Appendix 7. Location, physical characteristics, borehole-geophysical logs and interpreted structures for well Gates 2.

The Gates Pond site is located in Berlin, MA along I-495. There are four wells. The wells are approximately ±100 meters from Gates Pond, which is the surface water supply for the Town of Hudson, MA. The Town of Hudson commissioned the drilling of the wells in attempt to find a clean and sustainable groundwater source to augment their surface supplies. No such source was found so all four wells remain unused but open. The wells produced five gallons per minute or less based on driller pumping tests. Three wells were investigated for this study. They are named gates1.051507, gates2.062607 and gates3.071807.

The overburden material at the site is glacial till, with thicknesses less than 3 meters. The till is composed of a nonsorted, nonstratified matrix of sand with some clay, silt and boulders. The bedrock is schist of the Nashoba Formation. The Nashoba is a fine to medium grained, and well foliated, gray to silvery-gray quartz-mica schist that may contain biotite, garnet and sillimanite. All wells are cased approximately four meters into the bedrock.

The gates2.02607 well is approximately 100 meters away from gates1.051507. The well was logged from June 25 through 27, 2007. The well is 242 meters deep with a 6.7 meter long casing. There is approximately 2 meters of overburden. A total of 185 fractures were identified in the well. Of the total fractures measured in this well 116 are FPF, 20 are sheeting and 49 are tectonic.

The water table in this well was at approximately 4 meters depth at the beginning of logging. The well was pumped for the heat pulse flow meter pumping test for three hours; during that time the well was drawn down 0.11 meters. Three fractures were identified as flowing fractures and were located at 6.95, 34.8 and 69.5 meters. The fracture at 6.95 meters, which was measured as a foliation parallel fracture, is directly below the base of the casing. It can occur that fractures form near the casing as a result of the damage from drilling; however this fracture is the dominant flowing fracture, providing 70% of the total borehole flow. The other flowing fractures were also foliation parallel fractures.

Appendix 7, continued. Midpoint depth, strike and dip of features identified in optical televiewer log, fracture type and heat pulse flowmeter data from Gates 2 (azimuth and dip reported using right hand rule convention; t = tectonic fractures, s = sheeting joints, p = foliation parallel fractures). Data shown under the pumping test have not been normalized.

Site ID:	gates2.062607			
Location:	"Gates Pond II" Berlin, MA			
Elevation (m)	88			
Well Yield (gpm)	5			
Rock Type:	Schist			
Depth to water:	13.25	ft	4.04	m
Depth of casing:	22	ft	6.71	m
Depth of well:	793	ft	241.71	m
Land surface to MP:	0	ft	0	m

Fractures						Ambient			Pump at 0.5 gpm		
Number	Depth (m)	Depth (ft)	Azimuth	Dip	Type	Flow (y/n)	gpm (amb)	notes	Flow (y/n)	gpm (pump)	notes
1	6.65	21.8	262	61	p	y	-0.01	flow in	y	0.1	flow in
2	6.95	22.8	289	17	s	n	-0.01		n	0.03	
3	7.72	25.3	206	59	p	n	-0.01		n	0.03	
4	8.42	27.6	292	72	t	n	-0.01		n	0.03	
6	8.73	28.7	227	67	p	n	-0.01		n	0.03	
6	9.01	29.6	238	63	p	n	-0.01		n	0.03	
7	9.57	31.4	286	64	t	n	-0.01		n	0.03	
8	10.01	32.9	256	63	p	n	-0.01		n	0.03	
9	11.79	38.7	244	55	p	n	-0.01		n	0.03	
10	11.89	39.0	53	55	t	n	-0.01		n	0.03	
11	12.15	39.9	262	65	p	n	-0.01		n	0.03	
12	12.56	41.2	77	65	t	n	-0.01		n	0.03	
13	15.38	50.5	6	50	t	n	-0.01		n	0.03	
14	16.03	52.6	76	64	t	n	-0.01		n	0.03	
16	16.76	55.0	241	59	p	n	-0.01		n	0.03	
16	18.87	61.9	211	53	p	n	-0.01		n	0.03	
17	19.52	64.0	81	56	t	n	-0.01		n	0.03	
18	20.87	68.5	241	64	p	n	-0.01		n	0.03	
19	23.57	77.3	236	55	p	n	-0.01		n	0.03	
20	23.79	78.1	239	48	p	n	-0.01		n	0.03	
21	23.92	78.5	41	66	t	n	-0.01		n	0.03	
22	24.04	78.9	203	51	p	n	-0.01		n	0.03	
23	25.31	83.0	248	65	p	n	-0.01		n	0.03	
24	25.52	83.7	256	55	p	n	-0.01		n	0.03	
25	25.81	84.7	225	60	p	n	-0.01		n	0.03	
26	27.92	91.6	53	72	t	n	-0.01		n	0.03	
27	29.13	95.6	236	45	p	n	-0.01		n	0.03	
28	29.41	96.5	225	42	p	n	-0.01		n	0.03	
29	29.93	98.2	248	50	p	n	-0.01		n	0.03	
30	30.23	99.2	245	65	p	n	-0.01		n	0.03	
31	30.72	100.8	258	31	p	n	-0.01		n	0.03	
32	31.36	102.9	63	82	t	n	-0.01		n	0.03	
33	31.91	104.7	62	83	t	n	-0.01		n	0.03	
34	34.77	114.1	248	83	p	n	-0.01		y	0.03	flow in
35	35.58	116.8	47	68	t	n	-0.01		n	0.01	
36	36.21	118.8	250	47	p	n	-0.01		n	0.01	
37	36.47	119.7	247	48	p	n	-0.01		n	0.01	
38	36.71	120.5	239	42	p	n	-0.01		n	0.01	
39	36.89	121.0	253	52	p	n	-0.01		n	0.01	
40	37.33	122.5	247	44	p	n	-0.01		n	0.01	
41	37.82	124.1	227	59	p	n	-0.01		n	0.01	
42	38.76	127.2	228	52	p	n	-0.01		n	0.01	
43	39.02	128.0	235	63	p	n	-0.01		n	0.01	
44	39.29	128.9	73	62	t	n	-0.01		n	0.01	
45	39.47	129.5	73	75	t	n	-0.01		n	0.01	
46	39.87	130.8	265	58	p	n	-0.01		n	0.01	
47	40.62	133.3	232	49	p	n	-0.01		n	0.01	
48	42.31	138.8	226	60	p	n	-0.01		n	0.01	
49	42.57	139.7	271	52	p	n	-0.01		n	0.01	
50	42.82	140.5	235	48	p	n	-0.01		n	0.01	
51	43.05	141.2	220	29	p	n	-0.01		n	0.01	
52	43.21	141.8	228	42	p	n	-0.01		n	0.01	
53	43.59	143.0	226	62	p	n	-0.01		n	0.01	
54	44.92	147.4	216	60	p	n	-0.01		n	0.01	
56	46.76	153.4	167	68	t	n	-0.01		n	0.01	

