SHADOWS APPENDIX: MANUAL METHODS FOR CALCULATING SHADOWS

If access to the use of three-dimensional computer modeling software is not available, it is possible to graphically calculate the shadows for the Tier 3 Screening Analysis (Subsection 314) and the Detailed Shadow Analysis (Section 320), without the use of a computer. The methodologies outlined in this appendix can be used to carry out in a graphic form the shadow analyses described in Sections 314 and 320. All other analyses and assessments should be performed as outlined in the remaining sections of Chapter 8, "Shadows."

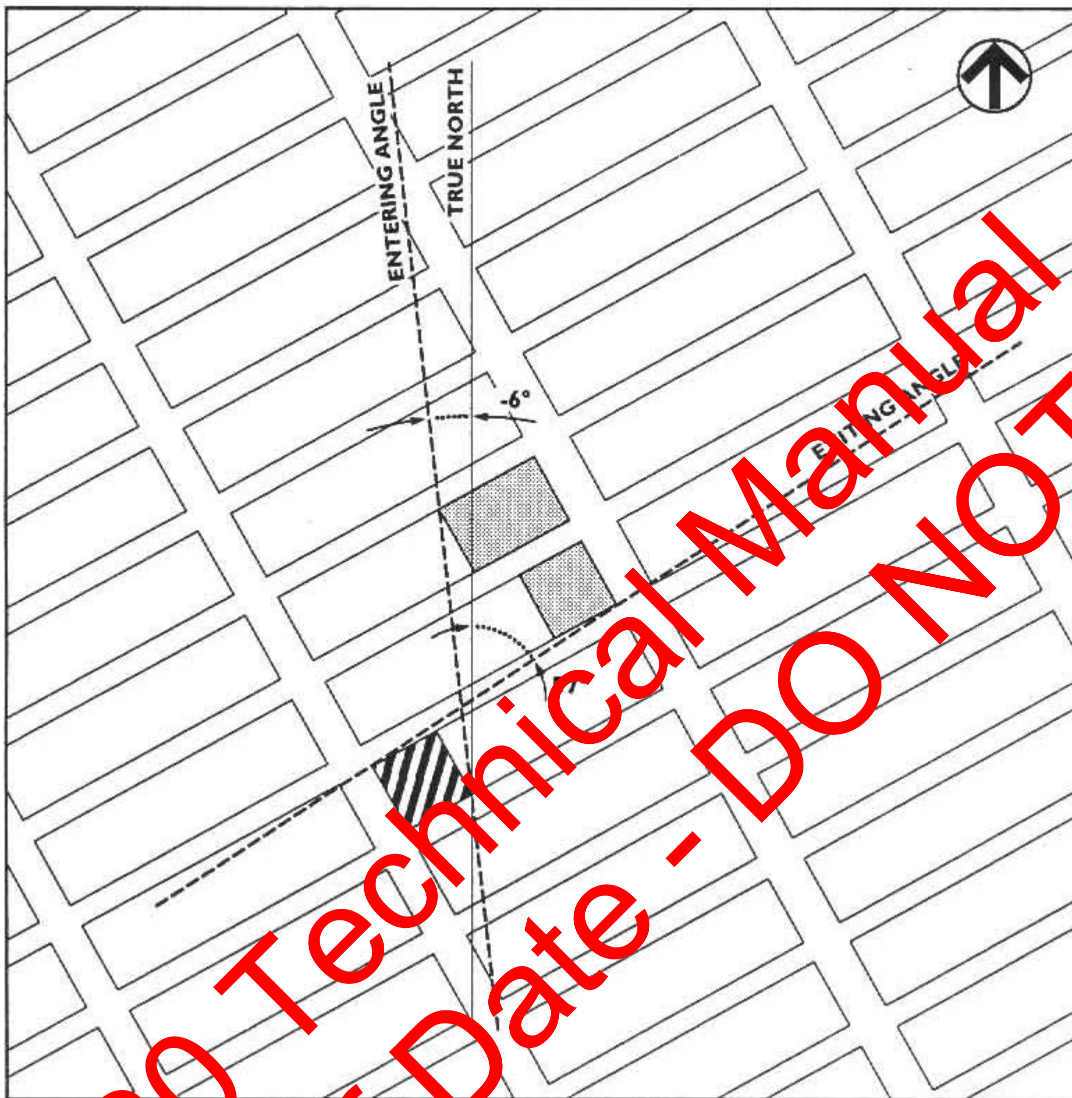
A. MANUAL METHOD FOR CALCULATING SHADOWS FOR THE TIER 3 SCREENING ANALYSIS

For an introduction to this part and related material regarding shadows analyses, see Subsection 314 (Tier 3 Screening Analysis).

The first step in the Tier 3 screening analysis is to determine the angle of the project's shadow on each sunlight-sensitive resource in relation to true north. On the base map (see Subsection 311), draw a line from the point on the building's footprint (or the corner of the project site, if the shape of the building is unknown) that will cast the earliest shadow on each open space or sun-sensitive architectural resource to the point on the open space or architectural resource that will first be in shadow. As explained in Section 100, above, because the sun rises in the east and travels across the southern part of the sky to set in the west, a project's earliest shadows would be cast almost directly westward. Throughout the day, they would shift clockwise (moving northwest, then north, then northeast) until sunset, when they would fall east. Therefore, a project's earliest shadow on an open space or architectural resource would occur in this same pattern, depending on the location of the open space or resource in relation to the project site. A simple method to find the earliest shadow is to begin with a line running due west from the project site. If this line does not meet the open space or architectural resource, rotate the line clockwise until it does. In the example in Figure A1, the earliest shadow on an open space is represented by a line between the southeast corner of the project site and the northwest corner of the open space. Intersect this line with a vertical line (a line drawn true north). This displays the shadow's angle from true north when it enters the open space or reaches the architectural resource. This is referred to as the "entering angle" in this discussion.

FIGURE A1

Entering and Exiting Shadow Angles and Distances to Open Space



0 500 FEET
SCALE

Proposed Building Site

Park

Entering and Exiting Angle

Extreme Angles: -6°, 57°

Distances at Extreme Angles: 780', 802'

Minimum Distance: 404'

Using the same approach, draw a line from the point on the building's footprint that will cast the latest shadow on the open space or architectural resource to the point in the open space that will last be in shadow. In the example, this is the line between the northwest corner of the site and the southeast corner of the open space. Intersect this line with a vertical line (a line drawn true north) to display the shadow's angle from true north as it leaves the open space or resource. This is the "exiting angle."

All angles between the two angles obtained above represent the portions of the open space or resource that could be in the shadow of the proposed project at some time during the year. In this example, these angles, measured using a protractor, are -6 degrees (a minus sign means that the shadow occurs before approximately noon) and 57 degrees for the entering and exiting shadows, respectively.

The entering and exiting angles set the limits of shadows that the project would cast on the open space or resource at all times of the year. In this example, these angles, measured using a protractor, are -6 degrees (minus sign means that the shadow occurs in the morning) and 57 degrees. This means that at any angle from -6 degrees to 57 degrees the building could potentially cast a shadow that would reach the open space.

Next, using Table A1, which gives the maximum shadow length factors for all shadow angles, determine the maximum shadow length of the building in question. The longest shadow that any building will cast during the year occurs on December 21st. The maximum shadow length for all angles between -6 and 57 degrees is 4.3 for -6 degrees on December 21st. This means that a 850-foot building, for example, would cast a maximum shadow of 3655 feet.

