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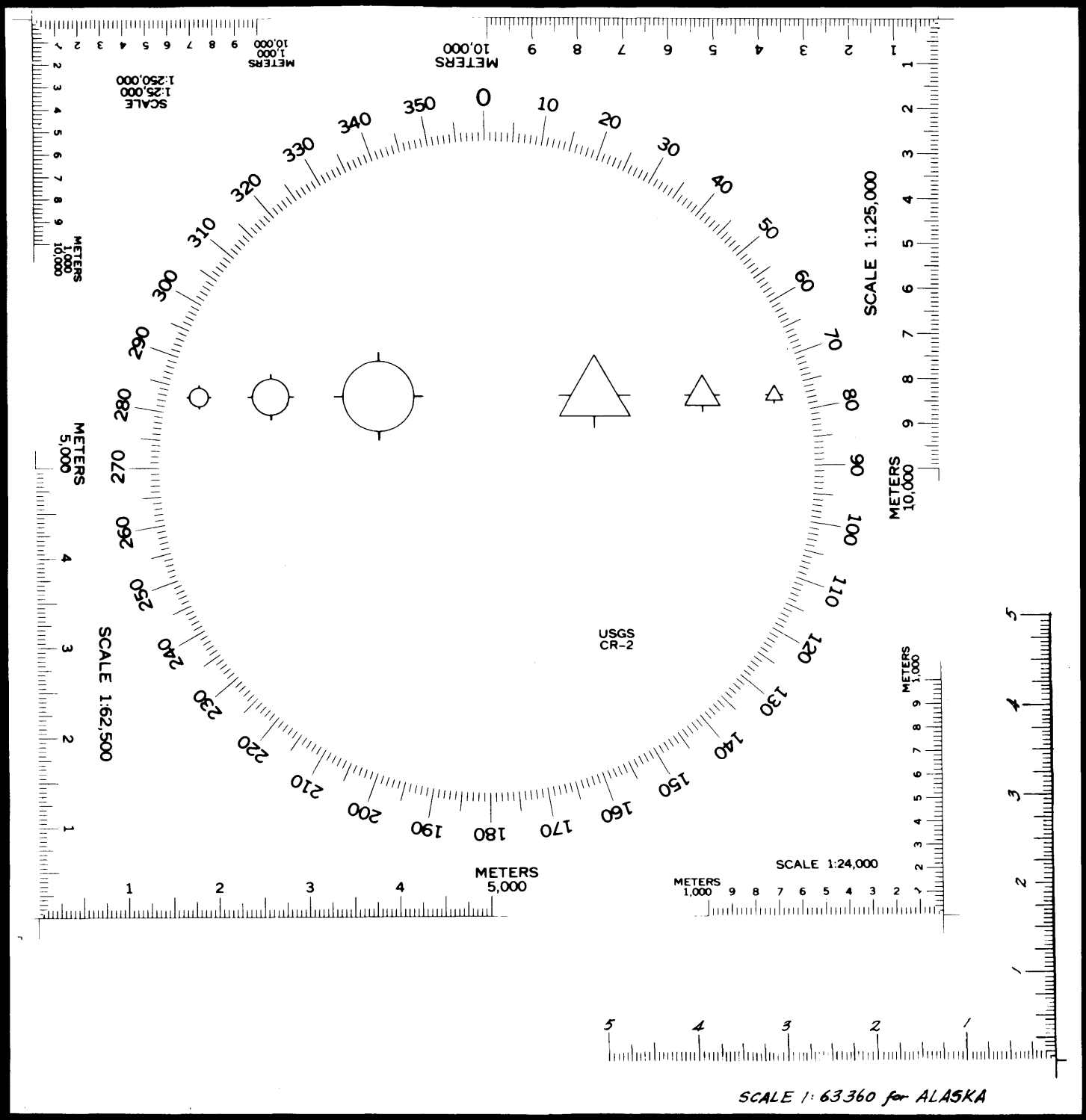
Using the UTM Grid System to Record Historic Sites



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·NATIONAL REGISTER·
BULLETIN

Technical information on comprehensive planning, survey of cultural resources, and registration in the National Register of Historic Places.

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Using the UTM Grid System to Record Historic Sites

by
Wilford P. Cole
U.S. Department of the Interior
National Park Service

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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Foreword

This publication was prepared in 1977 by the late Wilford P. Cole. It is an introduction to the Universal Transverse Mercator (UTM) Grid System and its application to mapping historic and archeological sites. The manual was written to provide a uniform procedure for recording site locations in the National Register of Historic Places. The UTM method has advantages of speed, precision, and reliability over the previously used Geographic Coordinate System (latitude/longitude). An advance version of this manual was distributed to all States in 1977 with a solicitation of comments. The version presented here was revised by Mr. Cole on the basis of those comments.