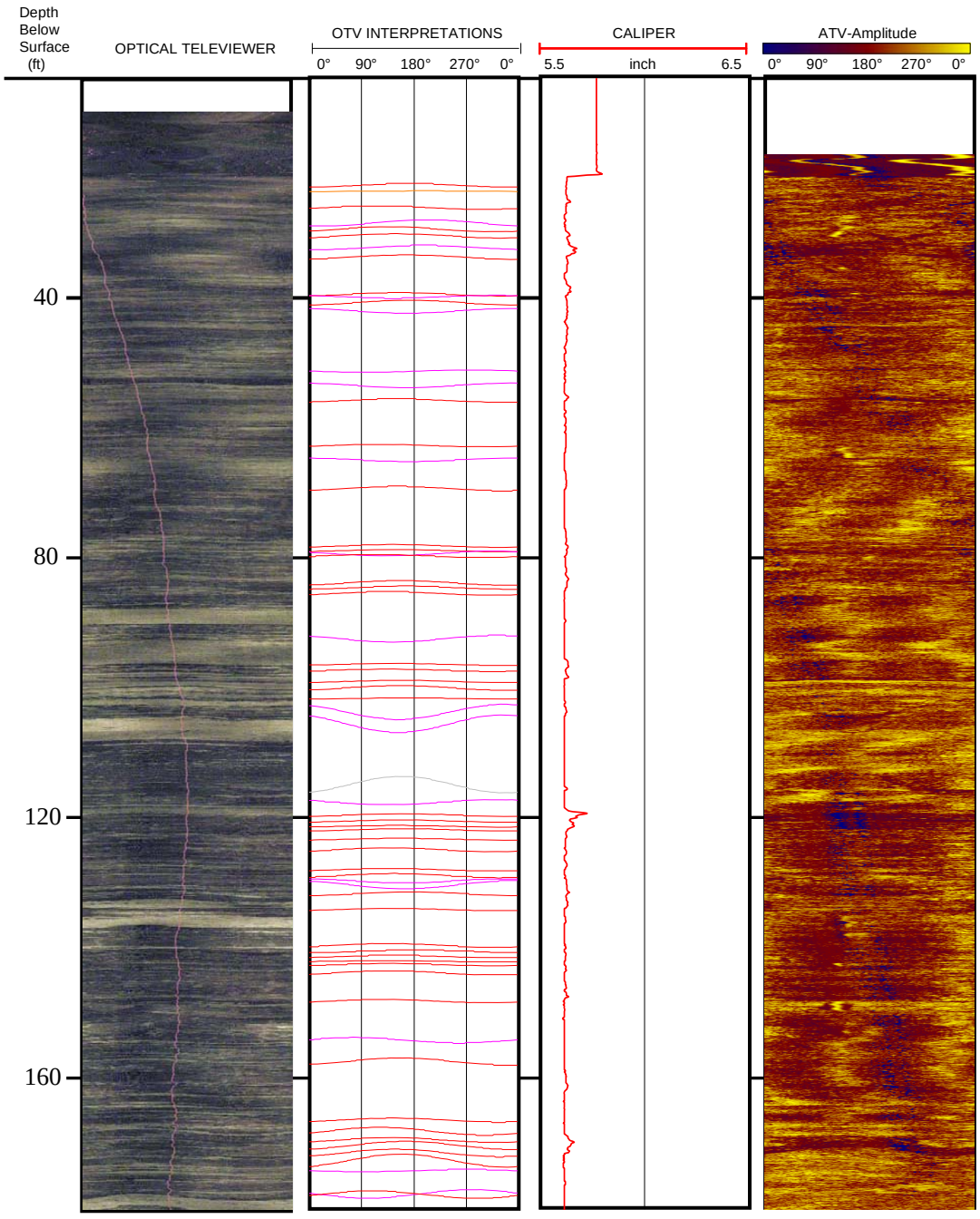
Appendix 7, continued. Midpoint depth, strike and dip of features identified in optical televiewer log, fracture type and heat pulse flowmeter data from Gates 2 (azimuth and dip reported using right hand rule convention; t = tectonic fractures, s = sheeting joints, p = foliation parallel fractures). Data shown under the pumping test have not been normalized.