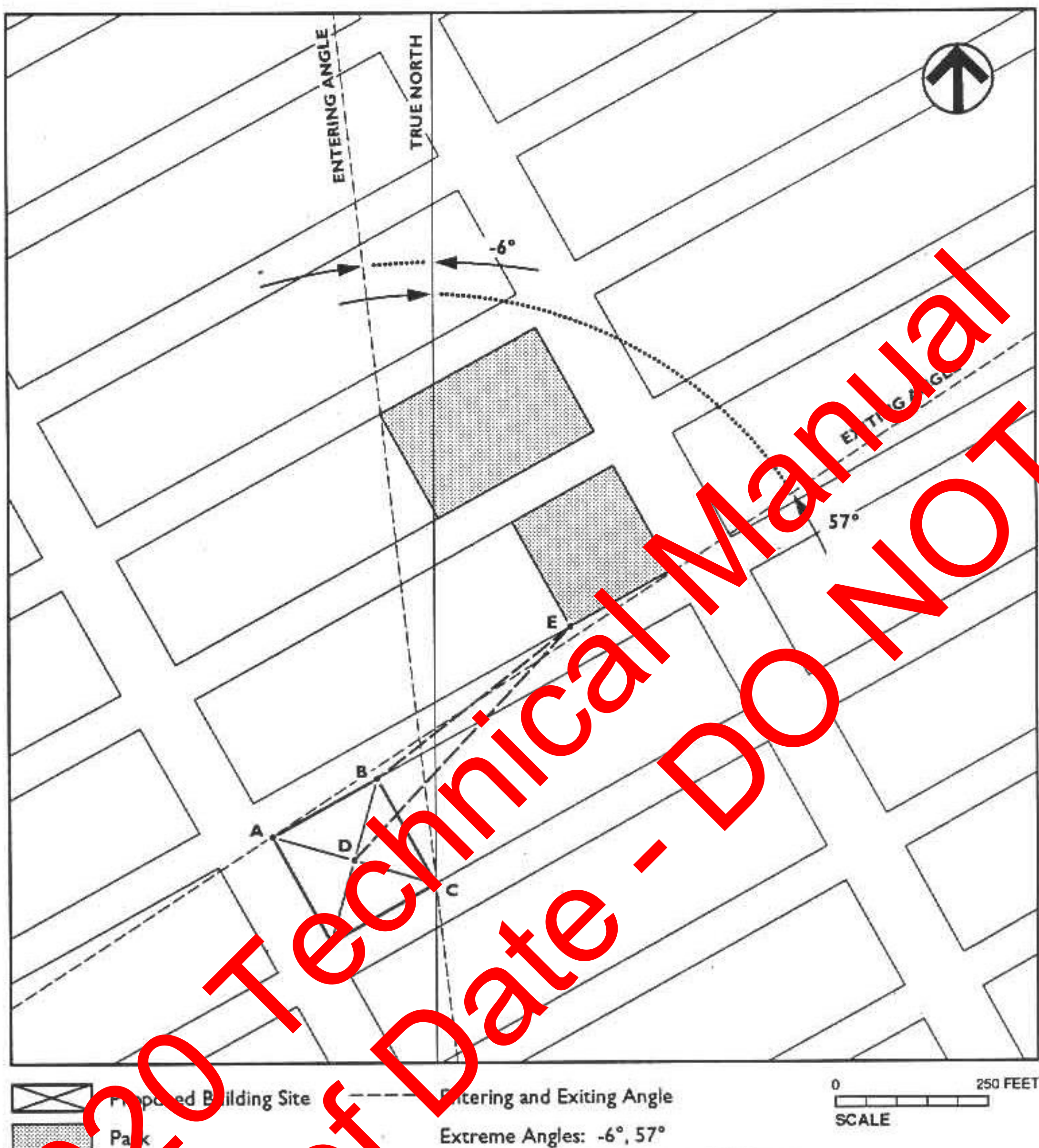
It may be necessary to adjust this calculation to account for differences in elevation between the building and the park or resource in question. If inspection of available maps shows, for example, that the building site is at an elevation approximately 20 feet higher than the park, that 20 feet is added to the building height in making the calculation. This provides the building height relative to the elevation of the park. With the difference in elevation, the maximum shadow length that could occur would be 3741 feet (4.3 times 870), about 86 feet longer than the shadow for the building at the same elevation as the open space.

If the analysis above indicates or cannot rule out that shadows from the proposed project would reach a sunlight-sensitive resource at any time during the year, a detailed shadow analysis is required. The manual method for performing this detailed analysis is described in Part B. If the results of the screening analysis demonstrate that no shadows will reach any sunlight-sensitive resources, no further shadow assessment is needed. Provide the necessary documentation to support this conclusion illustrating the screening analysis.

As shown on Figure A2, the distances between the project site and the open space range from 404 to 802 feet. Therefore, a 850-foot building would cast a shadow reaching the open space at some point in the year, and the next step in the screening is required.

FIGURE A2

Angles and Distances to Open Space



Extreme Angles: -6°, 57°
Distances at Extreme Angles: 780', 802'
B-E Angle from True North: 52°
Distance from B to E: 404'
D-E Angle from True North: 43°
Distance from D to E: 523'

B. MANUAL METHOD FOR CALCULATING SHADOWS FOR THE DETAILED SHADOW ANALYSIS

For an introduction to this part and related material regarding shadows analyses, see Subsection 314.2 (Determining the "worst case" scenario for shadows), Subsection 314.3 (Months of interest and representative days for analysis), Subsection 314.4 (Timeframe window of analysis), Section 320 (Detailed Shadow Analysis), Subsection 321 (Future No-Action conditions), Subsection 322 (Future With-Action conditions), Subsection 324 (Performing the detailed analysis), and Subsection 325 (Documenting the extent and duration of incremental shadows).

The example presented in this section supposes an existing open space and a building that rises 640 feet without set-back and then slopes back to a pointed, dome-like, symmetrical top at 850 feet. Therefore, the positions on the ground from which to measure the length of the shadow (and distance to the open space) would be the three leading corners and the center of the site, labeled A, B, C, and D, respectively on Figure A2. As shown on this example, the shortest distance to the open space is a line drawn from B to E, which yields an angle of 52 degrees from true north and measures 404 feet. The shortest distance from the building's tallest point, D, to the open space (at E) is at an angle of 43 degrees from true north and measures 523 feet.

Having identified "worst case" shadow conditions (see *Subsection* 314.2), next consult Table A2, which provides shadow length factors for all shadows angles for four representative days within the months of concern. Consider whether the entering and exiting angles and the angle defining the shortest distance between the building and the open space or resource would cast shadows long enough to reach the open space or resource. Figures B1, B2, B3, and B4 illustrate the shadows that would occur from the 850-foot building example on an open space nearby. As shown in these figures, entering and/or exiting shadows would reach the park on December 21 and March 21. For May 6, the entering and exiting shadows would not reach the open space, but at the shortest point (52 degrees), the shadow angle factor would be 0.68, the length of the shadow would be 0.68 times 640, or 435 feet. This is more than the distance between the site and the park at that point; therefore, the shadow would enter and extend into the park.