Lawrence E. Aten
Chief, Interagency Resources Division

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Introduction

The Universal Transverse Mercator (UTM) Grid System provides a simple and accurate method for recording the geographic location of a historic site. Its greatest advantage over the Geographic Coordinate System (latitude/longitude) is its reliability, because its measurements are cited in linear, decimal units, rather than in angular, non-decimal ones. Most people find meters easier to visualize than fractions of degrees, and consequently, are less likely to make mistakes.

The UTM System involves no complicated geometric constructions, and in its simplest application, requires as working tools only a straightedge, a coordinate counter, a plastic measuring device, illustrated in figure 1, and a sharp pencil. The coordinate counter used by the National Register of Historic Places is available from J & J Reproduction and Drafting Supplies, Inc., 9107F Mendenhall Court, Columbia, Maryland 21045.

The UTM grid has further benefits, such as simplicity of notation and greater precision, when compared to the Geographic Coordinate System. Locations are expressed in meters, instead of degrees, minutes, and seconds. The smallest common unit in the latter system, the second, is roughly equivalent to 100 feet depending on where it is measured, while the smallest practical unit of measure in the UTM system, as used here, is 10 meters, or approximately 30 feet. Because UTM measurements are made directly from a scale, they tend to be more accurate than geographic coordinates estimated from geometrical constructions.

The reader will see that, although the UTM System claims an advantage of simplicity over the Geographic Coordinate System, it is not without its "technical" aspects. Mastery of the system is worth the effort. Someone experienced with the system will apply it efficiently and without error; a person who masters the principles behind the system will be able to solve problems that arise. The methods given here may be followed as one might follow a cookbook, step by step, but as in cooking, experience and understanding are bound to be rewarded.

The UTM Grid System

The UTM grid location or reference of a point may easily be found if the point can be located on a map with UTM grid tick marks along its edges or with a UTM grid superimposed. USGS quadrangles published since 1959, and many published before then, have these ticks, which are printed in blue. Maps produced by many other federal agencies and by some states also have UTM ticks. If no USGS map with UTM ticks exists for a location, latitude and longitude coordinates, or certain local grid coordinates, may be converted to UTM references by a mathematical formula. However, computer programs are necessary to perform such a task. It is always preferable to initially record locations in UTM terms rather than to use translated values. (See Method V for a manual, nonmathematical way to determine UTM references without tick marks, and Digitizing for an automated method.)

The simplicity of the UTM grid method follows from certain assumptions, which do not seriously compromise the accuracy or precision of measurements made on the common types of USGS topographical maps. The primary assumption is that narrow sections of the earth's nearly spherical surface may be drawn on flat maps with little distortion. Larger sections, however, such as the contiguous United States, cannot be drawn on a single flat map without noticeable distortion.

In the UTM system, the earth is divided into 60 zones, running north and south, each 6° wide. Mapping on flat sheets within one of these narrow zones is satisfactory for all but the most critical needs. Each zone is numbered, beginning with zone 1 at the 180th meridian near the International Date Line, with zone numbers increasing to the east. Most of the United States is included in Zones 10 through 19, as shown in figure 2. On a map, each zone is flattened, and a square grid is superimposed upon it. Any point in the zone may be referred to by citing its zone number, its distance in meters from the equator ("northing"), and its distance in meters from a north-south reference line ("easting"). These three figures—the zone number, easting, and northing—make up the complete UTM Grid Reference for any point, and distinguish it from any point on earth. (See also Extended Grids.)

Figure 3 shows a zone, its shape somewhat exaggerated, with its most important features. Note that when drawn on a flat map, its outer edges are curves, since they follow meridian lines on the globe, which are farther apart at the equator than at the poles. Note also that it is the accepted practice to terminate the UTM grid system before it reaches the poles. This should not, however, affect any historic sites in the United States, or its possessions or territories.

The two most important features of the zones are the equator, which runs east and west through its center, and the central meridian, a north-south line through its center. Easting and northing measurements are based on these two lines. The easting of a point represents its distance, in meters, from the central meridian of the zone in which it lies. The northing of a point represents its distance, in meters, from the equator.

By common agreement, there are no negative numbers for the eastings of points west of the central meridian. Instead of assigning a value of 0 meters to the central meridian of each zone, each is assigned an arbitrary value of 500,000 meters. Since at their widest points, along the equator, the zones somewhat exceed 600,000 meters from west to east, easting values range from approximately 200,000 meters to approximately 800,000 meters at the equator, with no negative values. The range of possible easting values narrows as the zone narrows toward the poles.

