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E74-10325
CR-136820

Detection of Moisture and Moisture Related Phenomena from Skylab

Joe R. Eagleman
Principal Investigator

Monthly Progress Report, February 1974

(E74-10325) DETECTION OF MOISTURE AND
MOISTURE RELATED PHENOMENA FROM SKYLAB
Monthly Progress Report, Feb. 1974
(Kansas Univ. Center for Research, Inc.)
11 p HC \$4.00

N74-18001

Unclas
00325

G3/13

CSCL C8M

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Center for Research, Inc.
University of Kansas

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Phenomena from Skylab

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EREP NO. 540-A2 March 19, 1973 to August 31, 1974

Contract Number NAS 9-13273

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COMPOSITE RELATIONSHIP BETWEEN S194 ANTENNA
TEMPERATURE AND SOIL MOISTURE

The S194 antenna temperatures have been correlated with the measured soil moisture content in the test sites for Skylab 2 and Skylab 3 (see December 1973 and January 1974 progress reports). The correlation coefficients showed that the soil moisture from the surface to a depth of one inch gave the best relationship with the S194 antenna temperatures. All 185 data points for the five sets of Skylab data have been combined and plotted as shown in Figure 1. The correlation coefficient is -0.97. In Figure 1, the x coordinate values represent the soil moisture content and y coordinate values are the changes in S194 antenna temperature. The (*'s) and (+'s) in the scatter diagram are computer plots of the best fitting curve.

The theoretical and one set of the experimental results were expressed as the relationship between soil moisture content and brightness temperature in the second-degree polynomial (see January progress report). Figure 2 compares the regression line obtained from the five combined data sets with the calculated curves. Although there are large differences between the two, S194 data agrees with other experimental data as shown in the January Progress Report. In Figure 2, the expected curves were plotted from theoretical calculations based on a ground temperature of 80°F, which was very close to the average temperature of the 5 sets of experimental data.

SOIL MOISTURE PREDICTION ACROSS THE
UNITED STATES FROM S194 DATA

Several flights of Skylab have provided S194 antenna temperatures across the United States. These data were used to predict the distribution of soil moisture along the flight track using the best fitting second-degree polynomial from Figure 1. The equation resulted from the combination of five sets of data relating soil moisture to antennae temperature obtained over sites in Kansas and Texas. The equation is:

$$SM = 567.15 - 3.9567AT + 0.00693AT^2$$

where SM is the predicted soil moisture in percentage by weight and AT is the S194 antenna temperature in °K. By inserting average air temperature (T) of the samples, the equation is modified into:

$$SM = 567.15 - 1187.01\frac{AT}{T} + 623.7\left(\frac{AT}{T}\right)^2$$

This equation was used to predict the distribution of soil moisture across the United States along the SL3 track for August 5, 1973 (Map 1). The air temperature was estimated from climatological data of the Environmental Data Service, NOAA. The location (No.), S194 antenna temperature (AT), air temperature (T) and predicted soil moisture content (SM) are listed as Table 1. Since the regression equation was calculated using soil moisture ranging from 1% to 36% by weight, this equation is useful for land only. Thus, the predicted soil moisture at locations 1-5 and locations 526-530 is in

error because the S194 antennae temperature is responding to portions of the Pacific Ocean and Gulf of Mexico. The estimated soil moisture is within a few percent of the measured values where data are available for comparison in the central United States.

SUMMARY OF SIGNIFICANT RESULTS

Data from five Skylab passes were combined to give a composite relationship between the S194 antennae temperature and soil moisture content in the surface to one inch layer. The five data sets were comparable and resulted in a correlation coefficient of -0.97. The regression equation was used to predict soil moisture content across the United States for one particular pass on August 5, 1973.