In the example, on June 21, no shadow from the building would extend into the open space. The entering and exiting shadows would not reach the open space. The shadow over the shortest distance from the site to the park (B to E) would be 0.46 times 640, or 294 feet (110 feet less than 404 feet). Over the shortest distance from the tallest point to the park (D to E) the shadow would be 0.40 times 850, or 340 feet. This is less than the distance between D and E on the ground (523 feet). Thus, no project shadow would enter the open space on June 21.

FIGURE B1

Shadows from 850-foot Building: June 21

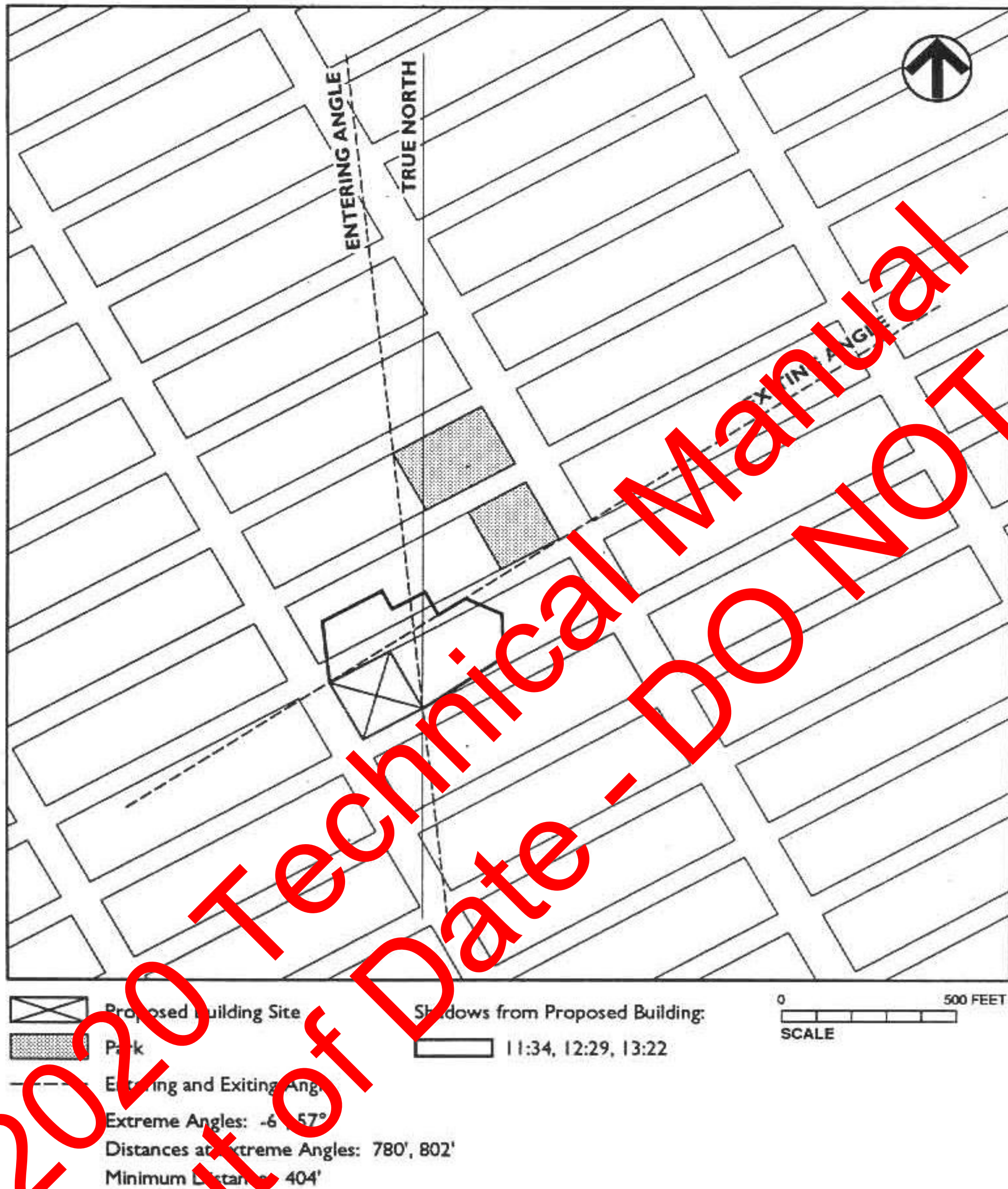


FIGURE B2

**Shadows from 850-foot Building:
May 6**

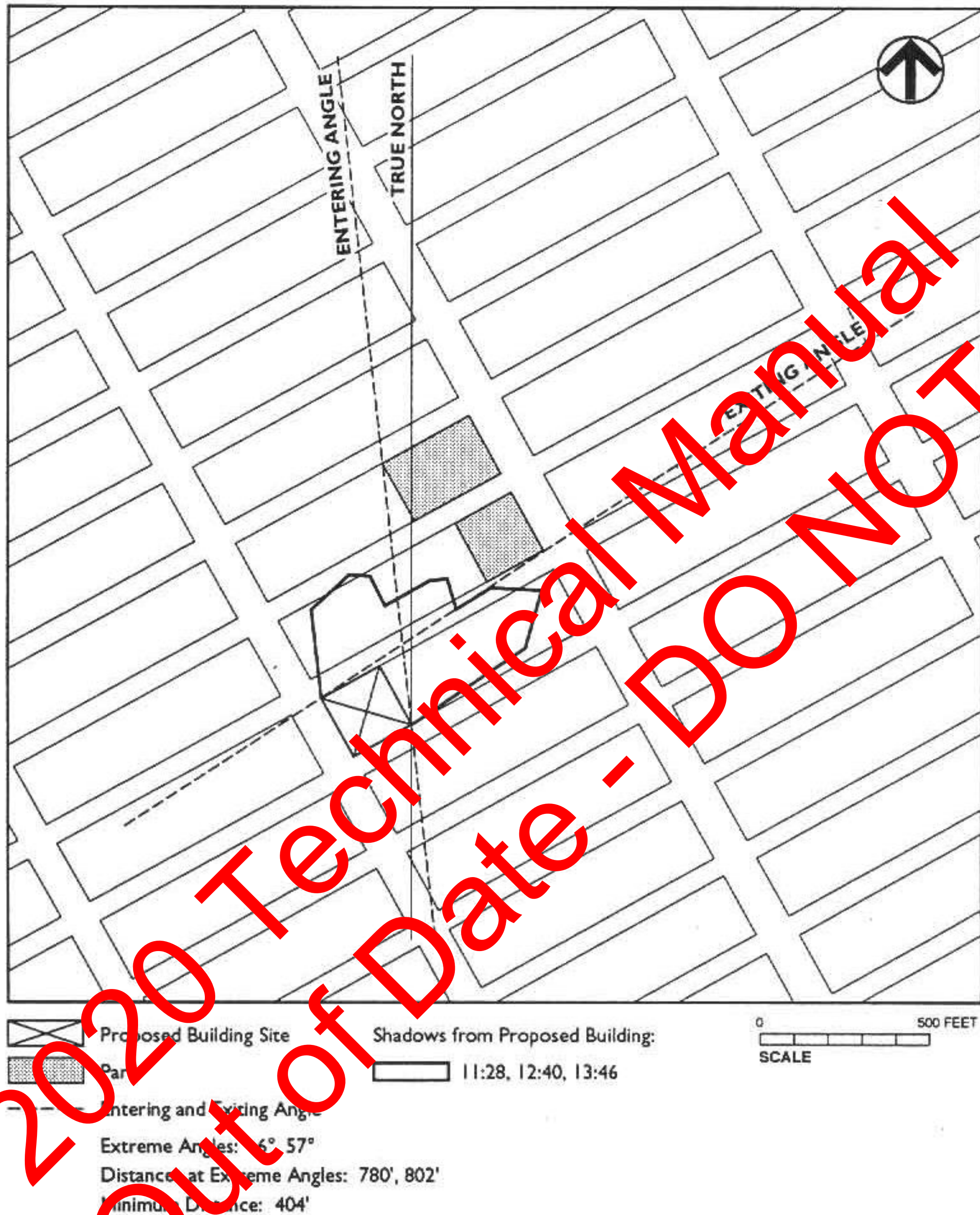


FIGURE B3

Shadows from 850-foot Building: March 21

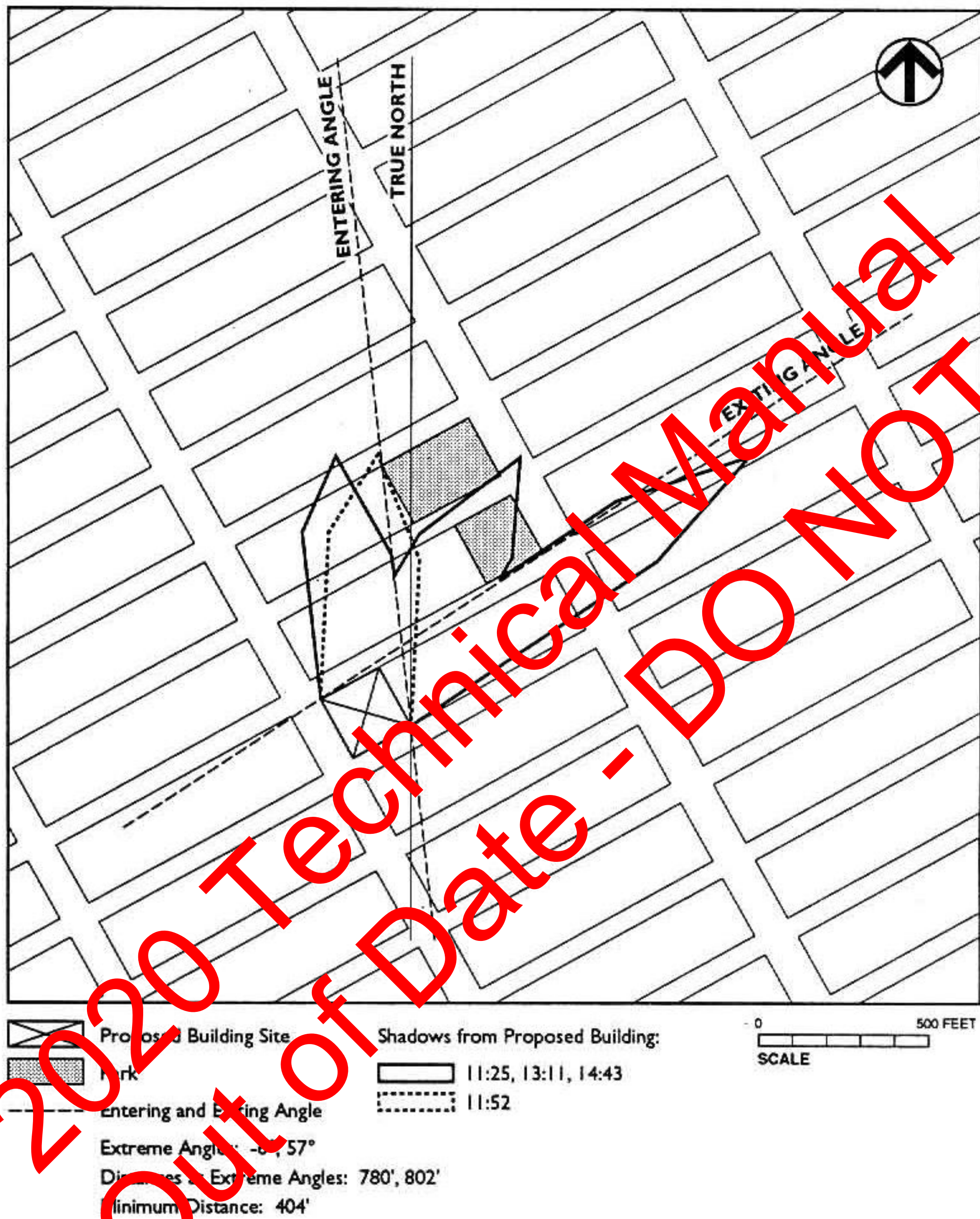


FIGURE B4

Shadows from 850-foot Building: December 21

Proposed Building Site	Shadows from Proposed Building:
Park	11:13, 14:37
Entering and Exiting Angle	

0 500 FEET
SCALE

Extreme Angles: -6°, 57°
Distances to Extreme Angles: 780', 802'
Minimum Distance: 404'

The length of time that the project shadows stay on the open space or resource depends on the entering and exiting angles from true north and the time of year. Because of differences in the sun's height in the sky throughout the year, shadows are longer but move more quickly (are of shorter duration) during the winter than during the summer. Using Table A2, it is possible to estimate shadow duration for each of the analysis months. For example, on March 21, the entering angle of -6 degrees would occur at approximately 11:47 a.m., and the exiting angle of 57 degrees would occur at approximately 3:04 p.m. (shown as 15:04 on the table). Thus, for a building tall enough that its shadow reaches an open space at both the entering and exiting angles, the shadow would be on some part of the park for 3 hours and 17 minutes.