66	47.74	156.6	246	73	p	n	-0.01		n	0.01	
67	50.50	165.7	235	63	p	n	-0.01		n	0.01	
68	51.00	167.3	210	75	p	n	-0.01		n	0.01	
69	51.44	168.8	231	66	p	n	-0.01		n	0.01	
60	51.69	169.6	255	75	p	n	-0.01		n	0.01	
61	52.02	170.7	237	75	p	n	-0.01		n	0.01	
62	52.40	171.9	247	80	p	n	-0.01		n	0.01	
63	52.86	173.4	1	45	t	n	-0.01		n	0.01	
64	53.96	177.0	10	76	t	n	-0.01		n	0.01	
66	53.98	177.1	198	74	p	n	-0.01		n	0.01	
68	55.70	182.8	232	78	p	n	-0.01		n	0.01	
67	55.96	183.6	69	75	t	n	-0.01		n	0.01	
68	56.21	184.4	76	68	t	n	-0.01		n	0.01	
69	56.48	185.3	220	10	s	n	-0.01		n	0.01	
70	56.67	185.9	52	75	t	n	-0.01		n	0.01	
71	56.70	186.0	229	71	p	n	-0.01		n	0.01	
72	57.14	187.5	60	49	t	n	-0.01		n	0.01	
73	57.55	188.8	61	56	t	n	-0.01		n	0.01	
74	58.15	190.8	80	71	t	n	-0.01		n	0.01	
76	58.54	192.1	239	66	p	n	-0.01		n	0.01	
78	59.20	194.2	229	72	p	n	-0.01		n	0.01	
77	59.70	195.9	228	55	p	n	-0.01		n	0.01	
78	61.33	201.2	129	72	t	n	-0.01		n	0.01	
79	61.68	202.4	200	69	p	n	-0.01		n	0.01	
80	61.93	203.2	308	45	t	n	-0.01		n	0.01	
81	62.19	204.0	201	57	p	n	-0.01		n	0.01	
82	63.19	207.3	241	83	p	n	-0.01		n	0.01	
83	63.40	208.0	239	84	p	n	-0.01		n	0.01	
84	63.55	208.5	224	74	p	n	-0.01		n	0.01	
86	64.33	211.1	247	77	p	n	-0.01		n	0.01	
88	64.94	213.1	260	74	p	n	-0.01		n	0.01	
87	65.36	214.4	264	76	p	n	-0.01		n	0.01	
88	65.91	216.3	241	62	p	n	-0.01		n	0.01	
89	66.38	217.8	233	40	p	n	-0.01		n	0.01	
90	67.53	221.6	234	74	p	n	-0.01		n	0.01	
91	67.99	223.1	237	57	p	n	-0.01		n	0.01	
92	68.88	226.0	229	62	p	n	-0.01		n	0.01	
93	69.02	226.5	221	63	p	n	-0.01		n	0.01	
94	69.39	227.7	224	42	p	n	-0.01		n	0.01	
96	69.50	228.0	234	60	p	y	0	flow out	y	0.01	flow in
98	69.59	228.3	242	54	p	n	0.01		n	0	
97	71.81	235.6	250	54	p	n	0.01		n	0	
98	73.81	242.2	226	56	p	n	0.01		n	0	
99	74.04	242.9	249	58	p	n	0.01		n	0	
100	74.15	243.3	257	61	p	n	0.01		n	0	
101	74.50	244.4	234	73	p	n	0.01		n	0	
102	76.03	249.4	237	48	p	n	0.01		n	0	
103	76.95	252.5	227	63	p	n	0.01		n	0	
104	77.55	254.4	231	46	p	n	0.01		n	0	
106	78.06	256.1	46	65	t	n	0.01		n	0	
108	82.79	271.6	256	37	p	n	0.01		n	0	
107	82.87	271.9	241	45	p	n	0.01		n	0	
108	83.04	272.5	233	49	p	n	0.01		n	0	
109	84.93	278.7	255	72	p	n	0.01		n	0	
110	85.88	281.8	249	80	p	n	0.01		n	0	
111	88.57	290.6	254	64	p	n	0.01		n	0	
112	89.76	294.5	246	71	p	n	0.01		n	0	
113	90.21	296.0	245	71	p	n	0.01		n	0	
114	90.99	298.5	263	54	p	n	0.01		n	0	
116	94.43	309.8	210	75	p	n	0.01		n	0	
118	96.61	317.0	223	43	p	n	0.01		n	0	
117	97.63	320.3	33	34	t	n	0.01		n	0	
118	106.02	347.9	14	87	t	n	0.01		n	0	
119	110.28	361.8	107	77	t	n	0.01		n	0	
120	111.24	365.0	46	69	t	n	0.01		n	0	
121	116.92	383.6	97	71	t	n	0.01		n	0	
122	117.82	386.6	94	62	t	n	0.01		n	0	
123	118.90	390.1	100	56	t	n	0.01		n	0	
124	122.09	400.6	176	17	t	n	0.01		n	0	

