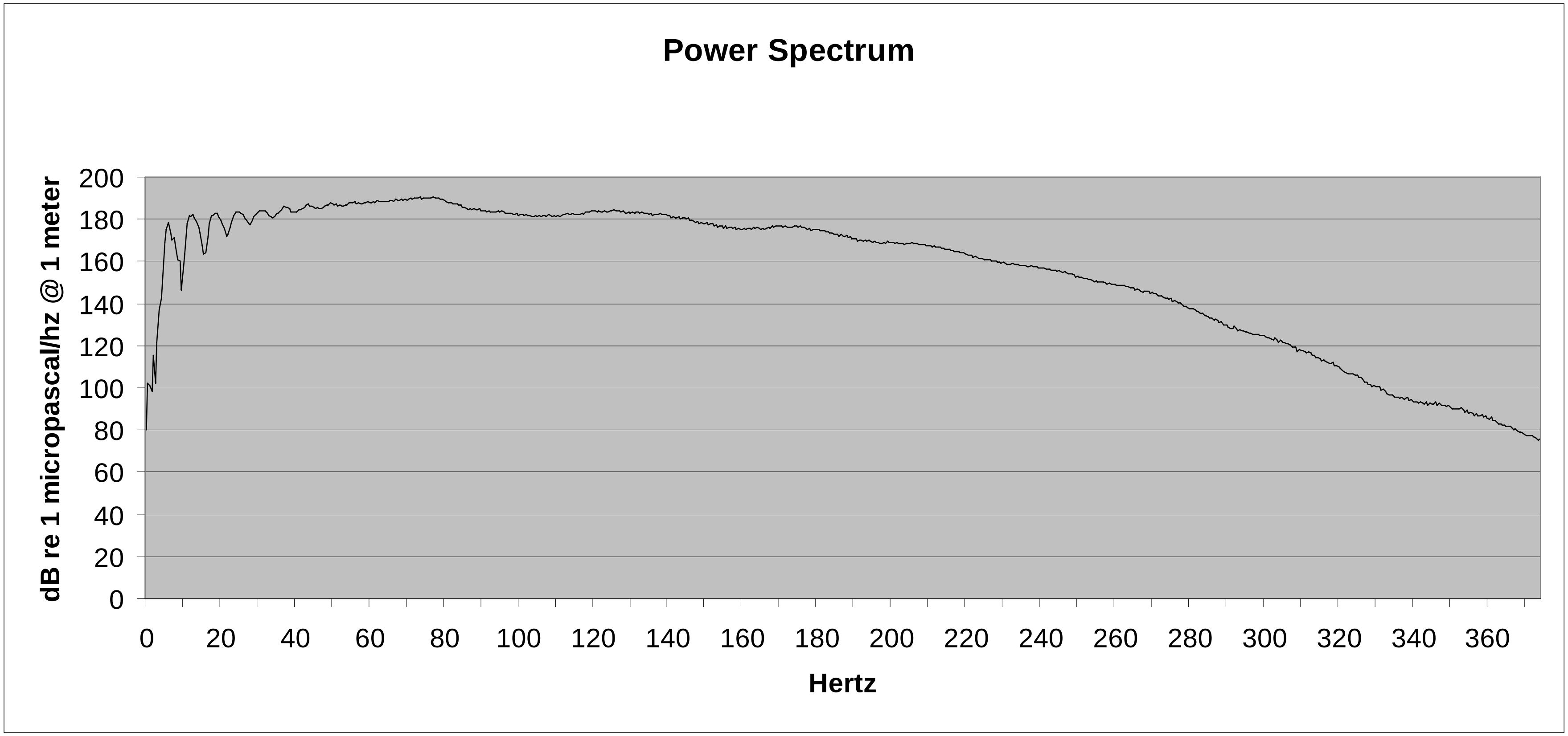
0-P Barm	10.96	P-P Barm	15.62	P/B Ratio =	18.18	Period =	164.00	Depth =	3.19	M	Power =	188.90	Db