If the shadow does not reach the open space or resource at both the entering and exiting angles, then the duration would be less. Using Table A2, it is possible to identify the angle (and thus the time) when the shadow would be long enough to reach and enter the park. In the March 21 example on Figure B3, because of the shape of the hypothetical building's top (it comes to a point), the shadow would not enter the park at the -6 degree angle. A line drawn from the center of the project site (the location of the top of the roof) to the westerly point of the park yields an angle of 3 degrees. Thus, the shadow would enter the park at 12:10 p.m. EST and exit at 3:04 p.m. EST for a duration of 2 hours and 54 minutes.

An exception to the above analysis occurs if the entering and exiting angles are greater than 42 degrees; then, no shadows from the project would exist on December 21 for areas beyond 42 degrees. Since the sun rises and sets in the narrowest arc on that day, during the period from an hour and a half after sunrise to an hour and a half before sunset, the shadows lie between -42 and +42 degrees from true north (see Table A2). In this case, pick the date closest to December 21 in which at least one of the entering or exiting angles occurs, and assess winter conditions on that date. If the longest shadow for the building in question does not occur in any of the months between November and February (shadow angle more than 63 degrees), it is not necessary to consider a winter case.

To understand the shadow that would be added to an open space or natural or architectural resource by a proposed project, shadows that would exist without the project must also be defined. Other buildings may already cast shadows (or be expected to cast shadows in the future) that would eliminate any new shadows cast by the proposed project. The analysis entails calculating and displaying the shadows from all buildings and structures that will be present in both the future With-Action and future No-Action conditions between the project site and the open space and that are also located within the two relevant entering and exiting angles from true north. The buildings in the surrounding area should also be considered for unusual circumstances; for example, extremely tall buildings farther from the open space than the project that may cast shadows within the entering and exiting angles (see Figure 8-8, Effects of existing buildings).