Northings for points north of the equator are measured directly in meters, beginning with a value of zero at the equator and increasing to the north. To avoid negative northing values for points south of the equator, the equator is arbitrarily assigned a value of 10 million meters, and points are measured with *decreasing*, but positive, northing values heading southward. For clarity, a minus sign usually precedes northing figures for points south of the equator. This arrangement is summarized in figure 3. The explanation may seem complicated, but experience has shown that dealing with negative values for measurements, and having to specify the direction of measurements from a reference line, are more complex and less reliable. When actually working with maps, especially at the scales commonly used for locating historic sites, the UTM grid system becomes extremely clear and straightforward to use.

The Five Methods

This manual describes five methods for measuring the UTM reference for a point. The first two are the easiest and most common, and each has specific advantages in certain situations.

Method I the simplest and least subject to mechanical errors, is best for measuring in simple situations, but is somewhat inconvenient for measuring a number of points widely scattered across a single map.

Method II is preferable for complicated situations, but requires, in addition to a straightedge and a coordinate counter, a drafting board and T-square or parallel rule. Carefully applied, however, either Method I or II will give satisfactory results on USGS maps drawn to common scales.

Method III may be applied to maps of any scale, that is, maps not represented on the coordinate counter, provided they have UTM tick marks or grid lines.

Method IV is designed for use on sites too near map edges to be measured by the first three methods.

Method V establishes UTM references on USGS quadrangle maps which lack UTM ticks.

General Information

Certain elements are common to all five methods, and should be studied carefully.

1. UTM zone numbers appear in the legend in the lower left margin of modern USGS maps.

2. On these maps, blue tick marks around the margins set off intervals of a thousand, 5 thousand, or 10 thousand meters, depending on the map scale. To check this, use the metric scale printed at the center of the lower map margin. The easting and northing values of these ticks are printed on maps in an abbreviated form that shows values in thousand-meter units such as $^{4}77$ or $^{36}23$. These abbreviations are clarified near the northwest and southeast corners of the maps, where at least one tick value will be written out in full, to the nearest whole meter, for each map edge. For example, an easting abbreviated $^{5}23$ would be printed in full as 523000mE, meaning 23,000 meters east of the central meridian. Similarly, an easting abbreviated as $^{4}77$ would be printed in full as 477000mE, meaning 23,000 meters west of the central meridian for the zone in which the map is located. **Remember that the central meridian always has an arbitrarily defined easting value of 500,000 meters.**

3. Lines connecting UTM grid ticks of equal value are seldom parallel with lines of latitude and longitude, or with the edges of quadrangle maps. This is a result of the map projections used and the fact that longitude lines converge toward the poles, whereas UTM grid lines do not coverge. The effect becomes more evident as the distance from the central meridian in each zone increases. None of this noticeably affects the accuracy of measurement at common map scales.

4. When drawing lines between UTM grid tick marks, make the finest line possible. Use a very sharp, hard pencil or very fine pointed pen to draw connecting lines. Lines drawn with dull or soft pencils, or with felt markers, are too wide for precise measurement. Number 3 office pencils, and number 3H or 4H drafting pencils, if kept sharp, do a good job.

5. USGS has announced that new and newly revised quadrangle maps will have printed UTM grid lines, making it unnecessary to draw them by hand. It will take several years to reprint all of the USGS quadrangles, but as they are issued, the labor needed to measure UTM references will be reduced significantly.

6. The UTM coordinate counter (see figure 1) is used in all methods except Method III. It has measuring scales to match the common USGS map series around its edges and each corner of the counter corresponds to a different map scale.

Be sure to choose the correct scale for the desired measurement to be made. The organization of each measuring scale is the same. Values near the corners are always lower than values toward the center of each edge.

In all cases, the basic unit of measure is the meter. For clarity, the smallest ruled divisions of each scale vary in size. In general practice, and with adequate care, the level of precision approaches the limits of visual resolution, for any map, as shown in the following chart.

Map Scale	Quadrangle Series	Smallest Unit Marked on Coordinate Counter	Measurements may be made to the nearest
1:24,000	7.5 minute	20 meters	10 meters
1:62,500	15 minute	50 meters	25 meters
1:125,000	——	100 meters	50 meters
1:250,000	——	200 meters	100 meters

7. If your UTM coordinate counter gets dirty, it can be cleaned by rubbing it gently with a soft, nonabrasive artist's eraser, for example, the Vitagum Dry-Cleaner. Putty-like erasers are not as effective because they pick up skin oils and dirt. Abrasive erasers will scrape the printing from the surface of the counter.