File 2.95: 900 cu in SeaScan Tri-Cluster ® array (#1,2,5,6,7,8 only) @ 10 ft



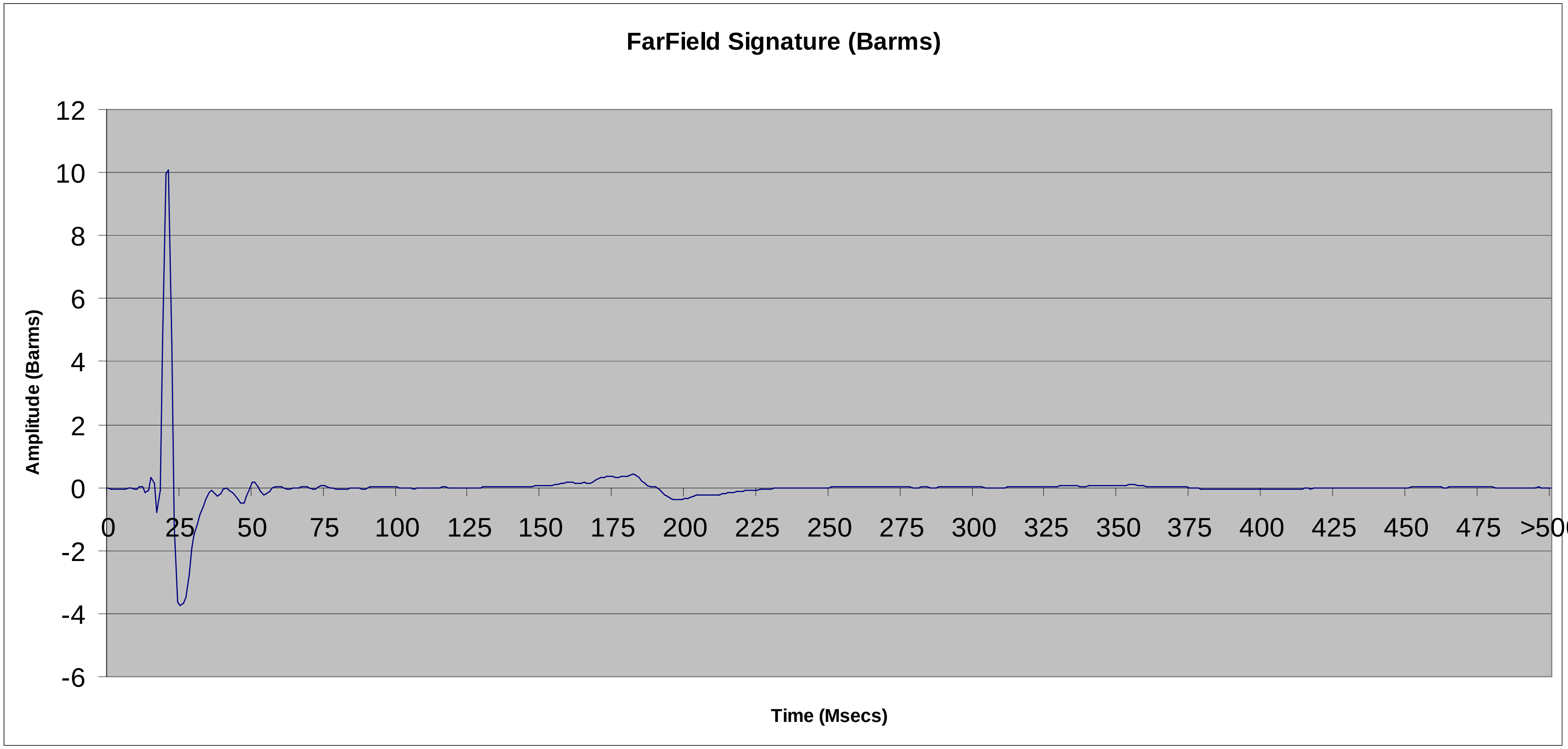
0-P Barm	10.78	P-P Barm	15.07	P/B Ratio =	18.30	Period =	162.50	Depth =	3.00	M	Power =	190.43 Db