The analysis is straightforward and requires an accurate map showing the footprints of existing and proposed or planned buildings and structures. The analyst should obtain data as accurate as possible on the heights of each building and its setbacks. Entering and exiting shadows are calculated and displayed for each of the representative days for analysis in the months of interest, within the timeframe window of analysis, as described in Subsections 314.3 and 314.4.

The project's shadow effect is the increment beyond shadows that would exist in the future No-Action conditions. Therefore, the project's shadows should be calculated and displayed clearly as an increment beyond the No-Action conditions shadows on the open space. Figures B5 and B6 illustrate a full and a partially blocked shadow from the 850-foot example building.

Once the shadows affecting the sunlight-sensitive resources have been calculated document the results as described in Section 325 and proceed with the assessment of shadow impacts as described in Section 400.

FIGURE B5

Incremental Shadows from 850-Foot Building: Example I

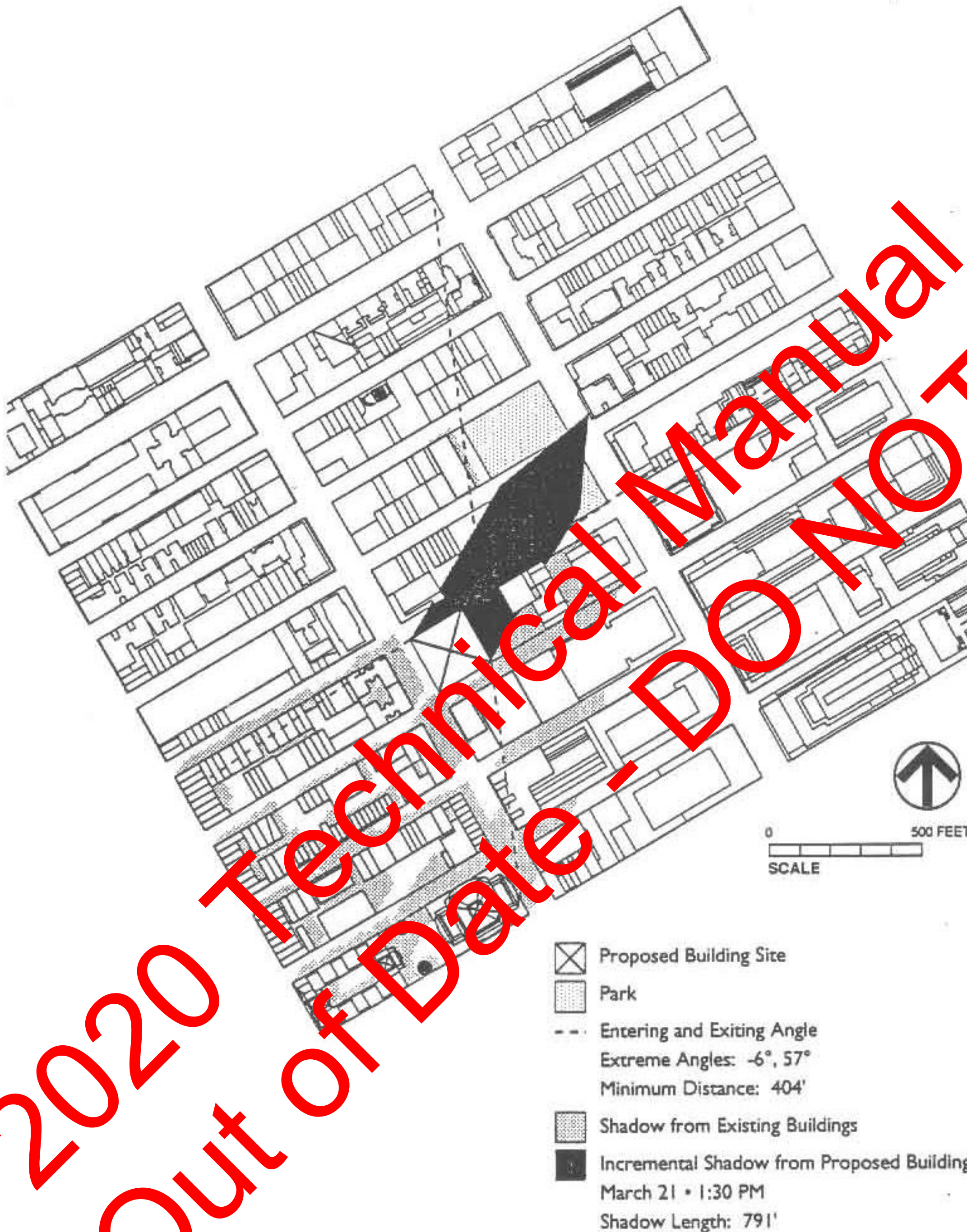


FIGURE B6

Incremental Shadows from 850-Foot Building: Example 2

TABLE A1 - MAXIMUM SHADOW LENGTH FACTOR FOR EACH ANGLE FROM TRUE NORTH

Angle	Shadow Length Factor*	Dates	Time (Eastern Standard Time)	
0	2.07	12/21	11:53	
1	2.07	12/21	11:49	11:56
2	2.07	12/21	11:45	12:00
3	2.07	12/21	11:41	12:04
4	2.07	12/21	11:37	12:08
5	2.08	12/21	11:33	12:12
6	2.09	12/21	11:29	12:16
7	2.09	12/21	11:25	12:20
8	2.10	12/21	11:21	12:24
9	2.11	12/21	11:17	12:28
10	2.13	12/21	11:13	12:32
11	2.14	12/21	11:09	12:36
12	2.15	12/21	11:05	12:41
13	2.17	12/21	11:01	12:44
14	2.19	12/21	10:57	12:48
15	2.21	12/21	10:53	12:52
16	2.23	12/21	10:49	12:56
17	2.25	12/21	10:45	13:00
18	2.28	12/21	10:41	13:04
19	2.30	12/21	10:37	13:08
20	2.34	12/21	10:32	13:13
21	2.37	12/21	10:28	13:17
22	2.40	12/21	10:24	13:21
23	2.44	12/21	10:[illegible]	13:25
24	2.48	12/21	10:15	13:30
25	2.52	12/21	10:11	13:34
26	2.57	12/21	10:07	13:38
27	2.62	12/21	10:02	13:43
28	2.67	12/21	9:58	13:47
29	2.73	12/21	9:54	13:51
30	2.79	12/21	9:49	13:56
31	2.86	12/21	9:45	14:00
32	2.93	12/21	9:40	14:05
33	3.02	12/21	9:35	14:10
34	3.10	12/21	9:31	14:14
35	3.20	12/21	9:26	14:19
36	3.31	12/21	9:21	14:24
37	3.44	12/21	9:16	14:29
38	3.55	12/21	9:12	14:33
39	3.69	12/21	9:07	14:38
40	3.85	12/21	9:02	14:43
41	4.02	12/21	8:57	14:48
42	4.27	12/20 12/21 12/22 12/23 12/24 12/25	8:51 8:51 8:52 8:53 8:53 8:54	14:55 14:55 14:56 14:57 14:57 14:58
43	4.27	12/29 1/4	8:54 8:55	15:00 15:07
44	4.19	12/7 1/7	8:41 8:56	14:53 15:08
45	4.19	12/2 1/12	8:35 8:54	14:55 15:14
46	4.10	11/26	8:29	14:57