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SCALE FACTOR ON Y IS 1.00E 02

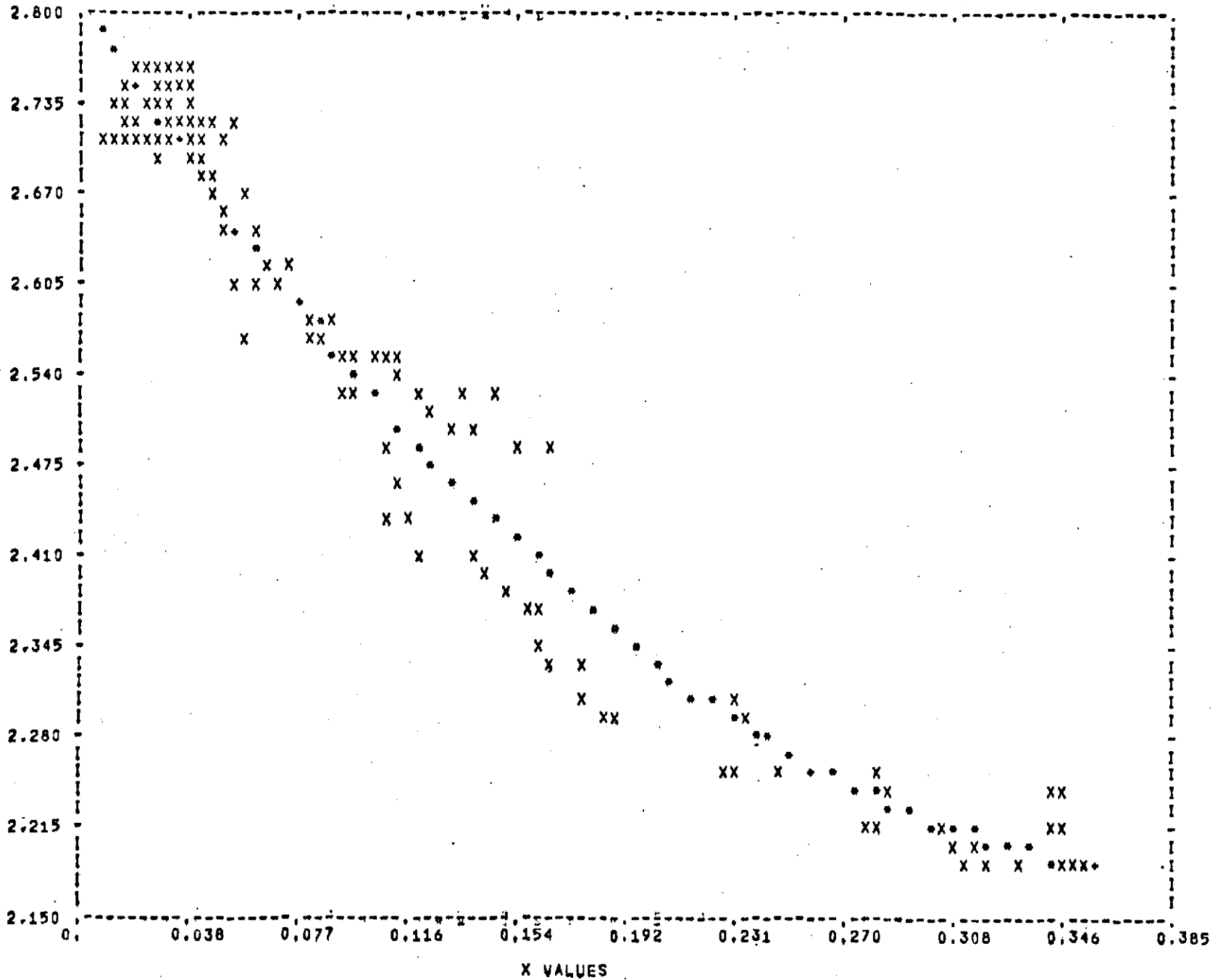


Figure 1.