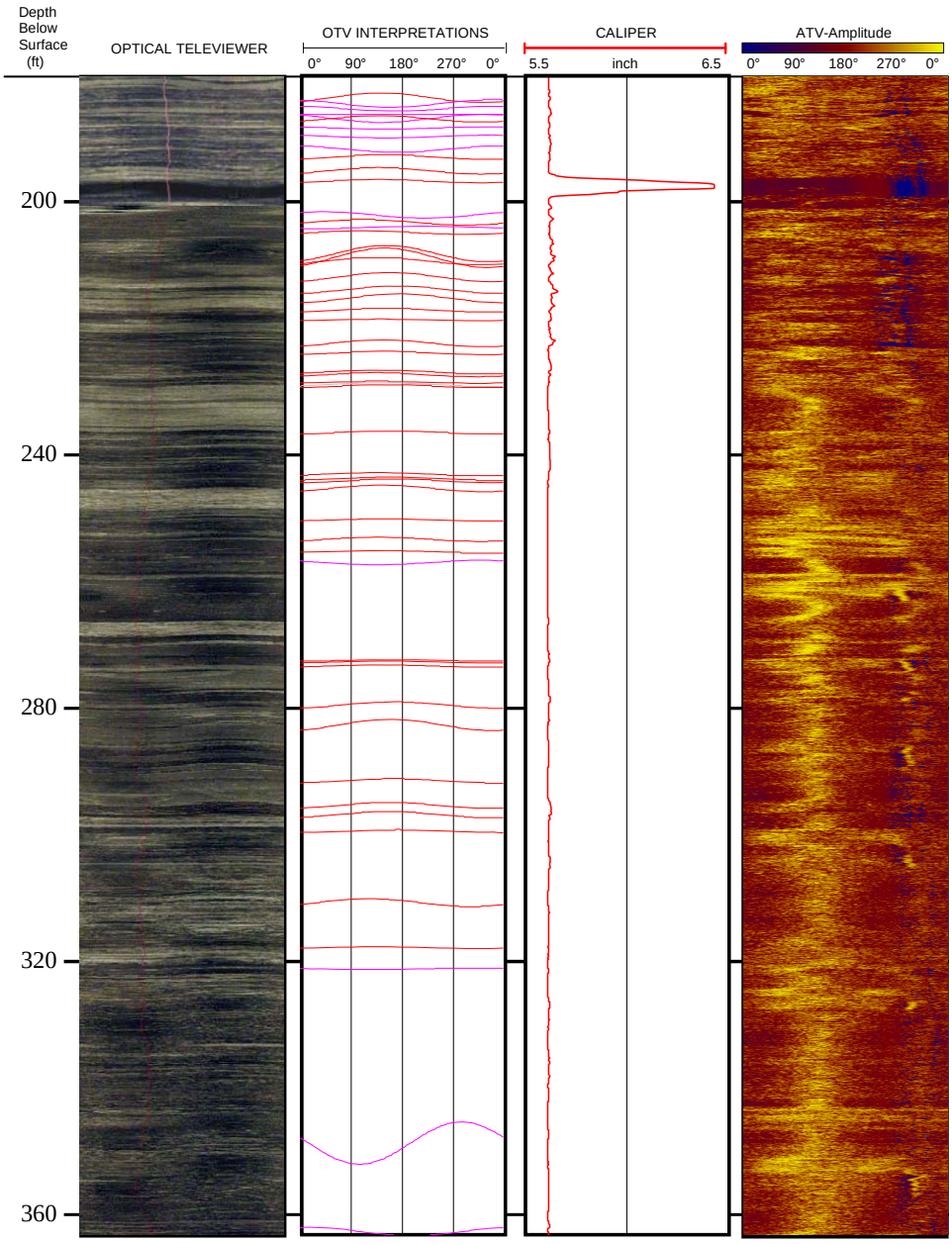
Appendix 7, continued. Midpoint depth, strike and dip of features identified in optical televiewer log, fracture type and heat pulse flowmeter data from Gates 2 (azimuth and dip reported using right hand rule convention; t = tectonic fractures, s = sheeting joints, p = foliation parallel fractures). Data shown under the pumping test have not been normalized.