		1/18	8:52	15:20
47	4.04	11/24 1/22	8:28 8:50	14:58 15:26
48	3.99	11/20 1/23	8:24 8:50	15:00 15:26
49	3.96	11/17 1/27	8:19 8:47	15:03 15:31
50	3.92	11/13 1/30	8:14 8:43	15:06 15:35
51	3.84	11/11 2/1	8:13 8:43	15:07 15:37
52	3.84	11/8 2/3	8:08 8:40	15:12 [illegible]
53	3.77	11/7 2/6	8:08 8:38	15:12 15:42
54	3.78	11/4 2/8	8:04 8:34	15:16 [illegible]
55	3.72	11/1 2/12	[illegible] 8:30	15:20 15:50
56	3.66	10/30 2/13	7:59 8:29	15:21 15:51
57	3.65	10/28 [illegible]	7:56 8:26	15:24 15:54
58	3.62	10/25 2/18	7:52 8:22	15:28 15:58
59	3.57	10/24 2/19	7:51 [illegible]	15:29 15:58
60	3.59	10/22 2/21	[illegible] [illegible]	15:33 16:02
61	3.55	[illegible] 2/24	7:45 8:13	15:37 16:05
62	3.49	10/18 2/25	7:45 8:13	15:37 16:05
63	3.50	10/16 2/28	7:42 8:09	15:42 16:07
64	3.47	10/14 3/1	7:40 8:06	15:44 16:10
65	3.44	10/11 3/4	7:37 8:02	15:49 16:14
66	[illegible]	10/10 3/5	7:36 8:01	15:50 16:13
67	3.41	10/8 3/7	7:34 7:57	15:54 16:17
68	3.39	10/5 3/10	7:30 7:52	15:58 16:20
69	3.36	10/4 3/11	7:38 7:51	16:00 16:21
70	3.36	10/2 3/13	7:27 7:48	16:03 16:24
71	3.34	10/1 3/14	7:27 7:46	16:05 16:24
72	3.34	9/29 3/16	7:24 7:43	16:08 16:27
73	3.32	9/26 3/19	7:21 7:39	16:13 16:31
74	3.30	9/25 3/20	7:21 7:37	16:15 16:31
75	3.30	9/23 3/22	7:18 7:33	16:18 16:33

76	3.32	9/22 3/23	7:17 7:31	16:21 16:35
77	3.31	9/19 3/26	7:14 7:25	16:26 16:37
78	3.24	9/17 3/28	7:14 7:24	16:28 16:38
79	3.30	9/16 3/29	7:11 7:21	16:31 16:41
80	3.29	9/13 4/1	7:08 7:16	16:36 16:44
81	3.24	9/12 4/2	7:08 7:16	16:36 16:44
82	3.29	9/10 4/4	7:05 7:11	16:41 16:47
83	3.23	9/8 4/6	7:05 7:10	16:43 16:48
84	3.29	9/7 4/7	7:02 7:0[illegible]	16:45 16:50
85	3.30	9/4 4/10	6:59 7:01	16:51 16:53
86	3.24	9/2 4/12	6:59 7:00	16:53 16:54
87	3.31	9/1 4/13	6:56 6:57	16:56 16:57
88	3.29	8/30 4/15	6:55 6:54	16:59 16:58
89	3.31	8/27 4/18	6:52 6:49	17:04 17:01
90	3.29	8/25 4/19	6:51 6:48	17:05 17:02
91	3.33	8/24 4/21	6:48 6:45	17:08 17:05
92	3.35	8/21 4/24	6:45 6:40	17:13 17:08
93	3.30	8/19 4/26	6:45 6:39	17:15 17:09
94	3.37	8/17 4/27	6:42 6:36	17:18 17:12
95	3.37	8/14 5/1	6:39 6:31	17:23 17:15
96	3.33	8/12 5/3	6:38 6:30	17:24 17:16
97	3.40	8/9 5/4	6:35 6:27	17:29 17:19
98	3.42	8/6 5/8	6:31 6:22	17:33 17:22
99	3.42	8/5 5/10	6:30 6:20	17:34 17:24
100	3.43	8/2 5/14	6:29 6:16	17:35 17:28
101	3.42	7/30 5/16	6:25 6:15	17:39 17:29
102	3.48	7/28 5/18	6:22 6:12	17:42 17:32
103	3.52	7/24 5/22	6:18 6:09	17:46 17:37
104	3.56	7/19 5/27	6:14 6:05	17:50 17:41
105	3.53	7/18	6:14	17:50

		5/28	6:05	17:41
106	3.59	7/13 6/2	6:10 6:02	17:54 17:46
107	3.63	7/5 6/10	6:04 5:59	17:56 17:51
108	3.61	6/16	6:00	17:54

Note: Negative angles and positive angles of the same value would have similar shadow length factors.
All values are for New York City, City Hall:
Latitude: 40°42'23" north (40.706389°)
Longitude: 74°0'29" west (74.008056°)
All times are Eastern Standard Time. Daylight Savings Time is NOT considered.

* Factor for shadow angle by degree (azimuth) from true north (0°).

TABLE A2 - SHADOW FACTORS AND TIME OF DAY FOR EACH SHADOW ANGLE, JUNE 21, MAY 6, MARCH 21, DECEMBER 21

Angle	21 June		6 May[a]		21 March[a]		21 December	
	Shadow Length Factor[b]	Eastern Standard Time	Shadow Length Factor[b]	Eastern Standard Time	Shadow Length Factor[b]	Eastern Standard Time	Shadow Length Factor[b]	Eastern Standard Time
-108	3.66	5:57						
-107	3.37	6:04						
-106	3.12	6:11						
-105	2.90	6:17						
-104	2.71	6:24						
-103	2.54	6:31						
-102	2.38	6:38						
-101	2.24	6:45						
-100	2.11	6:51						
-99	2.00	6:58						
-98	1.89	7:05						
-97	1.80	7:11	3.31	6:27				
-96	1.71	7:18	3.07	6:33				
-95	1.63	7:25	2.87	6:40				
-94	1.55	7:31	2.68	6:46				
-93	1.48	7:38	2.52	6:52				
-92	1.42	7:44	2.38	6:59				
-91	1.36	7:51	2.25	[illegible]				
-90	1.30	7:57	2.13	[illegible]				
-89	1.25	8:03	2.02	7:17				
-88	1.20	8:09	1.92	7:23				
-87	1.15	8:15	1.84	7:29				
-86	1.11	8:20	1.75	7:35				
-85	1.07	8:26	1.68	7:41				
-84	1.03	8:32	[illegible]	7:46				
-83	0.99	8:37	1.54	[illegible]				
-82	0.96	8:42	1.48	[illegible]				
-81	0.93	8:47	1.43	8:03				
-80	0.90	8:53	1.37	8:09				
-79	0.87	8:57	1.33	8:14				
-78	[illegible]	9:02	1.28	8:19				
-77	[illegible]	9:07	[illegible]	8:24				
-76	[illegible]	9:12	1.20	8:29				
-75	[illegible]	9:16	1.16	8:34				
-74	0.75	[illegible]	1.12	8:39	3.24	7:36		
-73	0.73	9:25	1.09	8:44	3.05	7:41		
-72	0.71	9:29	1.05	8:48	2.88	7:47		
-71	0.69	9:33	1.03	8:53	2.73	7:52		
-70	0.67	9:37	1.00	8:57	2.59	7:57		
-69	0.66	9:41	0.98	9:02	2.47	8:03		
-68	0.64	9:44	0.95	9:06	2.36	8:08		
-67	0.62	9:48	0.93	9:10	2.26	8:13		
-66	0.61	9:51	0.90	9:14	2.17	8:18		
-65	0.59	9:55	0.88	9:18	2.09	8:23		
-64	0.58	9:58	0.86	9:22	2.01	8:28		
-63	0.57	10:01	0.84	9:26	1.94	8:33		
-62	0.55	10:04	0.82	9:30	1.88	8:38		

