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E. Shadows

100. Definitions

Sun and shadows affect people and their use of open space all day long and all year, although in different ways depending on the season. As the sun travels across the sky during the day, shadows follow a curve on the ground opposite the sun. When the sun rises, shadows fall to the west. As the sun travels across the southern part of the sky throughout the day, shadows move clockwise until they stretch east, as the sun sets in the west. Midday shadows are always shorter than those at other times of the day because the sun is highest in the sky then. Further, because of the tilt of the earth's axis, the angle at which the sun's rays strike the earth varies throughout the year, so that during the summer, the sun is higher in the sky and shadows are shorter than during the winter. Winter shadows, although longest, move the most quickly along their paths (because of the earth's tilt) and do not affect the growing season of outdoor trees and plants.

Under CEQR, a shadow is defined as the circumstance in which a building or other built structure blocks the sun from the land. An adverse shadow impact is considered to occur when the shadow from a proposed project falls on a publicly accessible open space (see Chapter 3D), historic landscape or other historic resource if the features that make the resource significant depend on sunlight (see Chapter 3F), or important natural feature (see Chapter 3I) and adversely affects its use and/or important landscaping and vegetation or, in the case of historic resources, obscures the features or details that make that resource significant. In general, shadows on City streets and sidewalks or on other buildings are not considered significant under CEQR. In addition, shadows occurring within an hour and a half of sunrise or sunset generally are not considered significant under CEQR.

The shade created by trees and other natural features is not considered to be shadow as defined for the impact analysis. Trees cast shade and help cool their immediate environment in the hot summer; deciduous trees allow sun to penetrate to the earth in the cold months, when such warmth is needed. The tree canopy requires sunlight, even when the earth beneath the trees is shaded. Thus, a building that casts a shadow on a tree-shaded environment may create an adverse impact; its shadow is not redundant with tree shade.

200. Determining Whether a Shadow Assessment is Appropriate

The shadow assessment considers actions that result in new shadows long enough to reach a publicly accessible open space (except within an hour and a half of sunrise or sunset). Therefore, a shadow assessment is required only if the action would result in new structures or additions to existing structures (including the addition of rooftop mechanical equipment) and those structures are tall enough for the shadows to reach a park or natural feature.

For any actions that would result in new structures or additions to existing structures, determine whether the structure or enlargement resulting from the proposed action would be less than 50 feet in height. If so, are there any parks, historic landscapes or other historic resources (see Chapter 3F), or important natural features adjacent (including across the street) to the site of the proposed action? For actions less than 50 feet tall, no assessment of shadows is generally necessary unless the site is adjacent to a park, historic resource, or important natural feature.

For actions resulting in structures or enlargements 50 feet high or taller, and for shorter structures adjacent to important features, the following screen may be used. The longest shadow that any structure will cast during the year (except within an hour and a half of sunrise or sunset) is 4.3 times its height. Multiply this factor by the height of the building in question (including all rooftop structures). For example, if the action would result in a building 100 feet tall, its longest shadow would be approximately 430 feet. If there are no parks or publicly accessible open spaces within 430 feet of the project site, generally, no assessment of shadows on such resources is needed. If open space resources are present or if the historic resources analysis has identified a known or potential architectural resource with historically significant features that depend on sunlight, the screening analysis described in Section 310 can be applied as the first step in assessing shadows, to determine the potential for impact and the need for further analysis.

Certain open spaces or sunlight-sensitive architectural resources may not need to be assessed, because their location relative to the location of the project site ensures that no project shadows could fall in the direction of the resources. Generally, this occurs with resources south of a proposed project site. More information is provided in the screening analysis in Section 310.

300. Assessment Methods

For CEQR, the assessment of a project's shadow impacts begins with a preliminary or screening analysis to ascertain whether project shadows might reach any open spaces or sunlight-sensitive architectural resources. If this analysis indicates that they might, then further evaluation is needed. Then, the extent and duration of project shadows and the effect of those shadows on uses and vegetation or on the sunlight-sensitive features of architectural resources are assessed. The results of each of these steps are documented in technical memoranda or the EAS or EIS. The following discussion outlines the approach and framework of the shadow assessment analysis. Note that additional methodologies have been, and will continue to be, developed with improvements in technology. In many cases, it may be appropriate to use the services of an architect or other professional skilled in use of computer analysis to perform the shadow assessment. Note that anyone undertaking the analysis should use the longitude, latitude, and time information for New York City that are set forth in the tables provided later in this section.

310. SCREENING ANALYSIS

The first step in an examination of a project's shadows is a screening analysis to determine whether the project's shadows would fall on any open spaces at any time of the year, considering not only the height of the proposed structure, but also its location relative to the open space, natural feature, or architectural feature in question. This analysis combines estimates of the area of open space that could be shaded by the project throughout the year and of the longest shadow the project might cast to ascertain whether it would reach the open space or architectural resource. This screening analysis should be completed for all projects that appear to require shadow assessments (see Section 200, above).

1. Begin by choosing a street map, such as one of the Borough Presidents' engineers maps, that contains the project site and all publicly accessible open spaces within the maximum radius a shadow from the project might reach (as described in Section 200, above). If the historic resources analysis has identified any sun-sensitive architectural resources within that radius, denote those on the map as well. Locate north on the map; make sure it is true north, not magnetic north—the maps listed above display true north. Place the map so that true north is vertical (see example on Figure 3 II E-1).

   The base map must also contain topographic information, either from a site survey or from a source like the USGS topographic maps. Topography is critical to determining possible shadow impacts because the height of a structure is affected by the site elevation. For example, a 100 foot structure on a flat site is lower in height than an identical structure on a site with an elevation of +30 feet, and its shadow effect would in most cases be less.

2. The next step is to determine the *angle* of the project's shadow on each open space or sun-sensitive architectural resource in relation to true north. On the map, 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. On the example in Figure 3E-2, 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.