File 2.95: 900 cu in SeaScan Tri-Cluster ® array (#1,2,5,6,7,8 only) @ 10 ft



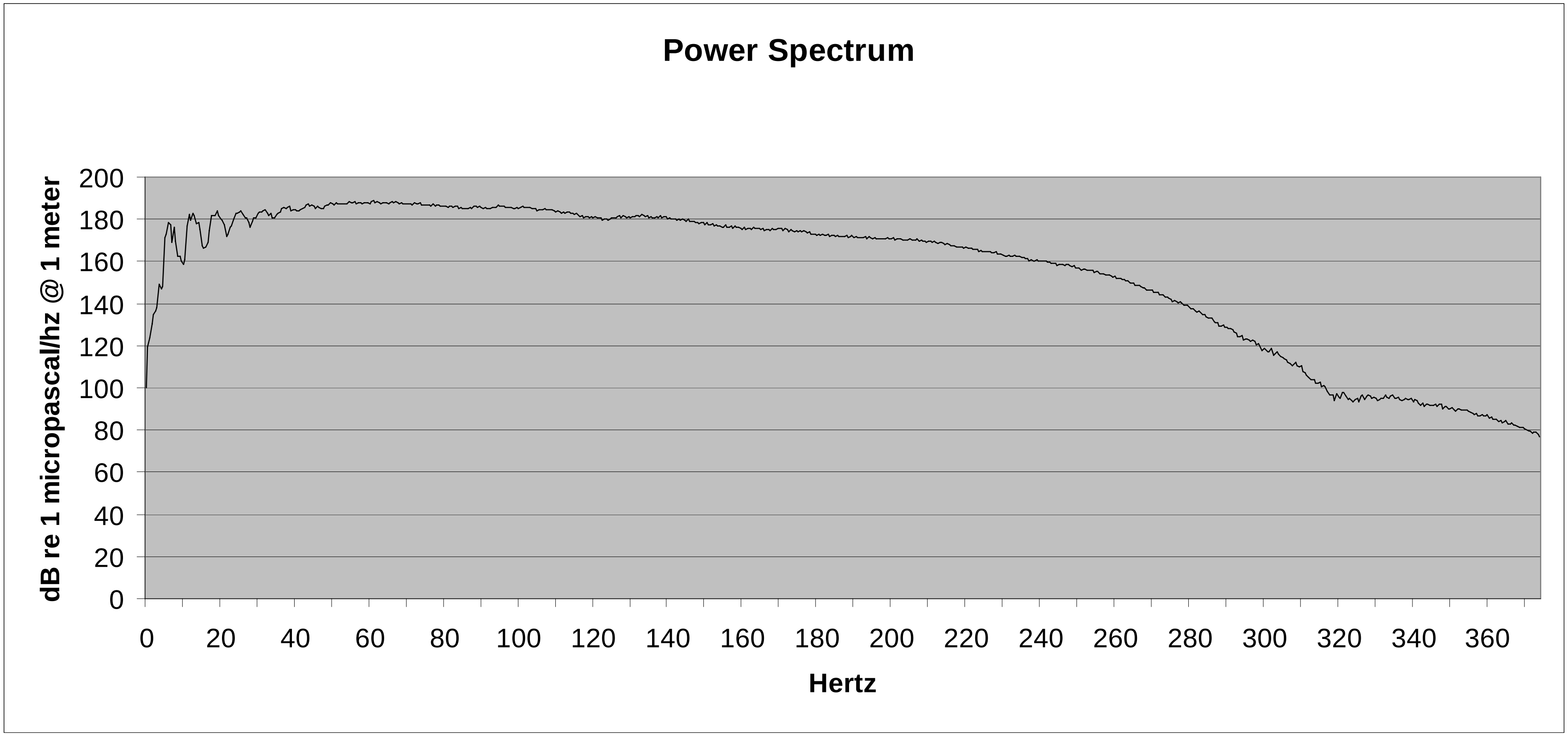
0-P Barm 10.78 P-P Barm 15.07 P/B Ratio = 18.30 Period = 162.50 Depth = 3.00 M Power = 190.43 Db

File 2.96: 900 cu in SeaScan Tri-Cluster ® array (#1,2,5,6,7,8 only) @ 10 ft



0-P Barm	10.90	P-P Barm	14.70	P/B Ratio =	18.10	Period =	161.75	Depth =	3.00	M	Power =	188.68	Db