Angle	21 June		6 May[a]		21 March[a]		21 December	
	Shadow Length Factor[b]	Eastern Standard Time	Shadow Length Factor[b]	Eastern Standard Time	Shadow Length Factor[b]	Eastern Standard Time	Shadow Length Factor[b]	Eastern Standard Time
-61	0.54	10:07	0.81	9:33	1.82	8:42		
-60	0.53	10:10	0.79	9:37	1.76	8:47		
-59	0.52	10:13	0.77	9:40	1.71	8:52		
-58	0.51	10:16	0.76	9:44	1.66	8:56		
-57	0.50	10:19	0.74	9:47	1.61	9:01		
-56	0.49	10:21	0.73	9:50	1.57	9:05		
-55	0.48	10:24	0.72	9:54	1.53	9:09		
-54	0.48	10:27	0.70	9:57	1.49	9:14		
-53	0.47	10:29	0.69	10:00	1.46	9:18		
-52	0.46	10:31	0.68	10:03	1.42	9:22		
-51	0.45	10:34	0.67	10:06	1.39	9:26		
-50	0.45	10:36	0.66	10:09	1.36	9:30		
-49	0.44	10:38	0.65	10:11	1.34	9:34		
-48	0.43	10:41	0.64	10:14	1.31	9:38		
-47	0.43	10:43	0.63	10:17	1.28	9:42		
-46	0.42	10:45	0.62	10:20	1.26	9:45		
-45	0.41	10:47	0.61	10:22	1.24	9:49		
-44	0.41	10:49	0.60	10:25	1.22	9:53		
-43	0.40	10:51	0.59	10:27	1.20	9:56		
-42	0.40	10:53	0.59	10:30	1.18	10:00	4.27	8:51
-41	0.40	10:55	0.58	10:32	1.16	10:03	4.02	8:57
-40	0.39	10:57	0.57	10:35	1.14	10:07	3.85	9:02
-39	0.38	10:59	0.57	10:37	1.13	10:10	3.69	9:07
-38	0.38	11:00	0.56	10:40	1.11	10:14	3.55	9:12
-37	0.38	11:02	0.55	10:42	1.10	10:17	3.42	9:16
-36	0.37	11:04	0.55	10:44	1.08	10:20	3.30	9:21
-35	0.37	11:06	0.54	10:46	1.07	10:24	3.20	9:26
-34	0.37	11:07	0.54	10:49	1.06	10:27	3.10	9:31
-33	0.36	11:09	0.53	10:51	1.04	10:30	3.01	9:35
-32	0.36	11:11	0.53	10:53	1.03	10:33	2.93	9:40
-31	0.35	11:12	0.52	10:55	1.02	10:36	2.86	9:45
-30	0.35	11:14	0.52	10:57	1.01	10:39	2.79	9:49
-29	0.35	11:15	0.51	10:59	1.00	10:42	2.73	9:54
-28	0.35	11:17	0.51	11:01	0.99	10:45	2.67	9:58
-27	0.34	11:19	0.51	11:03	0.98	10:48	2.62	10:02
-26	0.34	11:20	0.50	11:05	0.97	10:51	2.57	10:07
-25	0.34	11:22	0.50	11:07	0.96	10:54	2.52	10:11
-24	0.34	11:23	0.50	11:09	0.96	10:57	2.48	10:15
-23	0.33	11:25	0.49	11:11	0.95	11:00	2.44	10:22
-22	0.33	11:26	0.49	11:13	0.94	11:03	2.40	10:24
-21	0.33	11:27	0.49	11:15	0.94	11:06	2.37	10:28
-20	0.33	11:29	0.48	11:17	0.93	11:09	2.33	10:32
-19	0.33	11:30	0.48	11:19	0.92	11:11	2.30	10:37
-18	0.32	11:32	0.48	11:21	0.92	11:14	2.28	10:41
-17	0.32	11:33	0.48	11:22	0.91	11:17	2.25	10:45
-16	0.32	11:34	0.47	11:24	0.91	11:20	2.23	10:49
-15	0.32	11:36	0.47	11:26	0.90	11:23	2.21	10:53
-14	0.32	11:37	0.47	11:28	0.90	11:25	2.19	10:57

Angle	21 June		6 May[a]		21 March[a]		21 December	
	Shadow Length Factor[b]	Eastern Standard Time	Shadow Length Factor[b]	Eastern Standard Time	Shadow Length Factor[b]	Eastern Standard Time	Shadow Length Factor[b]	Eastern Standard Time
-13	0.32	11:38	0.47	11:30	0.90	11:28	2.17	11:01
-12	0.32	11:40	0.47	11:31	0.89	11:31	2.15	11:05
-11	0.32	11:41	0.47	11:33	0.89	11:33	2.14	11:09
-10	0.32	11:42	0.46	11:35	0.89	11:36	2.13	11:13
-9	0.31	11:44	0.46	11:37	0.88	11:39	2.11	11:17
-8	0.31	11:45	0.46	11:39	0.88	11:41	2.10	11:21
-7	0.31	11:46	0.46	11:40	0.88	11:44	2.09	11:25
-6	0.31	11:48	0.46	11:42	0.88	11:47	2.09	11:29
-5	0.31	11:49	0.46	11:44	0.88	11:49	2.08	11:33
-4	0.31	11:50	0.46	11:46	0.88	11:52	2.07	11:37
-3	0.31	11:52	0.46	11:47	0.87	11:55	2.07	11:41
-2	0.31	11:53	0.46	11:49	0.87	11:57	2.07	11:45
-1	0.31	11:54	0.46	11:51	0.87	12:00	2.07	11:49
0	0.31	11:56	0.46	11:53	0.87	12:03	2.07	11:53
1	0.31	11:57	0.46	11:54	0.87	12:05	2.07	11:56
2	0.31	11:58	0.46	11:56	0.87	12:08	2.07	12:00
3	0.31	11:59	0.46	11:58	0.87	12:10	2.07	12:04
4	0.31	12:01	0.46	11:59	0.88	12:13	2.07	12:08
5	0.31	12:02	0.46	12:01	0.88	12:16	2.08	12:12
6	0.31	12:03	0.46	12:03	0.88	12:18	2.09	12:16
7	0.31	12:05	0.46	12:05	0.88	12:21	2.09	12:20
8	0.31	12:06	0.46	12:06	0.88	12:24	2.10	12:24
9	0.31	12:07	0.46	12:08	0.88	12:27	2.11	12:28
10	0.32	12:09	0.46	12:10	0.89	12:29	2.13	12:32
11	0.32	12:10	0.47	12:12	0.89	12:32	2.14	12:36
12	0.32	12:11	0.47	12:14	0.89	12:34	2.15	12:41
13	0.32	12:13	0.47	12:15	0.90	12:37	2.17	12:44
14	0.32	12:14	0.47	12:17	0.90	12:40	2.19	12:48
15	0.32	12:15	0.47	12:19	0.90	12:42	2.21	12:52
16	0.32	12:17	0.48	12:21	0.91	12:45	2.23	12:56
17	0.32	12:18	0.48	12:23	0.91	12:48	2.25	13:00
18	0.32	12:19	0.48	12:24	0.92	12:51	2.28	13:04
19	0.33	12:21	0.48	12:26	0.93	12:54	2.30	13:08
20	0.33	12:22	0.48	12:28	0.93	12:57	2.34	13:13
21	0.33	12:24	0.49	12:30	0.94	12:59	2.37	13:17
22	0.33	12:25	0.49	12:32	0.94	13:02	2.40	13:21
23	0.33	12:26	0.49	12:34	0.95	13:05	2.43	13:25
24	0.34	12:28	0.50	12:36	0.96	13:08	2.49	13:30
25	0.34	12:29	0.50	12:38	0.97	13:11	2.52	13:34
26	0.34	12:31	0.50	12:40	0.97	13:14	2.56	13:38
27	0.34	12:32	0.51	12:42	0.98	13:17	2.62	13:43
28	0.35	12:34	0.51	12:44	0.99	13:20	2.67	13:47
29	0.35	12:36	0.51	12:46	1.00	13:23	2.71	13:51
30	0.35	12:37	0.52	12:48	1.01	13:26	2.79	13:56
31	0.36	12:39	0.52	12:50	1.02	13:29	2.84	14:00
32	0.36	12:40	0.53	12:52	1.03	13:32	2.93	14:05
33	0.36	12:42	0.53	12:54	1.04	13:35	3.02	14:10
34	0.37	12:44	0.54	12:56	1.05	13:38	3.09	14:14