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Figure II.E-1

Sample Study Area for 200-Foot Building

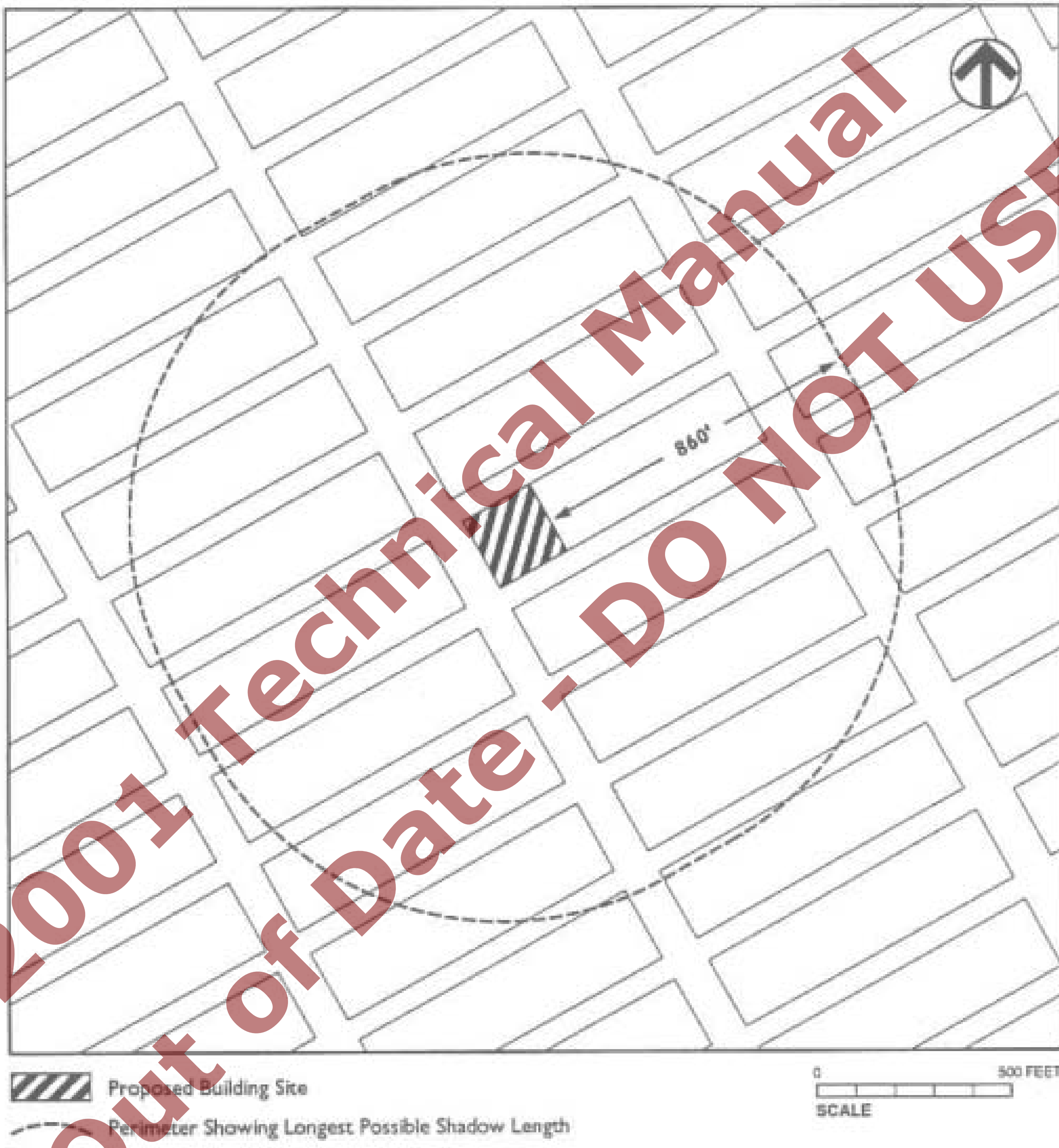

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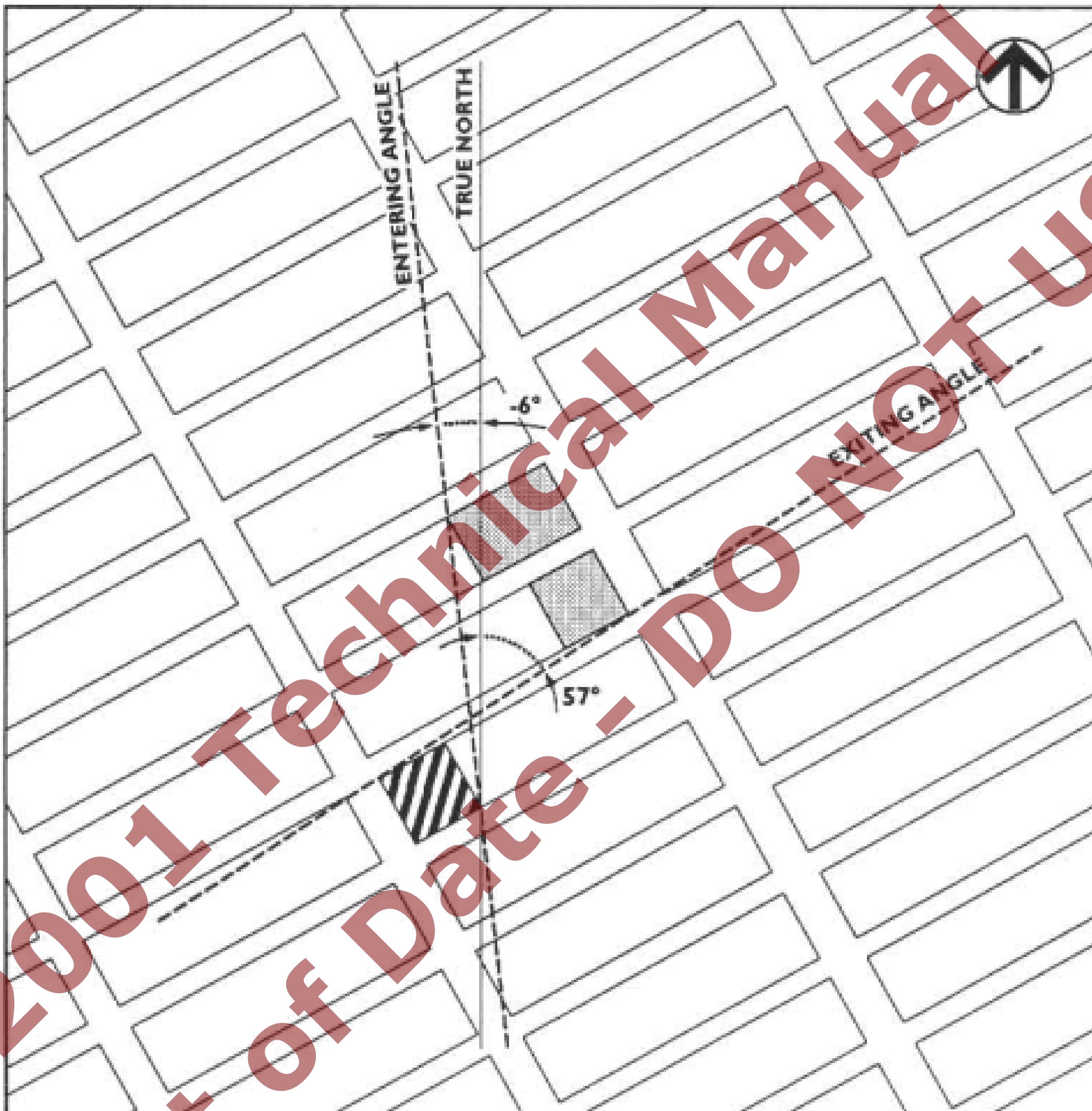
Figure 3E-2

Entering and Exiting Shadow Angles and Distances to Open Space



Proposed Building Site

Park

Entering and Exiting Angle

Extreme Angles: -6°, 57°

Distances at Extreme Angles: 780', 802'

Minimum Distance: 404'

0 500 FEET

SCALE

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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. On 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 shadow from the proposed project at some time during the year. In the 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 action would cast on the open space or resource at all times of the year. In the 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.

3. Next, consider the project site's location relative to the location of the open space, natural feature, or architectural resource in question. Because of the path that the sun travels across the sky, no shadow can be cast in a triangular area south of any given project site. Therefore, if the open space, natural feature, or architectural resource in question is located in that triangular area, no assessment of shadows is required. In New York City, that is the area between -108 degrees from true north and 108 degrees from true north. In other words, any open space (or portion of an open space) for which shadows cast by the proposed action would have to be at an angle from true north greater than -108 degrees or 108 degrees could never be shaded by the proposed project (see Figure 3E-3). No further analysis is needed for those spaces. Further, if the sun-sensitive feature on an architectural resource is on a facade that faces directly *away* from the proposed project site, no analysis is needed. For example, if the architectural resource is west of the proposed project site, and the sun-sensitive feature is on the west facade of that structure, no shadows from the proposed project could fall on that sun-sensitive face. For all other cases, continue with the remaining steps of the screening analysis.

4. Next, using Table 3E-1, 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 42 degrees on December 21st. This means that a 200-foot building, for example, would cast a maximum shadow of 860 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 946 feet (4.3 times 220)—about 86 feet longer than the shadow for the building at the same elevation as the open space.

5. As shown on Figure 3E-4, the distances between the project site and the open space range from 404 to 802 feet. Therefore, a 200-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.