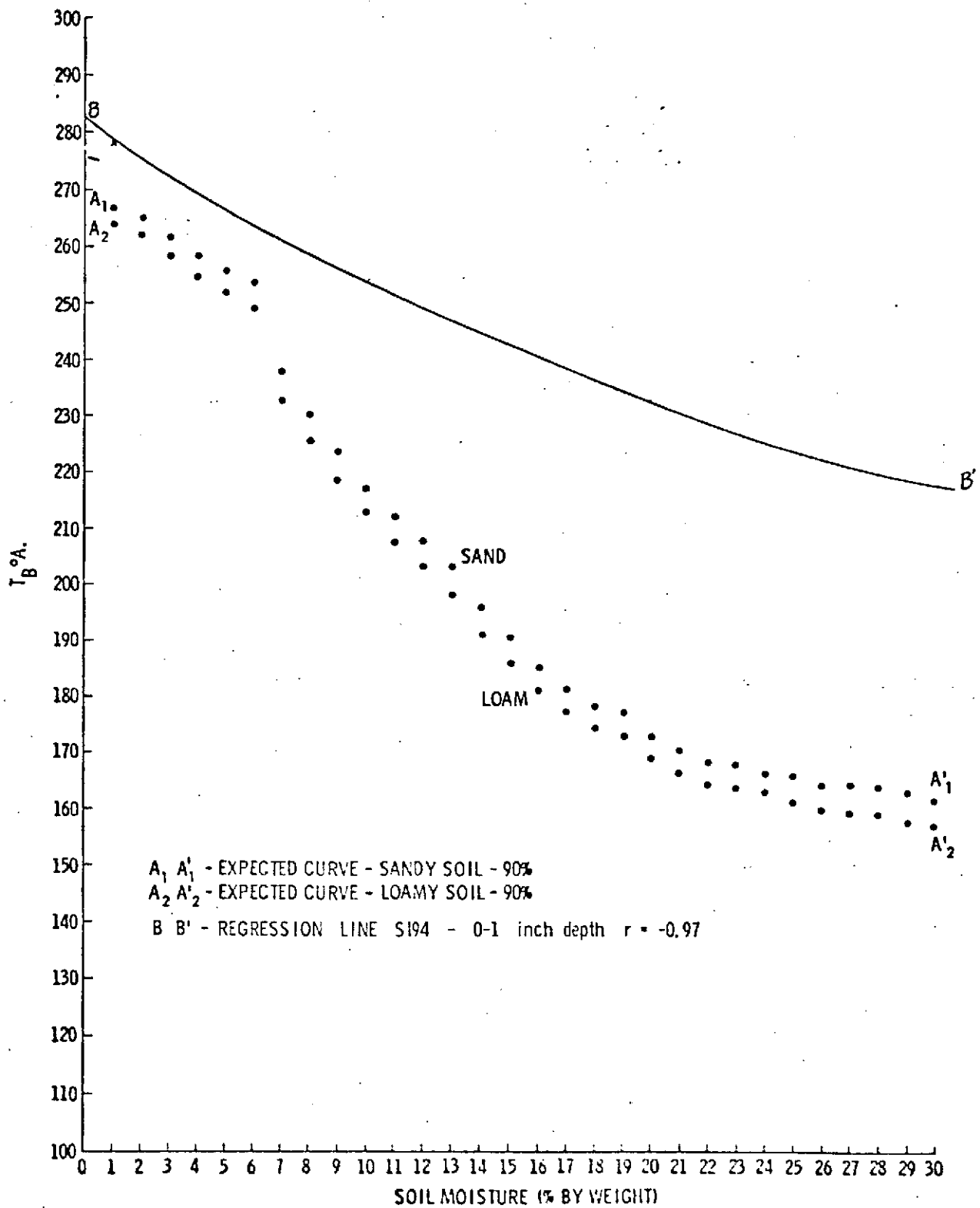