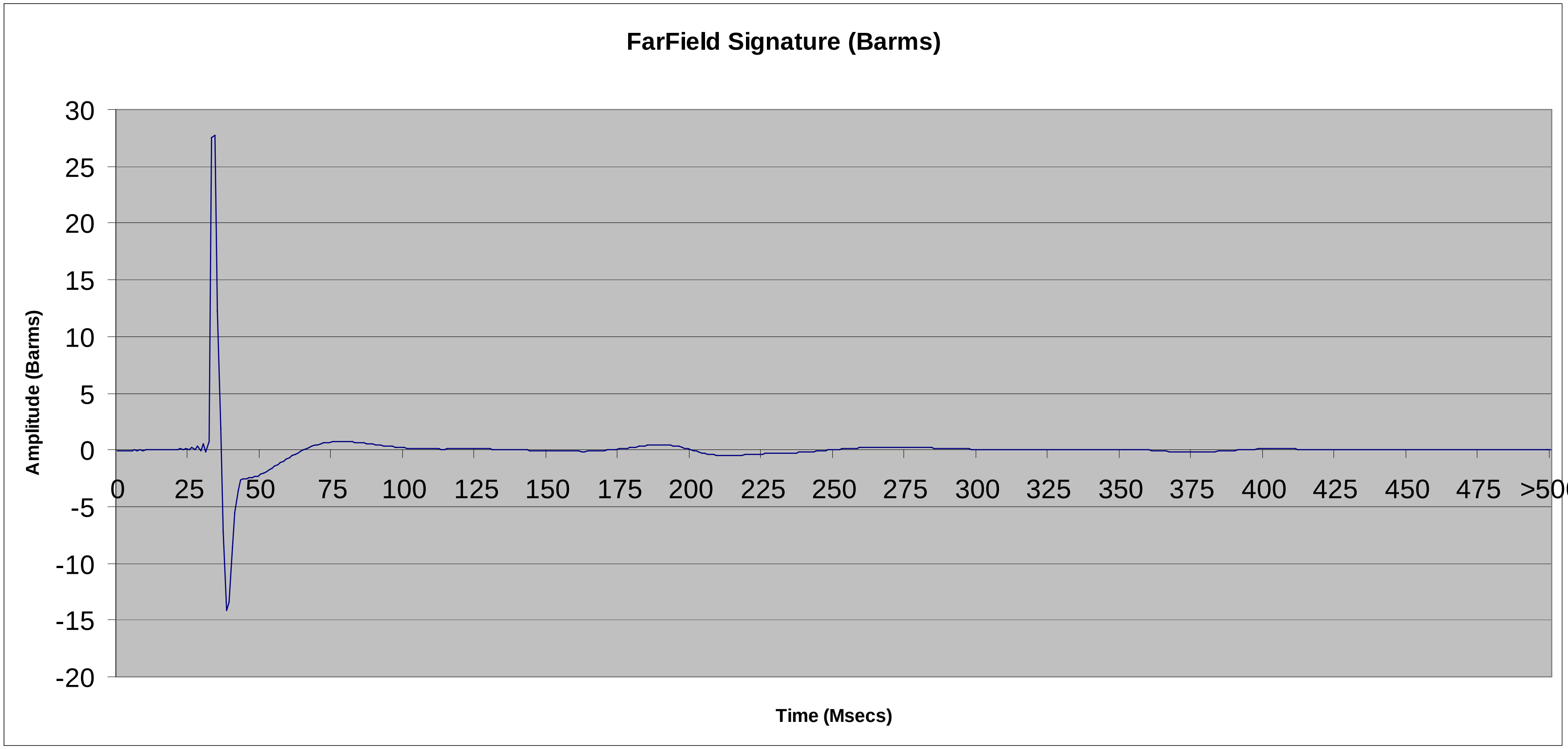
File 2.96: 900 cu in SeaScan Tri-Cluster ® array (#1,2,5,6,7,8 only) @ 10 ft