6. The screening analysis also considers the sensitivity of open space to shadow. Facilities such as children's playgrounds and sprinklers, swimming pools, sitting or sunning areas, ballfields and other play areas that are covered with turf do require direct sunlight for some part of the day or at some times of the year. If the open space contains these or like facilities and the project's shadow would reach the open space, then further analysis is required. Some open spaces contain facilities that are not sensitive to sunlight. These are usually paved

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Figure 3E-3

Area that Cannot be Shaded by Project

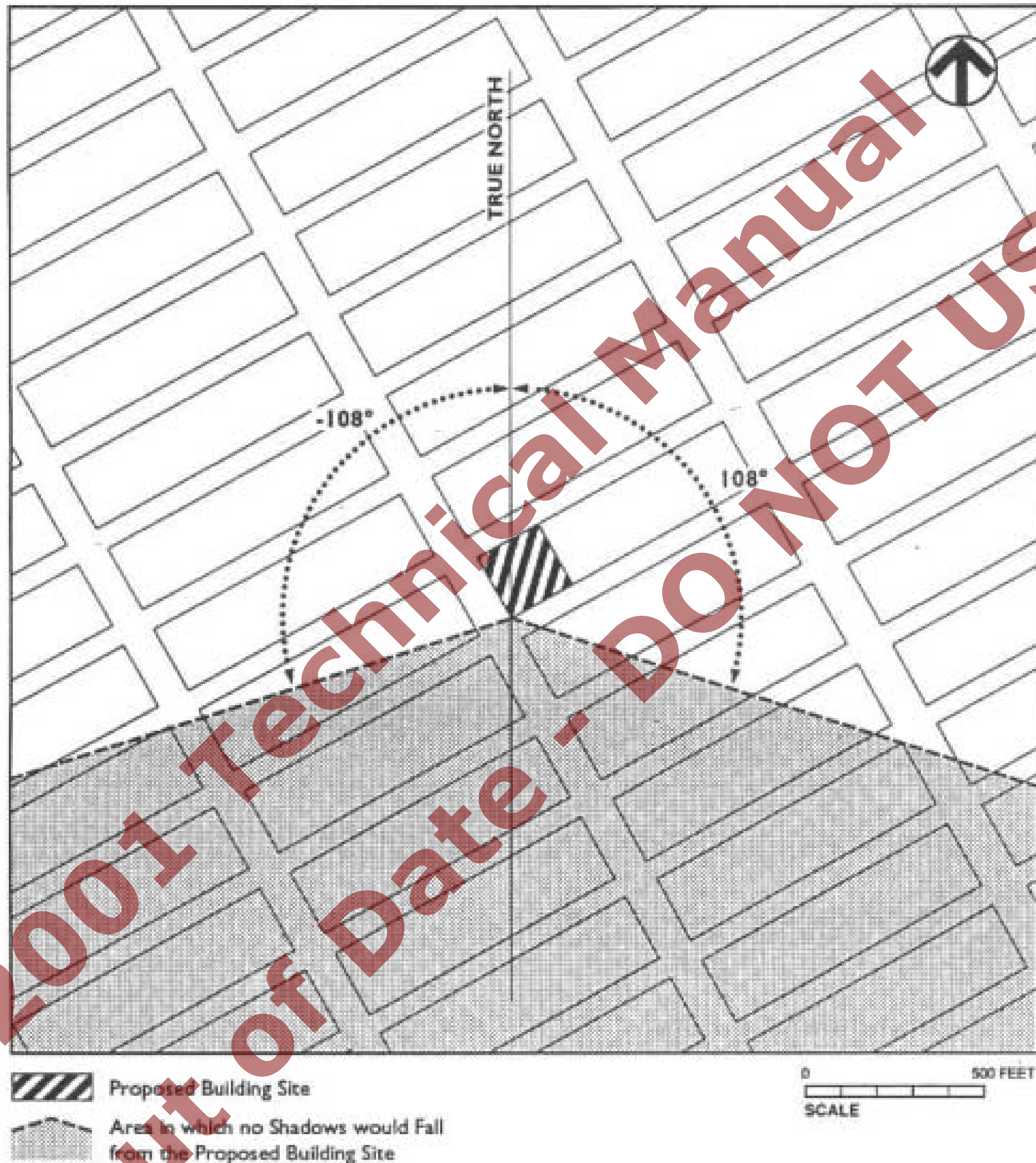

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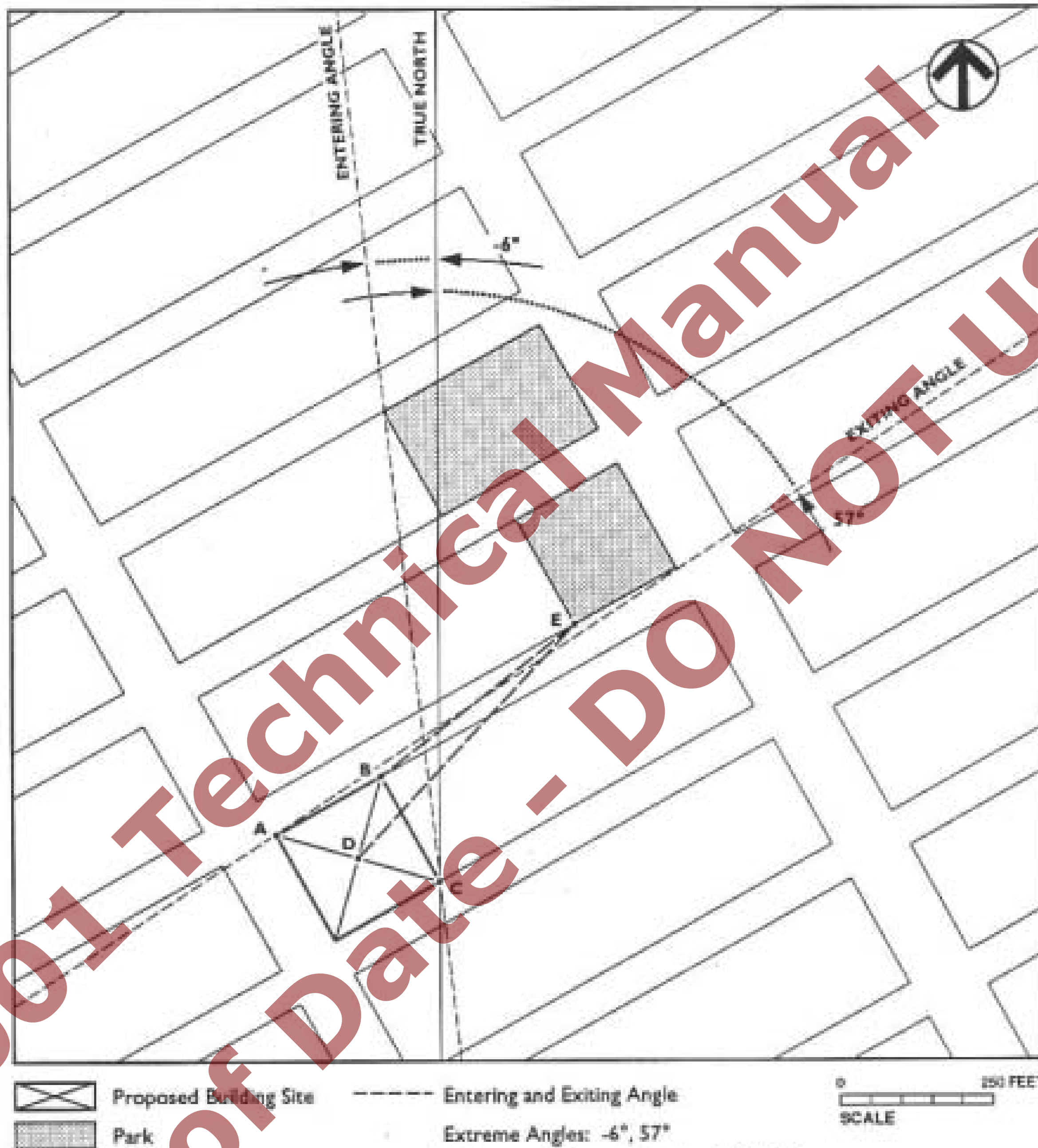
Figure 3E-4
Angles and Distances to Open Space



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'

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(such as handball or basketball courts), contain no sitting areas, and no vegetation, no unusual or historic plantings, or contain only unusual or historic plantings that are shade tolerant. If the open space contains these types of conditions, then no further analysis would be necessary.

If the project's shadow would reach the open space and it is not known whether the open space facilities and/or plantings are sensitive to shadows, then further analysis is required.

If steps 1 through 6 above indicate or cannot rule out that shadows from the project would reach a shadow-sensitive public open space or architectural resource at any time during the year, a more detailed shadow analysis is required. This analysis is described in Section 320. If the results of the screening demonstrate that no shadows will reach any shadow-sensitive open spaces or architectural resources, then no further shadow assessment is needed, but the results should be documented in a technical memorandum in the lead agency's files or accompanying the EAS.