126	127.66	418.9	239	32	t	n	0.01		n	0
128	129.35	424.4	44	50	t	n	0.01		n	0
127	132.59	435.0	45	47	t	n	0.01		n	0
128	133.99	439.6	196	45	p	n	0.01		n	0
129	135.64	445.0	32	37	t	n	0.01		n	0
130	136.16	446.7	229	44	p	n	0.01		n	0
131	137.27	450.4	253	60	p	n	0.01		n	0
132	139.08	456.3	148	5	s	n	0.01		n	0
133	139.38	457.3	215	66	p	n	0.01		n	0
134	142.07	466.1	351	63	t	n	0.01		n	0
136	144.53	474.2	222	40	p	n	0.01		n	0
138	145.64	477.9	178	31	p	n	0.01		n	0
137	147.43	483.7	203	42	p	n	0.01		n	0
138	147.72	484.7	215	66	p	n	0.01		n	0
139	148.84	488.4	23	12	s	n	0.01		n	0
140	154.52	507.0	246	34	p	n	0.01		n	0
141	155.06	508.7	247	36	p	n	0.01		n	0
142	156.27	512.7	313	72	t	n	0.01		n	0
143	157.05	515.3	312	68	t	n	0.01		n	0
144	161.78	530.8	287	32	t	y	0.01	flow in	n	0
146	163.36	536.0	29	30	t	n	0		n	0
148	164.28	539.0	213	8	s	n	0		n	0
147	164.40	539.4	237	26	p	n	0		n	0
148	164.47	539.6	258	54	p	n	0		n	0
149	164.89	541.0	283	15	s	n	0		n	0
150	165.72	543.7	32	56	t	n	0		n	0
151	167.16	548.5	247	9	s	n	0		n	0
152	167.48	549.5	199	23	s	n	0		n	0
153	168.06	551.4	200	18	s	n	0		n	0
154	170.03	557.9	236	42	p	n	0		n	0
156	171.11	561.4	172	48	t	n	0		n	0
158	171.36	562.2	163	41	t	n	0		n	0
157	171.68	563.3	248	74	p	n	0		n	0
158	172.20	565.0	214	61	p	n	0		n	0
159	172.57	566.2	267	46	p	n	0		n	0
160	172.81	567.0	96	31	t	n	0		n	0
161	176.03	577.6	68	27	t	n	0		n	0
162	186.32	611.3	204	6	s	n	0		n	0
163	188.22	617.6	9	15	s	n	0		n	0
164	189.11	620.5	121	18	s	n	0		n	0
166	193.01	633.3	80	7	s	n	0		n	0
168	196.01	643.1	250	32	p	n	0		n	0
167	198.91	652.6	247	86	p	n	0		n	0
168	202.03	662.9	335	16	s	n	0		n	0
169	204.53	671.1	217	38	p	n	0		n	0
170	205.33	673.7	14	65	t	n	0		n	0
171	206.24	676.7	56	39	t	n	0		n	0
172	206.56	677.7	248	25	s	n	0		n	0
173	213.66	701.0	346	8	s	n	0		n	0
174	215.53	707.2	218	58	p	n	0		n	0
176	218.17	715.8	223	79	p	n	0		n	0
178	218.79	717.9	249	70	p	n	0		n	0
177	219.53	720.3	296	15	s	n	0		n	0
178	221.01	725.1	263	52	p	n	0		n	0
179	221.59	727.1	206	67	p	n	0		n	0
180	222.20	729.0	229	56	p	n	0		n	0
181	224.55	736.7	257	44	p	n	0		n	0
182	224.72	737.3	344	29	t	n	0		n	0
183	226.17	742.1	268	52	p	n	0		n	0
184	230.48	756.2	354	8	s	n	0		n	0
186	238.95	784.0	111	14	s	n	0		n	0