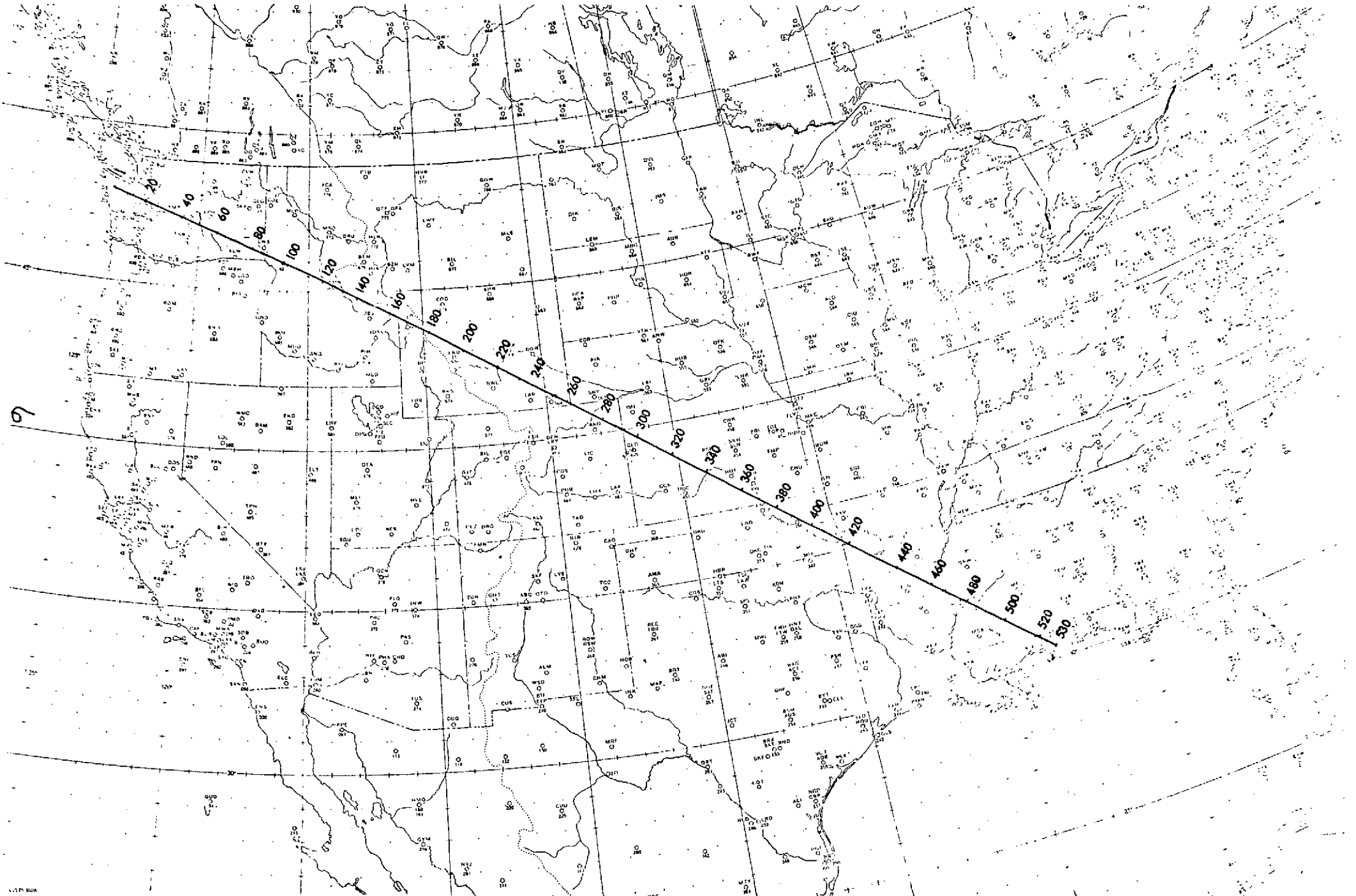