320. DEFINING THE EXTENT AND DURATION OF ADDITIONAL SHADOW ON A PUBLICLY ACCESSIBLE OPEN SPACE, OR NATURAL OR ARCHITECTURAL RESOURCE

The approach to shadow assessment is to define the extent and duration of *additional*, or new, shadow that the proposed action would cast on shadow-sensitive portions of publicly accessible open space(s), natural resource(s), or architectural resource(s) during the year, and to understand the effect of that shadow on the sun-sensitive aspects of these resources. Where more than one open space/resource is at issue, where the resource and/or the proposed building have irregular shapes, or where the project site is located in a densely developed area, it may be most efficient to use a computer program to calculate shadows and display them graphically. The following discussion presents five steps in the analysis of shadows: (1) determining the times of year when the project shadow may reach the open space/resource; (2) identifying those areas of the open space/resource that would be sensitive to shadow during the relevant times of year; (3) calculating the project's incremental (given other buildings in the area) shadow on the shadow-sensitive portions of the open space or resource; (4) estimating the duration of the project's incremental shadow on the shadow-sensitive open space or architectural resource; and (5) estimating the relative loss of sunlight from project shadows. The first three steps need not be taken in the order presented. For example, if there is reasonable probability that the facilities or plantings in an open space are not sensitive to shadow, then step 2 could be taken first. Should the work conclude that the open space is not sensitive, then no further study would be required. Similarly, if it appears probable that the project would never cast a shadow on the open space or resource in question because of intervening tall buildings, a step 3 type of analysis can be undertaken first. Should this study conclude that no project shadow would reach the open space or resource, then no further study would be required.

321. When Does the Project Shadow Reach the Open Space, or Natural or Architectural Resource

The first step in defining the extent and duration of project shadows on an open space, natural resource, or architectural resource is to establish the times of the year when the impacts may occur. The months of interest for an open space encompass the growing season (April through October) and December, representing a cold-weather month (and the longest shadow of the year). The analysis should consider three representative times of the growing season—March 21 (or September 21, which is approximately the same), June 21, and a spring or summer day halfway between the solstice and equinoxes (May 6 or August 6). December 21 is also included to demonstrate conditions during winter months; during these times people do use open spaces and rely most heavily on available sunlight for warmth. Project shadows that reach the open space during any of these months could be of concern. As representative of the full range of possible shadows, these months can also be used for assessing shadows on architectural resources.

Shadow analyses as described below should be performed for each of those four representative months of concern in which the project shadow would reach the open space or architectural resource. Although the following discussion assumes a situation in which the project shadow could reach the open space throughout the year, it is not necessary to analyze those months where no shadow from the project would reach the open space or architectural resource.

This analysis begins with a review of the analysis parameters. For example, if the screening or the task described in 322, below, shows that only a limited area of the open space is sensitive to shadow, then you may wish to identify entering and exiting angles focused only on that shadow-sensitive area. This is also true for sun-sensitive

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features of natural or architectural resources. It is also important to choose the "worst case" for shadows from the building itself. If the proposal contemplates a tower above a base, for example, then the position of the tower on the site would be critical for locating the shadow. If the building would fill the site with high street walls, then it would be prudent to consider the three closest corners of the site in screening for shadows. If the proposal is a rezoning, the analysis should frame a building that complies with the proposed zoning regulations and represents a worst case for shadows. (Generally, where the building is close to an open space or architectural resource, a bulkier building would produce the worst-case shadows. Where the building is farther from the open space or resource a taller tower would constitute a worst case.) Also note that this assessment considers the action's addition compared to the no action condition. If the action would add one story to an existing structure, only the effects of that additional story need be considered.

The example presented here supposes an open space that is entirely shadow-sensitive and a building that rises 640 feet without setback 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 3E-4. 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, next consult Table 3E-2, which provides shadow length factors for all shadows angles for each of the four representative months. 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 3E-5, 3E-6, 3E-7, and 3E-8 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.

An exception to the above is 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 3E-2). 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.

322. Sensitivity of the Publicly Accessible Open Space(s), Natural or Architectural Resource to Increased Shadows from the Project

The uses and vegetation in an open space establish its sensitivity to shadows. Uses that rely on sunlight include passive use, such as sitting or sunning, and such activities as gardening, or children's wading pools and sprinklers. Vegetation requiring sunlight includes the tree canopy and flowering plants. Where lawns are actively used, the turf also requires extensive sunlight. For these activities and plants, four to six hours a day of sunlight, particularly in the growing season, is often a minimum requirement. The assessment of an open space's sensitivity to increased shadow thus focuses on identifying its facilities, plantings, and use, and the sunlight requirements for each. The sensitivity of a historic structure to sunlight depends on its design and setting: do the characteristics that make the resource historically significant depend on sunlight? An example would be a structure noted for stained glass windows that are visible only in the sunlight.

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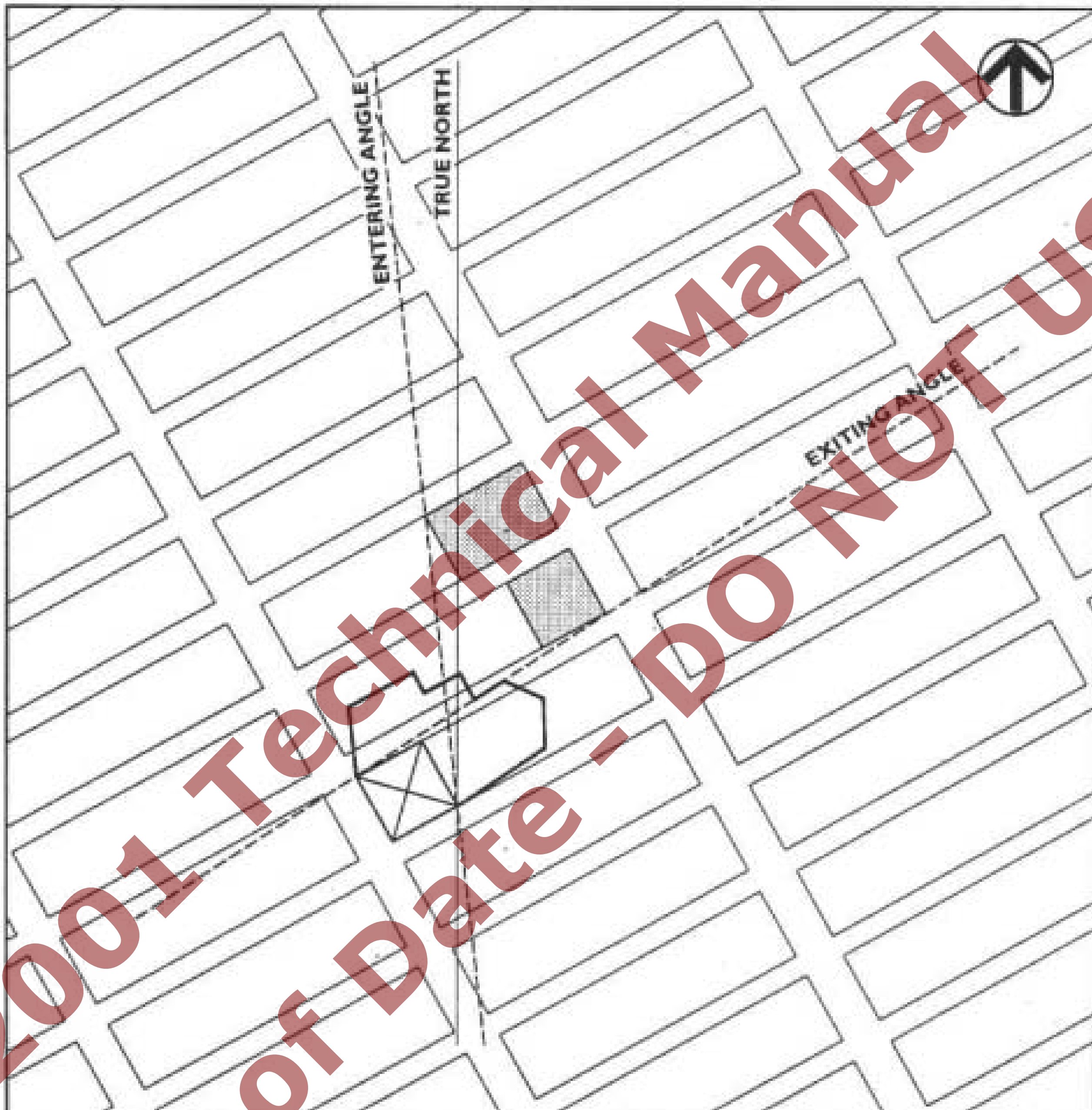
Figure 3E-5
Shadows from 850-foot Building: June 21