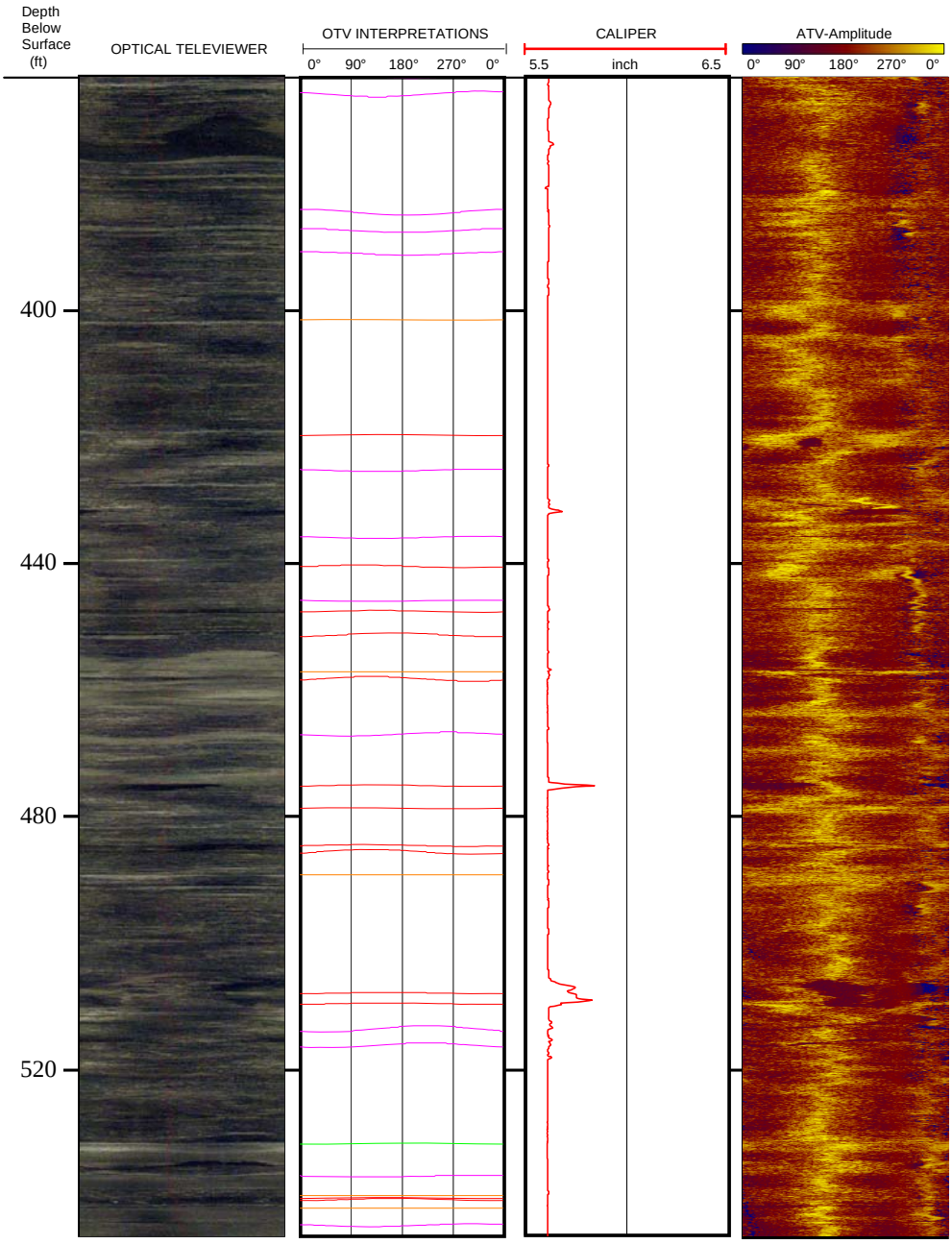
Appendix 7, continued. Interpreted features for Gates 2. Optical televiewer interpretations indicated by color: orange – subhorizontal sheeting joint; magenta – tectonic joint; red – foliation parallel fracture (FPF); cyan – transmissive subhorizontal sheeting joint; green – transmissive tectonic joint; grey – transmissive foliation parallel fracture (FPF). OTV – optical televiewer; ATV – acoustic televiewer.



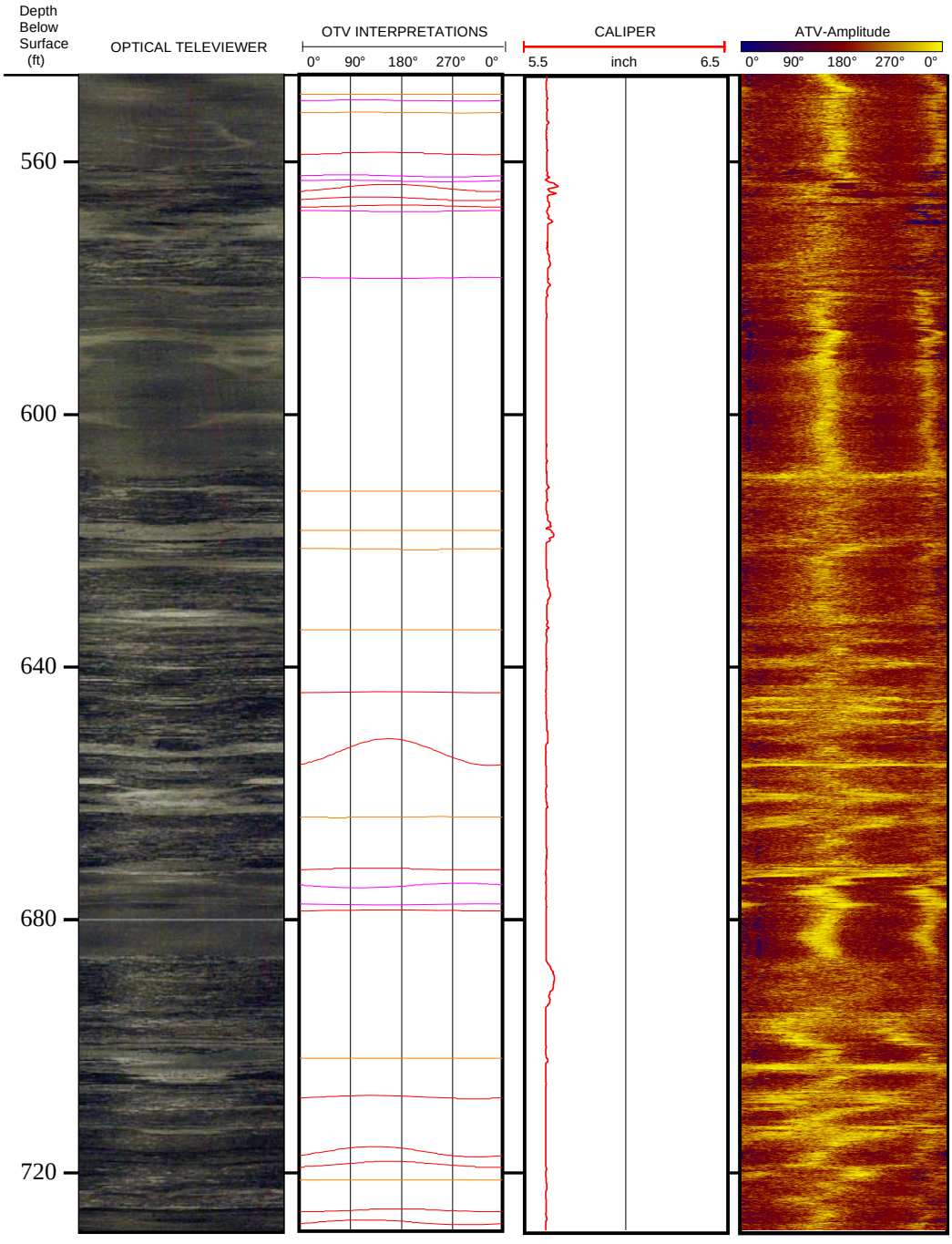
Appendix 7, continued. Interpreted features for Gates 2. Optical televiewer interpretations indicated by color: orange – subhorizontal sheeting joint; magenta – tectonic joint; red – foliation parallel fracture (FPF); cyan – transmissive subhorizontal sheeting joint; green – transmissive tectonic joint; grey – transmissive foliation parallel fracture (FPF). OTV – optical televiewer; ATV – acoustic televiewer.