8. Notice the format of the UTM Worksheet (see figure 4). It is an aid to taking notes while measuring UTM references. For a complete UTM grid reference for any point, there are spaces to be filled in for the zone number, easting value, and northing value. The position of each digit is clearly marked. The heavily underlined portions of the easting and northing values are read from the coordinate counter. All other digits may be read directly from the map.

9. One of the most frequent errors in writing UTM references is to reverse the easting and northing figures, with digits dropped or zeroes improperly added to make up for the different number of digits required for each. The correct formulation is easy to remember:
a) **Eastings** are distances **east** (6 digits);
b) **Northings** are distances **north** (7 digits);
c) The order for writing UTM references is **Z-E-N**, zone-easting-northing.

10. Cheap straightedges, especially the common school and office rulers made of wood with brass edges, are notorious for drawing crooked lines. Even small deviations have a drastic effect on the accuracy of measurements.

To check the trueness of any straightedge, draw a long line with it, using a very sharp pencil. Turn the straightedge end for end, and draw another line connecting the ends of the first line. If the second line does not fall precisely along the first line for its entire length, then the straightedge is not straight.

The best source for reliable straightedges is an art or drafting supply store. College bookstores at schools where engineering, architecture, or drafting are taught are also good sources. The dealer should not object to you testing the edge.

11. For sites mapped with more than one point:

a) Begin with the northeasternmost point and proceed clockwise. If coordinates are written consistently in this way, computerizing UTM data will be much simpler. For example, as shown in figure 5a, list the points in alphabetical order, beginning with point A. (See also UTM Representation of Extensive and Complicated Sites.)

b) The simplest way to find the northeasternmost point of a figure is to line the map up with a T-square along the map border, and to pass a 45° line (NW-to-SE) across the figure from the west to east. The last point it crosses before passing beyond the figure will be the northeasternmost point. A 45° draftsman's triangle, or an adjustable triangle set at 45°, moved along the T-square will show this line.

c) Some sites may have no point that is clearly farther northeast than the others. This will happen when a line connecting two or more corner points lies in the direction NW-to-SE; that is, 45° north of west. As in figure 5b, where neither of the points A or B is northeast of the other, start with the northernmost of the two, A.

d) It is a good idea to label the points, both on the map and anywhere you write the references, to avoid confusion.

UTM Representation of Extensive and Complicated Sites

The records of a historic site in the National Register of Historic Places may show three types of boundary descriptions: precise boundaries described verbally, boundaries drawn on USGS quadrangle maps, and approximate boundaries expressed by Universal Transverse Mercator (UTM) references to points on the drawn boundaries.

The goal of a UTM description is limited to fixing the location of a site in its geographical context and to conveying a reasonable impression of the site's shape and extent. Although it is an approximation, the UTM description should not be so loosely expressed that it could mislead a user by misrepresenting the site.

The UTM references for an extensive or complicated site have often been derived from the corner points of a rectangle drawn around the site (see figure 6a). While this approach fixes the site unambiguously on the map, and proves expedient for the mapper, it often falls short of the goal by seriously misrepresenting the shape and area of the site. The seriousness of this misrepresentation depends on how the data is to be used and on how much supporting information is available to guide a user's interpretation.

The general solution to the problem is to approximate such a site's boundaries by enclosing the site within a figure of more than four sides, or within a group of figures. As more points are plotted, less extraneous land is included. Figure 6b shows how the approximation of figure 6a could be improved by using more than four corner points, thereby reducing the extraneous (shaded) area. The mapper must reach a compromise between accuracy of representation and available working time, keeping in mind how the resulting information may be interpreted.

Extensive and complicated sites may be considered in four categories: complex, unclosed, discontinuous, and compound sites. Suggestions follow for choosing boundary points in each category.

Complex-Sites

Complex sites have at least one border that does not conform to a side of a rectangle drawn on a USGS quadrangle map. They may be best represented by polygons of more than four sides (see figure 6b). UTM references for complex sites should be listed in National Register nomination forms beginning with the northeasternmost point and continuing clockwise.

Unclosed Sites

An unclosed site does not form a closed geometric figure. If the site is small or if it follows a single straight line, a rectangle enclosing all points of the site may be an appropriate representation. However, if the site is extensive or if its boundaries curve or follow an irregular course, some other closed figure surrounding the site and conforming to its shape would be more appropriate (see figure 6c).