Proposed Building Site

Park

Entering and Exiting Angle

Extreme Angles: -6°, 57°

Distances at Extreme Angles: 780', 802'

Minimum Distance: 404'

Shadows from Proposed Building:

11:34, 12:29, 13:22

0 500 FEET

SCALE

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Figure 3E-6
Shadows from 850-foot Building: May 6

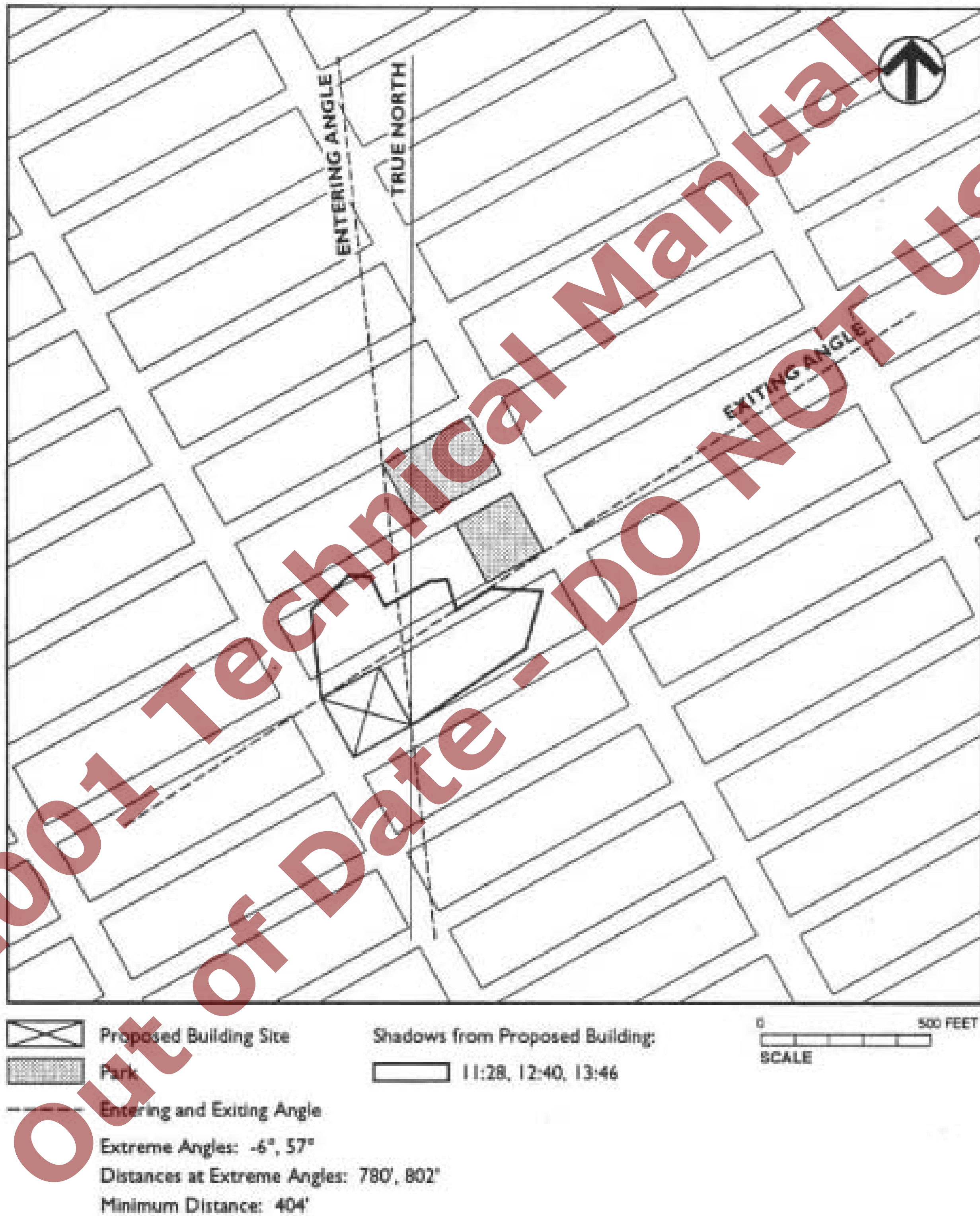

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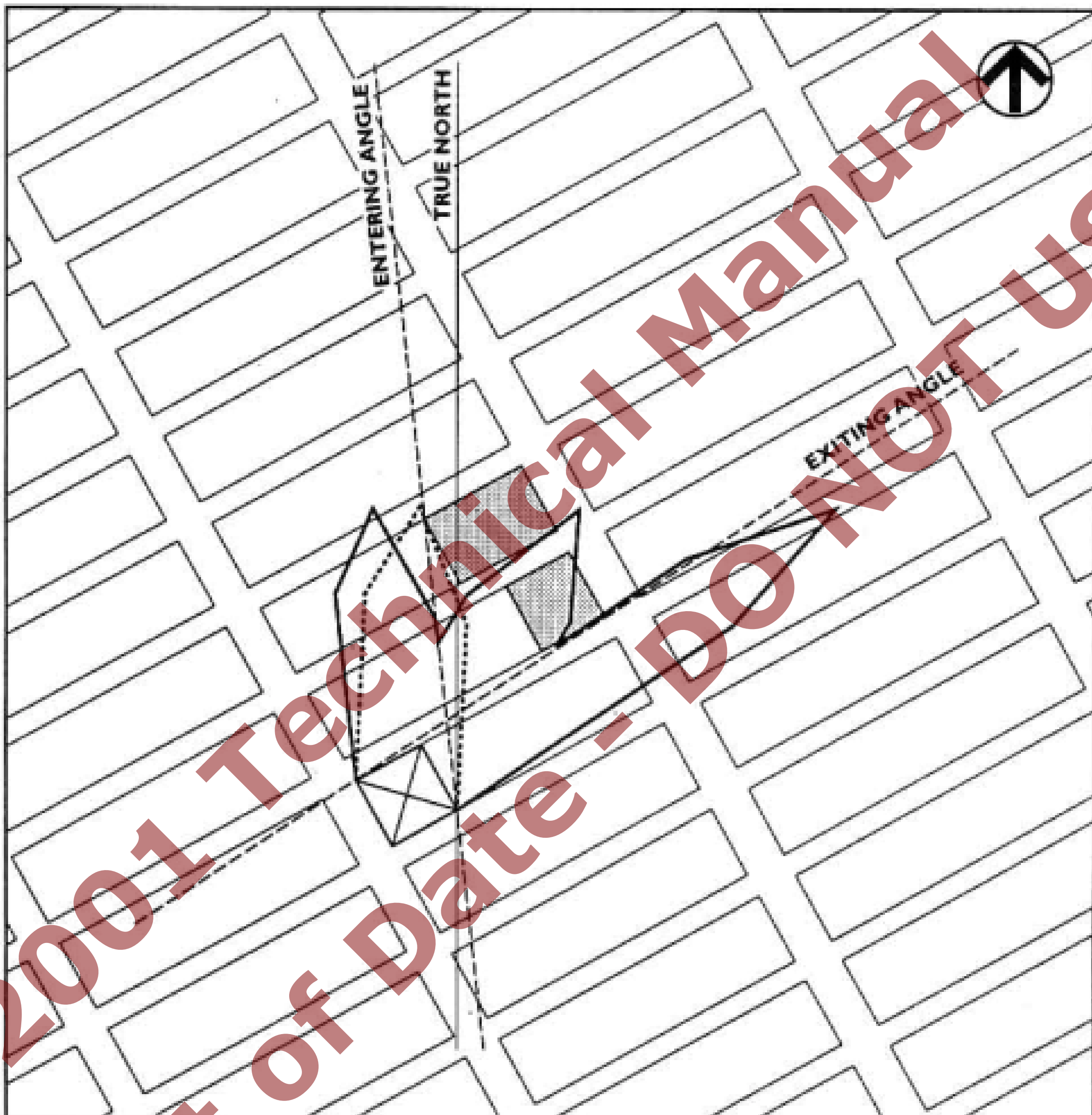
Figure 3E-7
Shadows from 850-foot Building: March 21