Figure 2.

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Map 1



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Table 1

No	AT	T	SM	No	AT	T	SM	No	AT	T	SM
1	169.70	285.94	82.36	60	268.20	298.72	4.18	120	261.70	293.16	4.54
2	182.80	285.94	63.20	61	268.20	298.72	4.18	121	261.70	292.05	4.30
3	191.30	285.94	52.17	62	268.20	298.72	4.18	122	261.70	292.05	4.30
4	196.00	286.49	46.99	63	270.10	298.72	3.78	123	260.70	292.05	4.54
5	200.70	286.49	41.69	64	271.00	298.16	3.51	124	257.90	290.94	5.02
6	201.60	286.49	40.71	65	271.00	298.72	3.61	125	257.90	290.94	5.02
7	207.20	286.49	34.90	66	271.00	298.72	3.61	126	257.90	290.94	5.02
8	209.10	287.05	33.43	67	271.00	298.72	3.61	127	257.90	289.83	4.76
9	211.00	287.05	31.62	68	271.00	298.72	3.61	128	257.90	289.83	4.76
10	214.70	287.05	28.24	69	272.90	298.72	3.28	129	257.90	289.83	4.76
11	215.70	287.05	27.36	70	272.90	298.72	3.28	130	257.00	289.83	5.90
12	217.50	287.05	25.82	71	272.90	298.72	3.28	131	256.10	288.72	4.98
13	219.40	287.05	24.25	72	272.90	299.27	3.36	132	259.10	288.72	4.21
14	221.30	287.05	22.73	73	272.90	299.27	3.36	133	251.70	288.72	6.35
15	224.10	287.60	20.91	74	272.90	297.60	3.12	134	251.40	288.72	6.45
16	226.00	287.60	19.52	75	272.90	297.60	3.12	135	251.40	287.60	6.12
17	226.00	287.60	19.52	76	272.90	297.60	3.12	136	251.40	287.60	6.12
18	226.00	287.60	19.52	77	272.90	297.05	3.05	137	251.40	287.60	6.12
19	226.00	287.60	19.52	78	272.90	297.05	3.05	138	251.40	287.60	6.12
20	229.70	287.60	16.96	79	272.90	296.49	2.98	139	250.40	289.27	6.99
21	231.60	287.60	15.73	80	272.90	296.49	2.98	140	250.40	290.38	7.35
22	231.60	287.60	15.73	81	272.90	296.49	2.98	141	250.40	290.38	7.35
23	237.30	288.16	12.61	82	272.90	295.94	2.92	142	250.40	290.38	7.35
24	237.30	288.72	12.87	83	272.90	295.94	2.92	143	250.40	290.94	7.53
25	237.30	289.27	13.12	84	272.90	295.94	2.92	144	249.50	290.94	7.89
26	237.30	288.72	12.87	85	271.00	295.94	3.18	145	246.70	289.83	8.66
27	244.80	288.16	8.87	86	270.10	295.94	3.32	146	246.70	289.83	8.66
28	247.60	287.60	7.51	87	269.20	295.94	3.48	147	246.70	288.72	8.26
29	247.30	287.60	7.63	88	269.20	295.38	3.39	148	248.50	288.72	7.53
30	247.60	286.49	7.14	89	269.20	295.38	3.39	149	250.40	288.72	6.81
31	250.30	285.38	5.84	90	269.20	295.38	3.39	150	250.40	288.72	6.81
32	251.90	284.27	5.05	91	269.20	295.38	3.39	151	250.50	287.60	6.43
33	258.80	253.16	3.26	92	269.20	294.27	3.22	152	250.50	287.60	6.43
34	258.30	282.05	3.10	93	269.20	294.27	3.22	153	249.50	287.60	6.79
35	262.60	280.94	2.56	94	269.20	293.16	3.07	154	249.50	288.72	7.14
36	262.60	280.94	2.56	95	269.20	293.16	3.07	155	248.60	289.27	7.68
37	259.80	282.05	2.96	96	269.30	293.16	3.06	156	248.60	289.27	7.68
38	259.30	284.83	3.35	97	269.30	292.05	2.92	157	248.60	289.27	7.68
39	259.80	287.60	3.83	98	269.30	292.05	2.92	158	248.50	289.27	7.72
40	259.80	288.72	4.05	99	269.30	290.94	2.80	159	248.60	289.27	7.68
41	259.80	288.72	4.05	100	265.40	290.94	3.34	160	247.60	288.72	7.89
42	260.70	290.94	4.30	101	265.40	290.94	3.34	161	247.60	288.72	7.89
43	262.60	293.16	4.32	102	265.40	290.38	3.26	162	247.60	288.72	7.89
44	263.50	294.27	4.34	103	265.40	290.94	3.34	163	247.60	288.16	7.70
45	264.50	295.38	4.34	104	265.40	292.05	3.52	164	247.60	287.60	7.51
46	264.50	296.49	4.59	105	265.40	292.60	3.62	165	247.60	287.60	7.51
47	264.50	296.49	4.59	106	264.50	292.60	3.79	166	247.60	287.60	7.51
48	262.20	296.49	5.20	107	263.60	294.27	4.32	167	247.60	287.05	7.32
49	265.40	298.72	4.86	108	263.60	294.27	4.32	168	247.60	287.05	7.32
50	265.40	298.72	4.86	109	263.60	295.38	4.56	169	242.90	287.05	9.31
51	265.40	298.72	4.86	110	263.60	295.38	4.56	170	242.90	287.05	9.31
52	265.40	298.72	4.86	111	263.60	296.49	4.82	171	242.90	287.05	9.31
53	268.20	298.72	4.18	112	263.60	297.05	4.95	172	242.90	287.60	9.52
54	268.20	298.72	4.18	113	263.60	296.49	4.82	173	242.90	287.60	9.52
55	268.20	298.72	4.18	114	263.60	296.49	4.82	174	242.90	288.16	9.74
56	268.20	298.72	4.18	115	263.60	295.38	4.56	175	244.80	288.16	8.87
57	268.20	298.72	4.18	116	263.60	295.38	4.56	176	247.60	288.16	7.70
58	268.20	298.72	4.18	117	261.70	294.27	4.80	177	244.30	288.16	8.87
59	268.20	298.72	4.18	118	261.70	294.27	4.80	178	242.90	288.16	9.74
				119	261.70	293.16	4.54	179	242.00	288.72	10.40