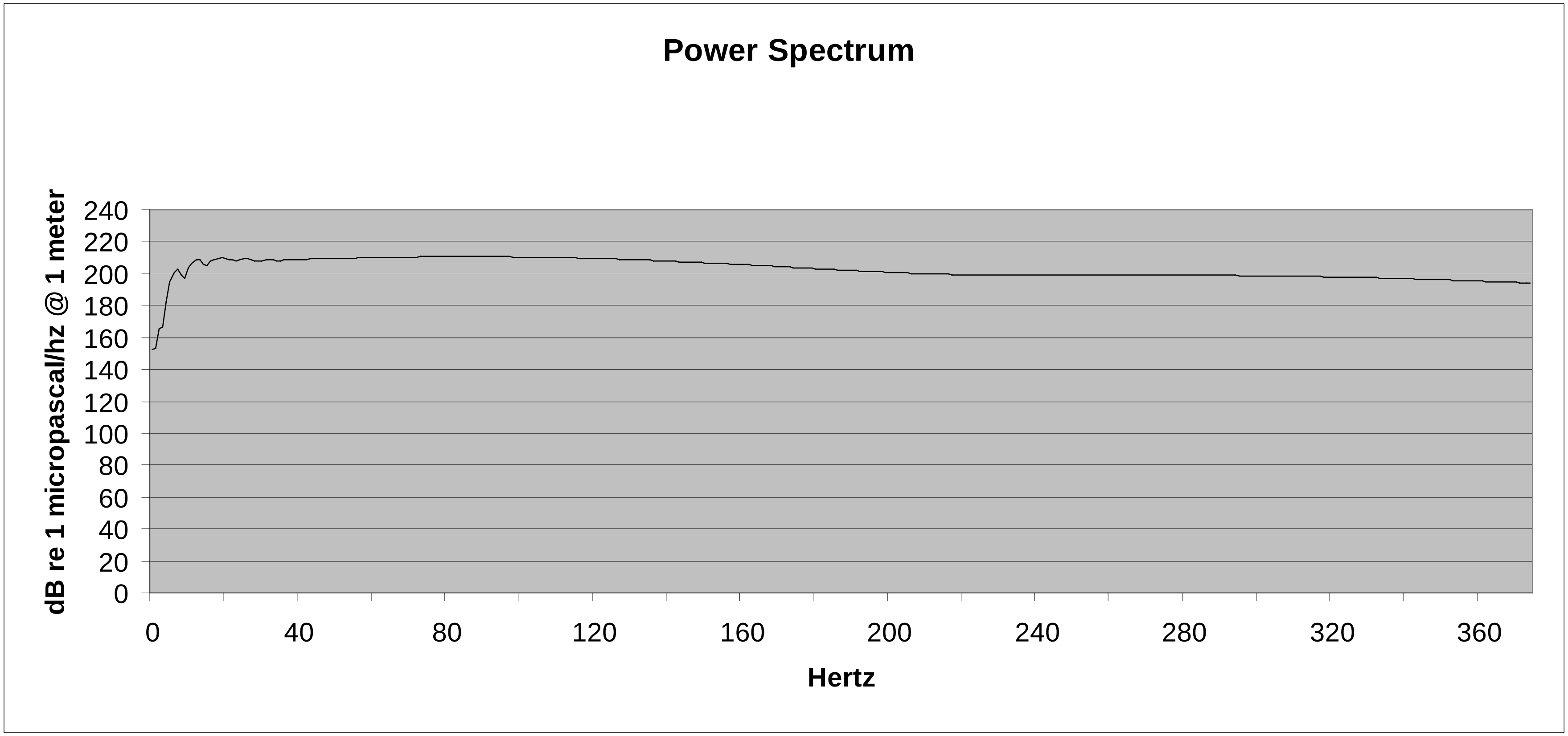
0-P Barm 10.90 P-P Barm 14.70 P/B Ratio = 18.10 Period = 161.75 Depth = 3.00 M Power = 188.68 Db

Simulated Signatures

The following display is a computer simulation of the 2400 cu in SeaScan Tri-Cluster ® Array.