Proposed Building Site
Park
Entering and Exiting Angle
Extreme Angles: -6°, 57°
Distances at Extreme Angles: 780', 802'
Minimum Distance: 404'

Shadows from Proposed Building:
11:25, 13:11, 14:43
11:52

0 500 FEET
SCALE

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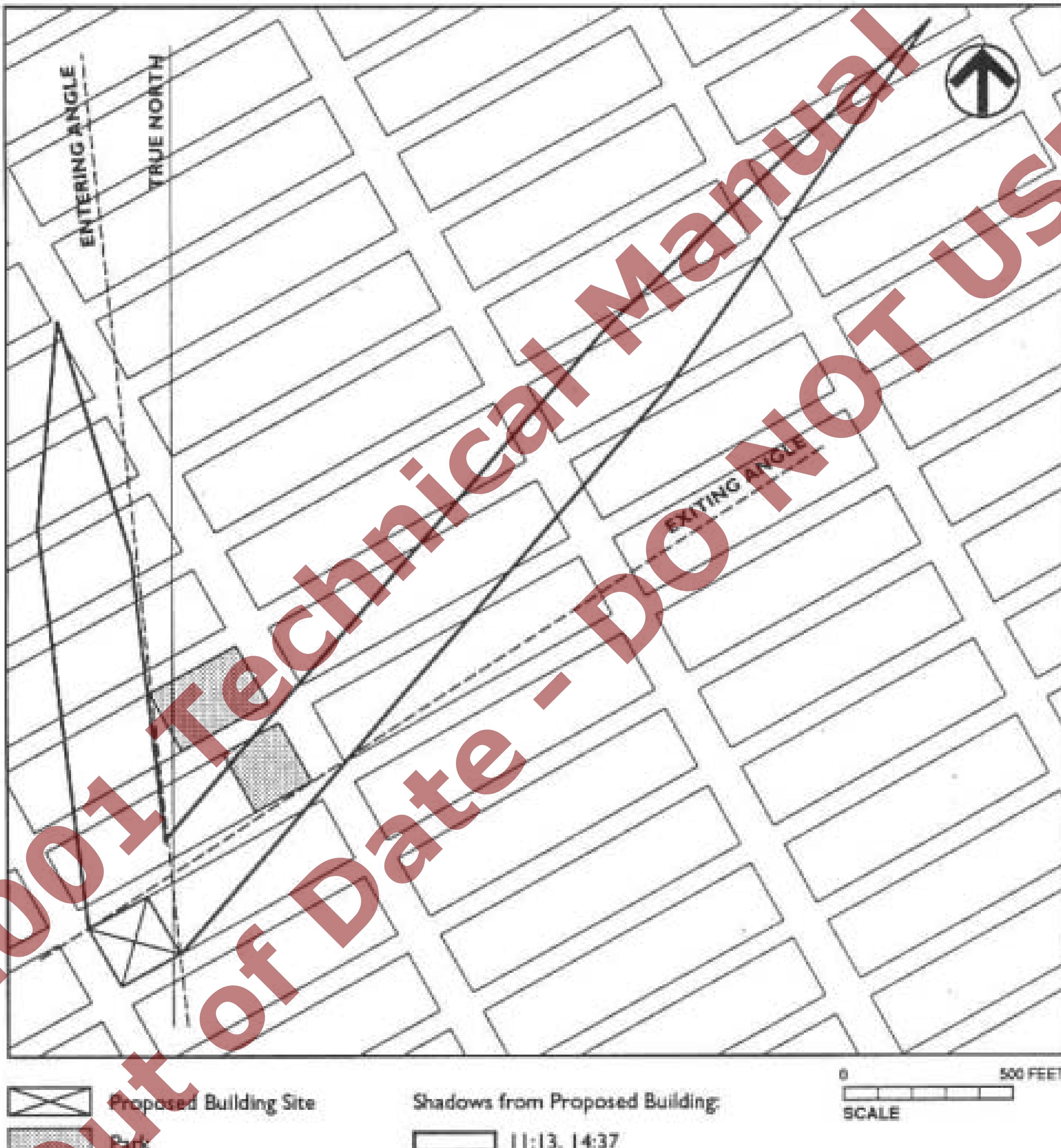
Figure 3E-8
Shadows from 850-foot Building: December 21



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

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It may be advisable to use the services of a recreation planner, landscape architect, or horticulturist to inventory, survey, and assess the sensitivity of the open space to shadow. The analyst should obtain a map of the open space, including its boundary, major facilities, and use patterns. In the area that would be cast in the project's incremental shadow (see Section 323 below), it is also necessary to inventory vegetation, noting species, caliper, height, and age, if possible. If the open space supports activities that rely on sunlight and these would be cast in project shadow, it is also appropriate to survey open space use. This should be done on a sunny day in the spring, summer, or fall, preferably on the weekend or at the time of peak use. Based on this work, the activities, plants, or other facilities in the open space that need sunlight and that may be affected by the project's shadows should be identified. To the extent possible, the acceptable and minimum amounts of daily sunlight required for the plants or activities should be estimated. The analysis then focuses on those uses that depend on sunlight.

323. What Shadow is Attributable to the Proposed Action

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 existing and no action condition between the project site and the open space and that are also located within the two relevant entering and exiting angles from true north (see also explanation in Sections 200 and 320, above). 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. Figure 3E-9 illustrates conditions in which other buildings could intercept or block out shadows from the proposed action. The shadows of interest are those that would occur in the future no action condition, which includes both existing conditions as well as proposed or planned developments (see "Land Use, Zoning, and Public Policy," Chapter 3A for an explanation). In some cases, it may be appropriate not to include in the future no action condition projects that have not yet received their discretionary approvals, particularly if the project is likely to have greater effects in the absence of that development. Consequently, it may be appropriate to assess existing and no build conditions, to distinguish new shadows attributable to potential new structures.

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 as accurate data as possible on the heights of each building and its setbacks. This information can be obtained from Fire Insurance Underwriters' maps, building plans, or visual inspection. Entering and exiting shadows are calculated and displayed for each of the four times of year presented in Section 321, above, and on Table 3E-2 (unless the project shadow would not reach the open space or resource during that time, or no uses that depend on sunlight are located there).

The project's shadow effect is the increment beyond shadows that would exist in the existing or no action condition case. Therefore, the project's shadows should be calculated and displayed clearly as an *increment* beyond those existing or no action condition shadows on the publicly accessible open space (see Figures 3E-10 and 3E-11, which illustrate a full and a partially blocked shadow from the 850-foot example building). Note that if the proposed building form is not known, the worst case under the (proposed) zoning for the site should be assumed. When the proposed building would be distant from the open space or architectural resource, the worst case would be the tallest building allowed by zoning; when the proposed building would be nearby, the worst case might be the bulkiest (widest) building permitted. Once this work is complete, if it is clear that the project's shadow increment would occur rarely or would be only marginal, then the project shadow would not have a significant adverse impact on the open space or architectural resource, and no additional analysis is required. If the project's incremental shadow cannot be clearly categorized as marginal, particularly if the open space is known to be sensitive, additional analysis to understand fully the effect of the shadow is required.