No	AT	T	SM
180	241.10	289.83	11.32
181	242.00	289.83	10.86
182	242.00	290.94	11.33
183	242.00	290.94	11.33
184	242.90	292.05	11.34
185	243.90	292.05	10.84
186	243.90	292.60	11.07
187	247.60	293.16	9.52
188	247.60	293.16	9.52
189	246.70	293.72	10.15
190	247.60	293.72	9.73
191	247.60	293.72	9.73
192	247.60	293.16	9.52
193	249.50	292.60	8.48
194	249.50	292.05	8.28
195	250.50	292.05	7.87
196	255.10	291.49	6.02
197	255.10	291.49	6.02
198	255.10	291.49	6.02
199	255.10	291.49	6.02
200	260.80	290.94	4.28
201	260.80	290.94	4.28
202	260.80	290.94	4.28
203	259.80	290.94	4.52
204	259.80	290.94	4.52
205	259.80	290.94	4.52
206	259.80	290.94	4.52
207	259.80	290.94	4.52
208	259.80	290.94	4.52
209	259.80	292.05	4.78
210	263.60	292.05	3.88
211	263.60	292.05	3.88
212	262.70	292.05	4.07
213	261.70	292.05	4.30
214	260.80	292.05	4.52
215	260.80	292.05	4.52
216	260.80	292.05	4.52
217	258.80	292.60	5.19
218	258.80	292.60	5.42
219	258.80	292.60	5.42
220	257.00	292.60	5.73
221	257.00	292.60	5.73
222	256.10	292.60	6.01
223	254.20	292.60	6.66
224	254.20	292.60	6.66
225	252.30	292.60	7.36
226	250.50	292.60	8.06
227	250.50	292.60	8.06
228	249.50	292.60	8.48
229	247.60	292.60	9.31
230	247.60	292.60	9.31
231	247.60	292.60	9.31
232	247.60	292.60	9.31
233	245.80	292.60	10.14
234	245.80	292.60	10.14
235	245.80	292.60	10.14
236	245.80	292.60	10.14
237	245.80	292.60	10.14
238	245.80	292.60	10.14
239	245.80	292.60	10.14

No	AT	T	SM
240	245.80	292.60	10.14
241	245.80	292.60	10.14
242	245.80	292.60	10.14
243	245.80	292.05	9.92
244	245.80	292.05	9.92
245	251.40	292.05	7.52
246	253.30	292.05	6.81
247	253.30	292.05	6.81
248	252.30	291.49	7.00
249	252.30	291.49	7.00
250	252.30	291.49	7.00
251	256.10	291.49	5.70
252	256.10	291.49	5.70
253	256.10	291.49	5.70
254	256.10	291.49	5.70
255	258.90	291.49	4.89
256	258.90	291.49	4.89
257	258.90	291.49	4.89
258	260.80	291.49	4.40
259	263.60	292.05	3.88
260	263.60	292.05	3.88
261	264.50	292.05	3.69
262	264.50	292.05	3.69
263	264.50	292.05	3.69
264	264.50	292.60	3.79
265	266.50	292.60	3.42
266	267.40	292.60	3.27
267	267.40	292.60	3.27
268	267.40	293.16	3.35
269	267.40	293.16	3.35
270	267.40	293.16	3.35
271	269.20	293.16	3.07
272	269.20	293.16	3.07
273	268.30	293.16	3.20
274	265.50	293.72	3.79
275	265.50	293.72	3.79
276	265.50	293.72	3.79
277	263.60	294.27	4.32
278	263.60	294.27	4.32
279	261.70	294.27	4.80
280	261.70	294.27	4.80
281	260.80	294.83	5.18
282	260.80	294.83	5.18
283	259.90	294.83	5.44
284	259.90	294.83	5.44
285	257.00	294.83	6.36
286	257.00	294.83	6.36
287	257.00	294.83	6.36
288	257.00	294.83	6.36
289	257.00	295.38	6.52
290	257.00	295.38	6.52
291	257.00	295.38	6.52
292	257.00	295.38	6.52
293	256.10	295.38	6.84
294	256.10	295.94	7.01
295	255.20	295.94	7.35
296	255.20	295.94	7.35
297	255.20	295.94	7.35
298	255.20	295.94	7.35
299	255.20	296.49	7.53