Angle	21 June		6 May[a]		21 March[a]		21 December	
	Shadow Length Factor[b]	Eastern Standard Time	Shadow Length Factor[b]	Eastern Standard Time	Shadow Length Factor[b]	Eastern Standard Time	Shadow Length Factor[b]	Eastern Standard Time
35	0.37	12:45	0.54	12:59	1.06	13:41	3.20	14:19
36	0.37	12:47	0.55	13:01	1.08	13:45	3.31	14:24
37	0.38	12:49	0.55	13:03	1.10	13:48	3.44	14:29
38	0.38	12:51	0.56	13:05	1.11	13:51	3.52	14:33
39	0.38	12:52	0.57	13:08	1.13	13:55	3.67	14:38
40	0.39	12:54	0.57	13:10	1.14	13:58	3.83	14:43
41	0.39	12:56	0.58	13:13	1.16	14:02	4.00	14:48
42	0.40	12:58	0.59	13:15	1.18	14:05	4.19	14:53
43	0.40	13:00	0.60	13:18	1.20	14:09		
44	0.41	13:02	0.60	13:20	1.21	14:12		
45	0.41	13:04	0.61	13:23	1.24	14:16		
46	0.42	13:06	0.62	13:25	1.26	14:20		
47	0.42	13:08	0.63	13:28	1.28	14:23		
48	0.43	13:10	0.64	13:31	1.31	14:27		
49	0.44	13:13	0.65	13:34	1.33	14:31		
50	0.45	13:15	0.66	13:36	1.36	14:35		
51	0.45	13:17	0.67	13:39	1.39	14:39		
52	0.46	13:20	0.68	13:42	1.42	14:43		
53	0.47	13:22	0.69	13:45	1.45	14:47		
54	0.47	13:24	0.70	13:48	1.49	14:51		
55	0.48	13:27	0.71	13:51	1.54	14:56		
56	0.50	13:30	0.73	13:55	1.57	15:00		
57	0.50	13:32	0.74	13:58	1.61	15:04		
58	0.51	13:35	0.76	14:01	1.66	15:09		
59	0.52	13:38	0.78	14:05	1.70	15:13		
60	0.53	13:41	0.79	14:08	1.76	15:18		
61	0.55	13:44	0.81	14:12	1.83	15:23		
62	0.56	13:47	0.82	14:15	1.87	15:27		
63	0.57	13:50	0.84	14:19	1.94	15:32		
64	0.58	13:53	0.86	14:23	2.02	15:37		
65	0.59	13:56	0.88	14:27	2.09	15:42		
66	0.61	14:00	0.91	14:31	2.18	15:47		
67	0.62	14:03	0.93	14:35	2.27	15:52		
68	0.64	14:07	0.95	14:39	2.36	15:57		
69	0.66	14:11	0.97	14:43	2.46	16:02		
70	0.67	14:14	1.01	14:48	2.62	16:08		
71	0.68	14:18	1.03	14:52	2.73	16:13		
72	0.70	14:22	1.06	14:57	2.86	16:18		
73	0.72	14:26	1.09	15:01	3.06	16:24		
74	0.75	14:31	1.12	15:06	3.22	16:29		
75	0.77	14:35	1.16	15:11				
76	0.79	14:39	1.20	15:16				
77	0.81	14:44	1.24	15:21				
78	0.84	14:49	1.28	15:26				
79	0.87	14:54	1.32	15:31				
80	0.89	14:58	1.37	15:36				
81	0.93	15:04	1.43	15:42				
82	0.96	15:09	1.48	15:47				

Angle	21 June		6 May[a]		21 March[a]		21 December	
	Shadow Length Factor[b]	Eastern Standard Time	Shadow Length Factor[b]	Eastern Standard Time	Shadow Length Factor[b]	Eastern Standard Time	Shadow Length Factor[b]	Eastern Standard Time
83	0.99	15:14	1.55	15:53				
84	1.02	15:19	1.62	15:59				
85	1.07	15:25	1.67	16:04				
86	1.11	15:31	1.75	16:11				
87	1.14	15:36	1.84	16:16				
88	1.19	15:42	1.93	16:22				
89	1.24	15:48	2.02	16:28				
90	1.29	15:54	2.13	16:34				
91	1.36	16:01	2.24	16:40				
92	1.42	16:07	2.36	16:46				
93	1.48	16:13	2.54	16:53				
94	1.56	16:20	2.68	16:59				
95	1.62	16:26	2.84	17:05				
96	1.72	16:33	3.09	17:12				
97	1.79	16:39	3.29	17:18				
98	1.89	16:46						
99	2.01	16:53						
100	2.13	17:00						
101	2.23	17:06						
102	2.37	17:13						
103	2.54	17:20						
104	2.72	17:27						
105	2.92	17:34						
106	3.09	17:40						
107	3.35	17:47						
108	3.65	17:54						
109	4.00	18:01						

Notes: All calculations are for New York City, City Hall.

Latitude: 40°42'23" north (40.706389°)
Longitude: 74°0'29" west (74.008056°)
Times are Eastern Standard times. Daylight Savings Time is NOT considered. To find apparent solar time, add 4 minutes to the clock time. Then, for 21 June, no change; for 6 May, add 3 minutes; for 21 March, subtract 7 minutes; for 21 December, add 3 minutes.

[a] Factors for May 6 and March 21 may be used for August 6 and September 21, respectively.
[b] Factor for shadow length by degree (azimuth) from true north 0°.