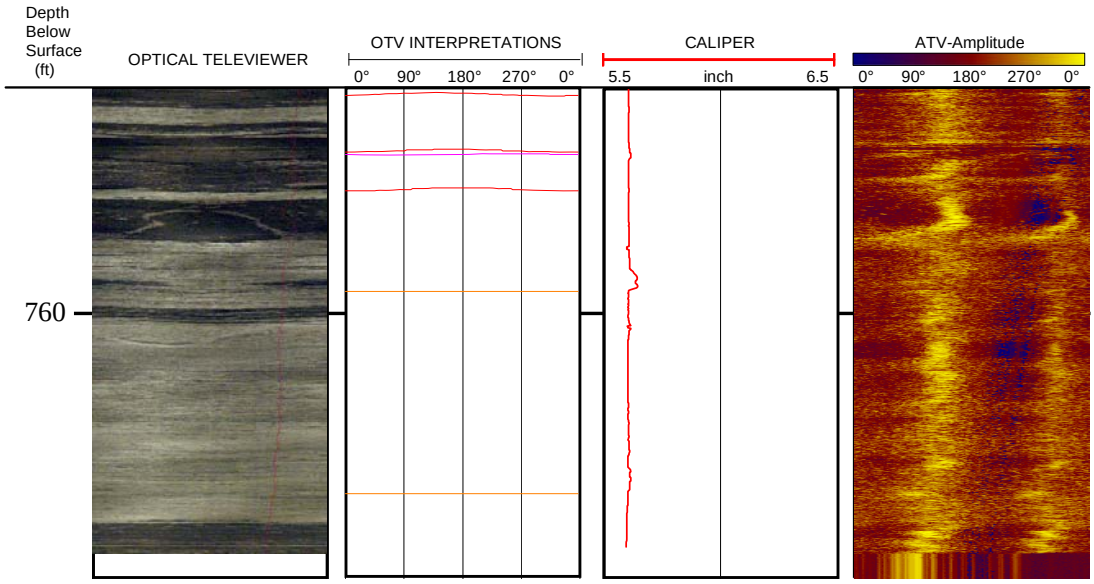
Appendix 7, continued. Interpreted features for Gates 2. Optical televiewer interpretations indicated by color: orange – subhorizontal sheeting joint; magenta – tectonic joint; red – foliation parallel fracture (FPF); cyan – transmissive subhorizontal sheeting joint; green – transmissive tectonic joint; grey – transmissive foliation parallel fracture (FPF). OTV – optical televiewer; ATV – acoustic televiewer.