No	AT	T	SM
300	255.20	296.49	7.53
301	254.20	297.05	8.11
302	253.30	297.05	8.47
303	253.30	297.05	8.47
304	253.30	297.05	8.47
305	253.30	297.05	8.47
306	253.30	297.05	8.47
307	253.30	297.05	8.47
308	254.20	297.05	8.11
309	257.00	297.05	7.04
310	257.00	297.05	7.04
311	257.00	297.05	7.04
312	257.00	297.05	7.04
313	257.00	297.05	7.04
314	258.90	297.05	6.37
315	258.90	297.05	6.37
316	258.90	297.05	6.37
317	258.90	297.05	6.37
318	258.90	297.05	6.37
319	258.90	297.05	6.37
320	260.80	297.05	5.76
321	260.80	297.05	5.76
322	262.70	297.05	5.20
323	262.70	297.05	5.20
324	263.60	297.05	4.95
325	263.60	297.05	4.95
326	263.60	297.05	4.95
327	263.60	297.05	4.95
328	263.60	297.05	4.95
329	263.60	297.05	4.95
330	264.50	297.05	4.71
331	264.50	297.05	4.71
332	265.50	297.05	4.46
333	265.50	297.05	4.46
334	266.50	297.05	4.23
335	266.40	297.60	4.36
336	263.90	297.60	5.00
337	270.20	297.60	3.57
338	270.20	297.60	3.57
339	270.20	297.60	3.57
340	270.20	297.60	3.57
341	270.20	297.60	3.57
342	270.20	297.60	3.57
343	271.10	297.60	3.41
344	271.10	297.60	3.41
345	273.00	297.60	3.11
346	273.00	297.60	3.11
347	273.00	297.60	3.11
348	273.00	297.60	3.11
349	273.00	297.60	3.11
350	273.00	297.60	3.11
351	273.00	297.60	3.11
352	273.00	297.60	3.11
353	273.00	297.60	3.11
354	273.00	297.60	3.11
355	272.10	297.60	3.25
356	272.10	297.60	3.25
357	272.10	297.60	3.25
358	272.10	297.60	3.25
359	271.10	297.60	3.41