324. Duration of the Project Shadows

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. As described in Section 100, 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 3E-2,

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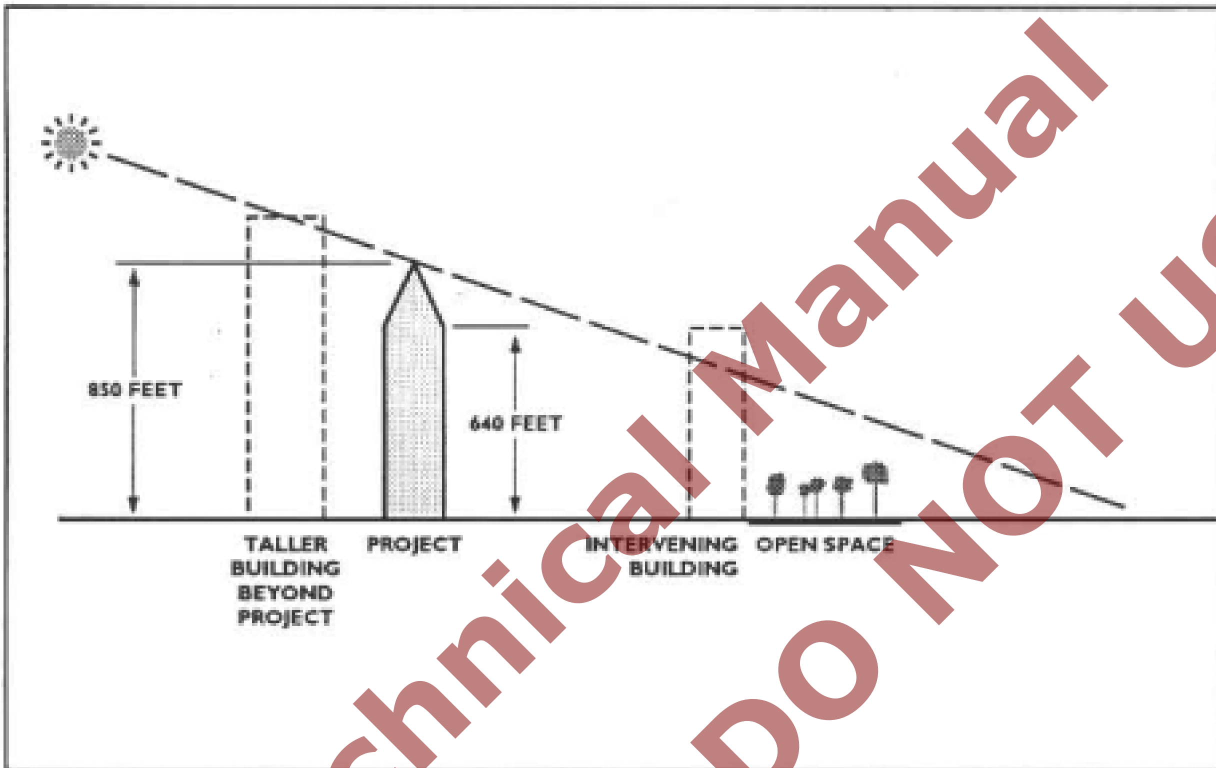
Figure 3E-9
Example Shadow Profile



NOTE: BOTH INTERVENING BUILDINGS AND BUILDINGS BEYOND THE PROJECT SITE MAY CAST SHADOWS THAT ELIMINATE THE PROJECT SHADOW

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Figure 3E-10

Incremental Shadows from 850-Foot Building: Example 1

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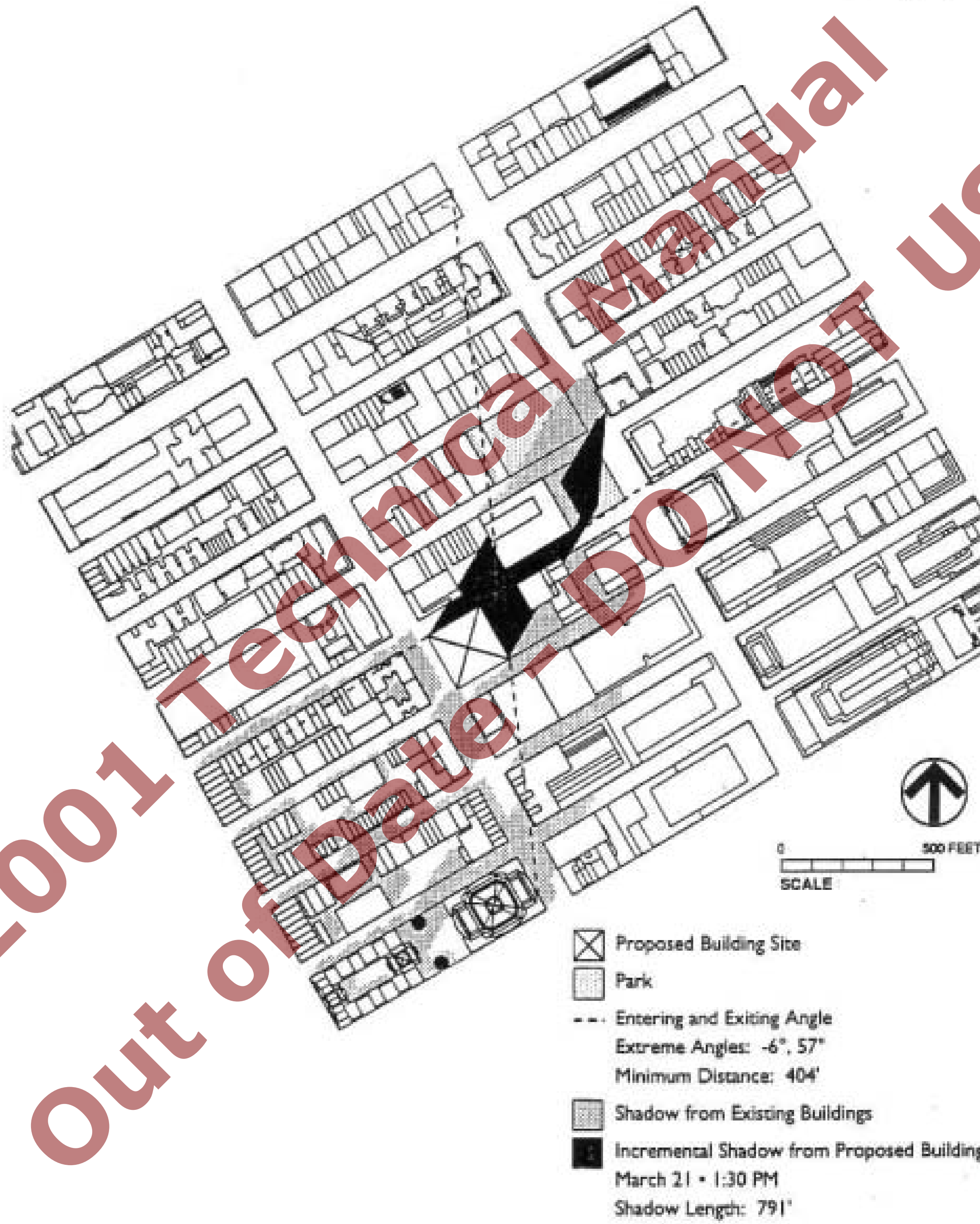
Figure 3E-11
Incremental Shadows from 850-Foot Building: Example 2



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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 am EST, and the exiting angle of 57 degrees would occur at approximately 3:04 pm EST (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 3E-2, 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 3E-7, 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 pm EST and exit at 3:04 pm EST for a duration of 2 hours and 54 minutes.

This technique is also used when a shadow would fall on the park for a long time, but on a particularly sensitive portion of it for a shorter time. The inventory undertaken in Section 322 will identify features in the open space of particular concern—such as warm-weather-dependent features like wading pools and sand boxes; benches, which could be affected by a loss of winter sunlight; or vegetation, which could be affected by a loss of sunlight during the growing season. The entering and exiting angles of the building's shadows on the sensitive area are drawn as described in Section 321, so that the shadow length and duration can be computed. Similarly, only shadow duration on the sun-sensitive features of the architectural resource are of concern.