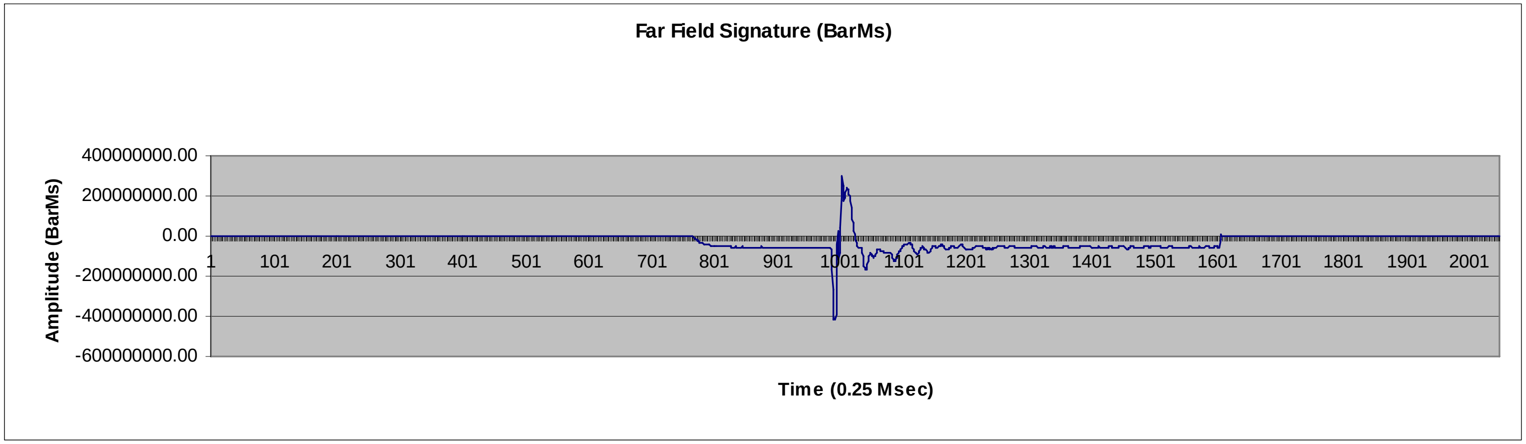


The following display is a computer simulation of the 2400 cu in SeaScan Tri-Cluster ® Array.



Compare with display 2.25

NEAR Field Hydrophone



This is a display of the near-field hydrophone. It is not very useful except for time-break measurement. It is distorted and the distortion is due to acoustic transmission through the frame on which it is mounted. A better approach would be to position the phone below the array. If the phone is monitoring a single gun, the best location is 1 meter below that gun.

If the phone is monitoring several guns, then the best location is about 3 meters below the guns and centrally located.

The phone should not be placed above the array because that would collect more of the returning ghost at higher amplitude. Therefore, placement below the array is preferred.

Resume – Rod Cotton

Rod Cotton – Resume

Dr. Rod Cotton gained his bachelors and doctoral degrees at the University of Glasgow, Scotland. He entered the oil exploration industry in 1965 and over the next 33 years; he worked in Europe, Africa, Central and East Asia and North America for companies that include Texas Instruments, Halliburton, Western Atlas and Baker Hughes.

After 24 years in technology, mostly in data processing and marine 3D seismic data acquisition and processing including a 15 year period of leading edge air gun array design for a wide variety of applications, he changed careers to direct the development of technical and managerial training programs within Halliburton and later Western Atlas. Of his ground-breaking mid-management Red, White and Blue programs, the Red and White courses continue to be offered internally by Baker Hughes trainers today. While at Western, he spearheaded an executive education program for Western Atlas executives through Houston Baptist University (HBU). This program placed 153 executives through 20 days of education in seven groups through five classes on two continents in 14 months. The relationship with HBU subsequently led to an adjunct position with HBU that was shortly after converted to the full time faculty position that continues today.

He is the chairman of the continuing education committee of the Society of Exploration Geophysicists. He is an honorary life member of the Dallas Geophysical Society and a member of the Geophysical Society of Houston, the Society of Exploration Geophysicists, the European Association of Geoscientists and Engineers, the Project Management Institute, and the Houston Typewatchers, the local chapter of the Association for Psychological Type where he acts as the local society treasurer. He is a Rotarian and a member of the Vestry committee of the Episcopal Church of the Epiphany.

Rod and his wife Judy have been married for 37 years (to each other)! They have three grown children including twin daughters and three grandchildren including one set of twins. Outside his professional life, Rod enjoys reading and writing adventure stories, history, motor racing, sailing, bicycling and tinkering with his four computers.