No	AT	T	SM	No	AT	T	SM	No	AT	T	SM
360	270.20	298.16	3.66	420	263.70	298.72	5.33	480	260.90	298.72	6.19
361	270.20	298.16	3.66	421	263.70	298.72	5.33	481	260.90	298.72	6.19
362	270.20	298.16	3.66	422	261.80	298.72	5.90	482	260.90	298.72	6.19
363	269.20	298.16	3.86	423	261.80	298.72	5.90	483	260.90	298.72	6.19
364	268.30	298.16	4.05	424	263.70	298.72	5.33	484	260.90	298.72	6.19
365	267.40	298.16	4.25	425	263.70	298.72	5.33	485	260.90	298.72	6.19
366	267.40	298.16	4.25	426	260.00	298.72	6.49	486	260.90	298.72	6.19
367	266.40	298.16	4.48	427	260.00	298.72	6.49	487	260.90	298.72	6.19
368	266.40	298.16	4.48	428	260.00	298.72	6.49	488	261.80	298.72	5.90
369	265.40	298.16	4.73	429	260.00	298.72	6.49	489	261.80	298.72	5.90
370	265.50	298.16	4.71	430	260.00	298.72	6.49	490	261.80	298.72	5.90
371	263.60	298.16	5.22	431	258.10	298.16	6.99	491	261.80	298.72	5.90
372	263.60	298.16	5.22	432	257.20	298.16	7.31	492	261.80	298.72	5.90
373	263.60	298.16	5.22	433	257.20	298.16	7.31	493	261.20	298.72	5.90
374	263.60	298.16	5.22	434	257.20	298.16	7.31	494	261.80	298.72	5.90
375	262.70	298.16	5.48	435	257.20	298.16	7.31	495	261.80	298.72	5.90
376	260.80	298.16	6.07	436	257.20	298.16	7.31	496	261.80	298.72	5.90
377	260.90	298.16	6.03	437	257.20	298.16	7.31	497	261.80	298.72	5.90
378	260.90	298.16	6.03	438	257.20	298.16	7.31	498	261.80	298.72	5.90
379	260.90	298.72	6.19	439	257.20	298.16	7.31	499	261.80	298.72	5.90
380	260.90	298.72	6.19	440	257.20	298.16	7.31	500	262.80	298.72	5.60
381	260.90	298.72	6.19	441	257.20	298.16	7.31	501	262.80	298.72	5.60
382	260.90	298.72	6.19	442	257.20	298.16	7.31	502	262.80	298.72	5.60
383	260.90	298.72	6.19	443	257.20	298.16	7.31	503	262.80	298.72	5.60
384	260.90	298.72	6.19	444	257.20	298.16	7.31	504	261.80	298.72	5.90
385	260.90	298.72	6.19	445	257.20	298.16	7.31	505	261.80	298.72	5.90
386	260.90	298.72	6.19	446	257.20	298.16	7.31	506	261.80	298.72	5.90
387	260.00	298.72	6.49	447	257.20	298.16	7.31	507	259.00	298.72	6.84
388	260.00	298.72	6.49	448	257.20	298.16	7.31	508	259.00	298.72	6.84
389	257.20	298.72	7.49	449	257.20	298.16	7.31	509	259.00	298.72	6.84
390	257.20	298.72	7.49	450	257.20	298.16	7.31	510	259.00	298.72	6.84
391	257.20	298.72	7.49	451	254.30	298.16	8.45	511	257.20	298.72	7.49
392	257.20	298.72	7.49	452	254.30	298.16	8.45	512	256.20	298.72	7.88
393	259.00	298.72	6.84	453	254.30	298.16	8.45	513	253.40	298.72	9.43
394	259.00	298.72	6.84	454	254.30	298.16	8.45	514	253.40	298.72	9.43
395	259.00	298.72	6.84	455	254.30	298.16	8.45	515	250.60	298.72	10.29
396	259.00	298.72	6.84	456	254.30	298.16	8.45	516	246.80	298.72	12.18
397	259.00	298.72	6.84	457	253.40	298.16	8.83	517	246.80	298.72	12.18
398	258.10	298.72	7.16	458	253.40	298.16	8.83	518	240.60	298.72	15.70
399	257.20	298.72	7.49	459	253.40	298.16	8.83	519	239.30	298.72	16.50
400	257.20	298.72	7.49	460	253.40	298.16	8.83	520	233.70	298.72	20.24
401	257.20	298.72	7.49	461	253.40	298.16	8.83	521	230.90	298.72	22.28
402	259.00	298.72	6.84	462	253.40	298.16	8.83	522	224.30	298.72	27.50
403	259.00	298.72	6.84	463	252.50	298.16	9.22	523	220.60	298.72	30.70
404	259.00	298.72	6.84	464	252.50	298.16	9.22	524	214.00	298.72	36.88
405	260.00	298.72	6.49	465	252.50	298.16	9.22	525	209.30	298.72	41.65
406	260.00	298.72	6.49	466	252.50	298.16	9.22	526	202.80	298.72	48.75
407	260.90	298.72	6.19	467	252.50	298.16	9.22	527	197.20	298.72	55.35
408	261.80	298.72	5.90	468	252.50	298.16	9.22	528	190.60	298.72	63.69
409	261.80	298.72	5.90	469	252.50	298.16	9.22	529	182.20	298.72	75.48
410	261.80	298.72	5.90	470	253.40	298.16	8.83	530	175.60	298.72	84.90
411	261.80	298.72	5.90	471	255.30	298.16	8.05				
412	263.70	298.72	5.33	472	255.30	298.16	8.05				
413	263.70	298.72	5.33	473	255.30	298.16	8.05				
414	263.70	298.72	5.33	474	255.30	298.16	8.05				
415	263.70	298.72	5.33	475	255.30	298.16	8.05				
416	263.70	298.72	5.33	476	258.10	298.16	6.99				
417	263.70	298.72	5.33	477	258.10	298.16	6.99				
418	263.70	298.72	5.33	478	258.10	298.72	7.16				
419	263.70	298.72	5.33	479	258.10	298.72	7.16				