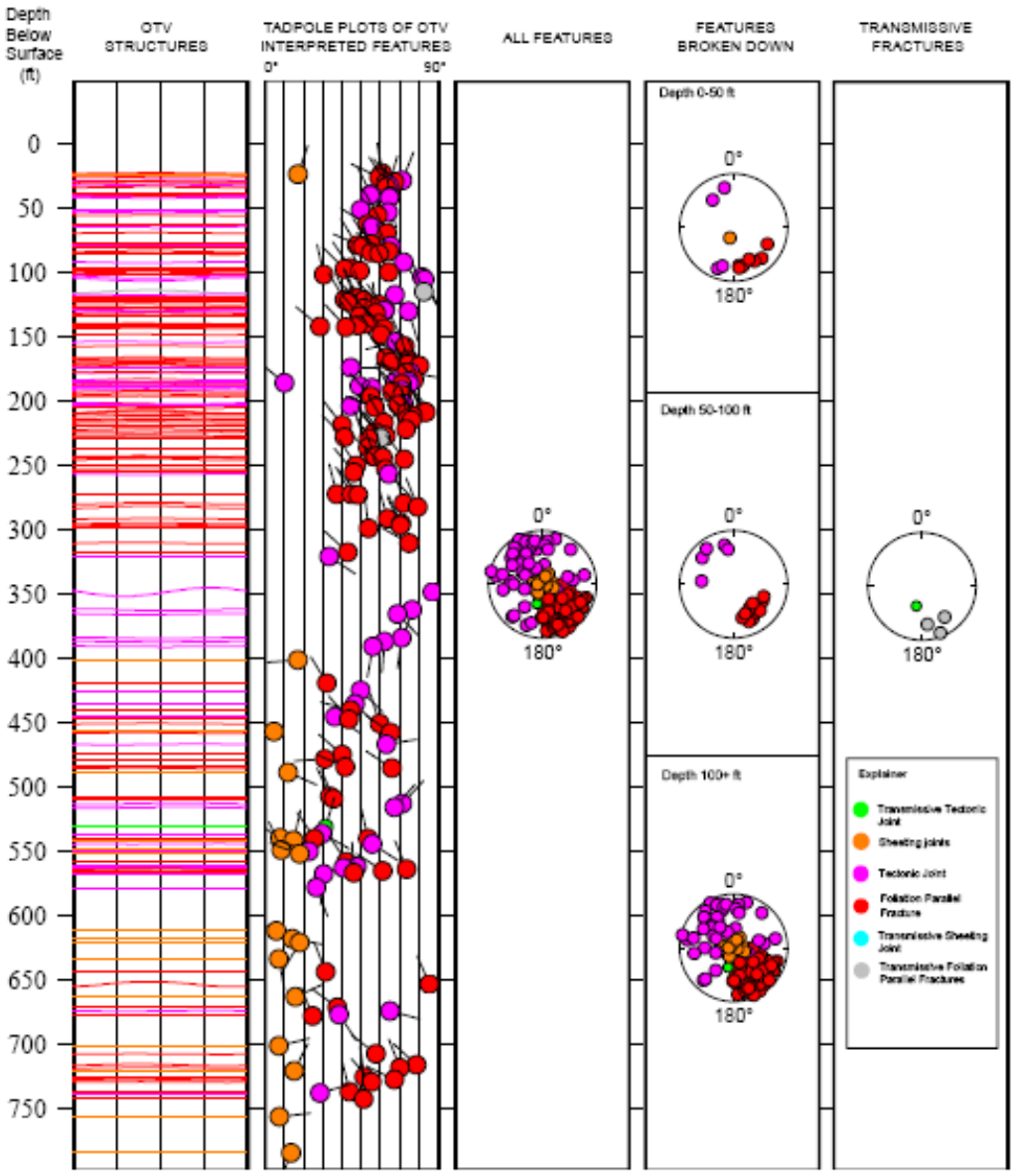
Appendix 7, continued. Interpreted features for Gates 2. Optical televiewer interpretations indicated by color: orange – subhorizontal sheeting joint; magenta – tectonic joint; red – foliation parallel fracture (FPF); cyan – transmissive subhorizontal sheeting joint; green – transmissive tectonic joint; grey – transmissive foliation parallel fracture (FPF). OTV – optical televiewer; ATV – acoustic televiewer.



Appendix 7, continued. Interpreted features for Gates 2. Optical televiewer interpretations indicated by color: orange – subhorizontal sheeting joint; magenta – tectonic joint; red – foliation parallel fracture (FPF); cyan – transmissive subhorizontal sheeting joint; green – transmissive tectonic joint; grey – transmissive foliation parallel fracture (FPF). OTV – optical televiewer; ATV – acoustic televiewer.



Appendix 7, continued. Tadpole plots and stereoplots of interpreted optical televiewer (OTV) structures for Gates 2. In the tadpole plot depth is plotted along the y-axis and magnitude of the dip plotted on the x-axis. The tail of the tadpole points in the direction of the dip, relative to true north, which is toward the top of the page. The stereonets represent poles to planar features plotted on a lower-hemisphere equal-area stereonet. Stereonets use right hand rule convention. Colors on the OTV structures plot correspond to those in the tadpole explanation.



Appendix 7, continued. Composite log for Gates 2 of natural gamma, fluid resistivity, fluid temperature and heat pulse flowmeter data under ambient and stressed (pumping) conditions. For the heat pulse flowmeter data collected under pumping conditions, the well was pumped at 0.5 gallons per minute and the data have been normalized.