If the duration is very short, for example, no more than 10 minutes at any time of year, the project shadow would not have a significant adverse impact on the open space or resource and no additional analysis is required. With longer shadow durations, it is necessary to assess the sensitivity of the open space or resource to shadows before the severity of project shadow impact can be assessed.

325. Estimating the Relative Loss of Sunlight from Project Shadows

Where the incremental shadows from the project on publicly accessible open space fall on uses and plants requiring sunlight, additional analysis is required to assess the loss of sunlight relative to sunlight that would be available without the project. For example, trees, many plants, and many activities can require a minimum of four to six hours of sunlight, particularly between April and October. If the project shadow is estimated to reduce sunlight from eight to seven hours on such a sensitive use, it would probably have no significant impact. If the same project shadow is estimated to reduce sunlight from four to three hours on a sensitive use, this could constitute a significant impact. Thus, it is necessary to estimate shadow patterns on the affected area of the open space or resource throughout the day. The analysis should be undertaken for each of the months where project shadow impacts could be significant. This is different from the estimate of the project's increment (Section 323, above) in that it considers all shadows on the portion of the park or resource affected by the project's shadow throughout the day, even times when the project itself is not casting any shadows on the open space. Therefore, a more detailed analysis is appropriate.

The first step in the analysis includes physical inspection to determine whether the area is in shadow for any appreciable time of the day. If the assessment is being prepared at a time of year that does not include the analysis months, then a physical inspection of the area surrounding the open space or resource and an examination of maps to inventory buildings to the east, south, and west of the open space or architectural resource is appropriate (this is a larger area than was used in Section 323). Since the sun rises and sets north of due east and west during the spring and summer, buildings east/northeast and west/northwest of the open space or resource should also be considered for analysis. The procedure described in Section 200 can be undertaken at this point if the buildings in question are relatively few, and they may be too short or too far from the open space or resource to cast shadows on it. If it is clear that there are other shadows on the affected area of the open space or resource, a full analysis should be undertaken. A simple and accurate way to chart the shadows on the subject is to observe and photograph it on the days of interest; this survey can be undertaken on a sunny day closest in time to the analysis day (if it is cloudy on the analysis day).

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If the schedule for the assessment does not permit waiting for the particular days in question, or if development is proposed for the no action condition that would cast shadows on the open space or resource, then an analytical method is used. (In the case where limited future no action development is proposed, the existing shadow can be observed by survey, and the future additional shadow calculated analytically.) Such a methodology can be very complex, and a computer program is probably the best approach. However, the work can be done at the drawing table. This involves establishing entering and exiting angles from true north for each of the buildings casting shadows on the affected area of the open space or resource and defining the extent, timing, and duration of each building's shadow. When the time of each shadow entering and exiting the affected area is ascertained, these can be plotted on one map and the pattern, extent, and duration of combined shadows defined for each representative month of interest.

330. ANALYSIS PRESENTATION

In presenting the results of the assessment, the following information should be included for each analysis period: duration of incremental shadow on affected features; times of shadow penetration; description of affected features (e.g., planting, seating, active uses); and times of sunrise and sunset for the day analyzed.

An example of a recommended format for providing the information is shown below.

Analysis Period: 21 June, 7:15 am – 6:00 pm.
Sunrise / Sunset: 6:45 am / 7:30 pm.
Duration of shadow: 4 hours 10 minutes.
Times of shadow penetration: 11 am-2 pm; 3 pm – 4:10 pm.
Affected features: passive seating area; planting area.

Because the shadow analysis can be intricate and is primarily visual, it is important that, in addition to a clear narrative description, the presentation of the analysis include clear graphic representations of the following as appropriate:

- Relationship between the project site and publicly accessible open spaces, natural or architectural resources.
- Calculation of the angles from north for project shadows entering and exiting the open space(s) or affected area of open space, natural or architectural resources.
- Map showing no action condition shadows and the incremental shadows from the project on the open space, natural or architectural resource on a representative day in each relevant month. While not required, this is often best illustrated with the use of color graphics. If an open space is analyzed for shadow impacts, a site plan of the open space should be used to illustrate the placement of incremental shadows. This will allow for a clear presentation of any impacts on sensitive features of a given open space. These graphic depictions should include information similar to that provided in Figures 3E-10 and 3E-11: blocks, lots, streets, parks, building outlines, and significant topographical features, as appropriate. The length and time of the project's shadows should be indicated on each map.
- Photographs of the open space or resource, focusing on elements sensitive to sunlight loss that may be in shadow caused by the proposed project.
- Plan of the open space or resource, locating elements sensitive to sunlight loss.
- Plan of the open space or resource showing composite shadows and the location and duration of sunlight.

400. Determining Impact Significance

In general, a significant shadow impact occurs if the shadow added by the project reduces sunlight on sensitive uses substantially or to unacceptable levels. This includes the following situations:

- Substantial reduction in sunlight where the sensitive use is already subject to substandard sunlight (i.e., less than minimum time necessary for its survival).
- Reduction in sunlight available to a sensitive use from more than to less than the minimum time necessary for its survival.
- Substantial reduction in sunlight to a sun-sensitive use or feature.
- Substantial reduction in the usability of the open space.

Although these situations frame a general guideline to determining impact significance, each case must be considered on its own merits. There may be situations where a very small loss of sunlight is important (for example, in areas where older people sit) or where a comparatively large loss is not significant (for example, where vegetative species are not critical to the character of the

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open space and its environment and can be easily replaced with more shade-tolerant species). A reduction in sunlight to a sun-sensitive use could be more critical when the use is already subject to substandard sunlight than when it is not. In all cases, the rationale for determining impact significance is presented in the EAS or EIS.

500. Developing Mitigation

Where a significant impact is identified, mitigation must be assessed. Types of mitigation that may be appropriate include relocating facilities within an open space to avoid sunlight loss, relocating or replacing vegetation, undertaking additional maintenance to reduce the likelihood of species loss, or replacement facilities on another nearby site. Where the affected open space is a City park, it is appropriate for the lead agency to coordinate mitigation options with the Department of Parks and Recreation (DPR). The lead agency may wish to coordinate with DPR as an expert agency on open spaces that are not City parks as well.

600. Developing Alternatives

Alternatives that reduce or eliminate shadow impacts include:

- Reorientation of building bulk to avoid shadow increments on sensitive areas of open space or of the natural or architectural resource.
- Reorientation of site plan to include replacement facilities (see also Section 500, above).
- When an open space that would be affected is proposed as part of the action, reorientation of the sun-sensitive features within the open space.

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Table 3E-1

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	10:22	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

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Angle	Shadow Length Factor*	Dates	Time (Eastern Standard Time)	
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 1/18	8:29 8:52	14:57 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 15:40
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 15:46
55	3.72	11/1 2/12	8:00 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 2/15	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 8:22	15:29 15:58

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Angle	Shadow Length Factor*	Dates	Time (Eastern Standard Time)	
60	3.59	10/22 2/21	7:47 8:18	15:33 16:02
61	3.55	10/19 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	3.40	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	7:05	16:41

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Angle	Shadow Length Factor*	Dates	Time (Eastern Standard Time)	
		4/4	7:11	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 7:06	16:46 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

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Angle	Shadow Length Factor*	Dates	Time (Eastern Standard Time)	
105	3.53	7/18 5/28	6:14 6:05	17:50 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°).

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Table 3E-2

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	7:05				
-90	1.30	7:57	2.13	7:11				
-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	1.61	7:46				
-83	0.99	8:37	1.54	7:52				
-82	0.96	8:42	1.48	7:58				
-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	0.84	9:02	1.28	8:19				
-77	0.82	9:07	1.24	8:24				
-76	0.79	9:12	1.20	8:29				
-75	0.77	9:16	1.16	8:34				
-74	0.75	9:20	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		

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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
-62	0.55	10:04	0.82	9:30	1.88	8:38		
-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
-13	0.32	11:38	0.47	11:30	0.90	11:28	2.17	11:01

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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
-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
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

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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
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	14:15		
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	13:18	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				
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				

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
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°.

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