In some cases it may be possible to give an adequate representation of the site by a series of points connected by straight line segments, where the points are close enough to follow the curves (see figure 6d) but do not form a closed figure. As in representing complex sites, accuracy must be balanced against the amount of work required to record the site.

Note: When the method chosen does not form a closed figure, the phrase "unclosed figure" should be written clearly on the nomination form beside the UTM references, and the references should be placed on the form in sequence from the northeasternmost end of the figure to the other end (A through E in figure 6d).

The common method of enclosing the meandering site in a series of rectangular boxes is no longer recommended. Although the results are similar to those in figure 6c, the method requires that many more corner points be drawn and measured.

Discontinuous Sites

A discontinuous site is composed of two or more separate features. Although the features of the site could be approximated by a single, closed figure (see figure 6e), the sense of the site would be distorted, implying that the area between the individual features is included. A better approach would be to plot a series of unconnected points or figures for each feature (see figure 6f), clearly labeling which points belong to each feature.

Compound Sites

A compound site is a discontinuous site with at least one feature described by multiple points, for example, two landing sites connected by a portage trail. Compound sites may be best represented by describing each feature separately. As shown in figure 6g, feature 1 is represented by points A-B-C; feature 2 by points D-E-F-G-H, feature 3 by points I-J-K-L. Features 1 and 3 are closed figures, but feature 2 is unclosed.

Method I

This involves drawing part of the UTM grid on the map and measuring from the grid lines to the point. It is the basic method, and its logic underlies the other methods. The following equipment is required:

- a flat work surface on which to spread out the map in full, drafting table helpful but not required;
- a straightedge long enough to reach completely across the map, generally about 36" to 48";
- a very sharp pencil; and
- a UTM coordinate counter.

For each point to be measured, follow these steps, which will be easier to understand with map and tools at hand:

1. Draw a line from the top of the map to the bottom, connecting the nearest equal-valued pair of UTM ticks to its west, that is, with the highest easting value west of the point.
2. Draw a line from the left side to the right side of the map, connecting the nearest equal-valued pair of grid ticks to its south, that is, with the highest northing value south of the point. This will intersect the previous line somewhere to the southwest of the point.

   Note: If the point is so close to a map edge that either of these lines cannot be drawn, use Method IV.
3. Remember that the UTM grid lines are generally not parallel to the map edges.
4. Copy the zone number onto the worksheet.
5. Copy onto the worksheet the printed portions of the easting and northing values appropriate to the UTM ticks through which the lines have been drawn. Not all ticks are labeled. It may be necessary to count from a nearby tick. Remember that $^{4}77$ is an abbreviation for 477,000 meters, that easting values increase going east, and that northing values increase going north. Check the distance between UTM ticks with the map scale before counting.
6. Locate the scale on the coordinate counter matching the scale of the map. If no coordinate counter scale matches the map, use Method III.

   Align the counter on the map so that:

   a) the side of the scale that reads from right to left lies along the east-west line, and

   b) the side of the scale that reads from left to right passes through the point being measured (see figure 7).
7. Read the coordinate counter scales, right-to-left for the easting and upward for the northing. Enter the measured values onto the worksheet (see figure 8).
8. Check the readings for plausibility. Are all figures in the correct decimal places: does the easting have six digits and the northing seven? Do points directly east or west of one another have nearly equal northings? Do points directly north and south of one another have nearly equal eastings? Can you account for the differences?
9. Check the figures for accuracy by remeasuring at least once.
10. Be sure that the correct order is observed: zone, easting, northing.

Method II

This method is based on the draftsman's technique of projecting a point to the edges of the map, along lines parallel to the UTM grid. It requires more care in setting up than Method I, but is faster where there are several points to be measured on the same map. The following equipment is required:

- a drafting table or drafting board large enough to conveniently hold any common USGS quadrangle map, 30″ × 36″ or 36″ × 42″ recommended,
- a T-square or parallel rule long enough to reach across any common USGS quadrangle map, 36″ to 48″ recommended,
- a very sharp pencil or pen,
- a UTM coordinate counter, and
- a draftsman's triangle, 30° × 60°, 12″ minimum, 15″ recommended.

For each point to be measured, follow these steps:

1. Align the map to the T-square or parallel rule, with any two UTM ticks of equal value along the eastern and western map margins.

   Note: This may not make the map's own neat lines (edges of printing) square with the T-square. Alignment with the neat lines will inevitably create errors. This step is the key to accuracy in all further steps, so check the alignment carefully. Folds or curls in the map will make alignment difficult. It is advisable to relax a folded or curled map between flat, weighted surfaces for a day or so before measuring coordinates.

   Fasten down the map corners with masking or draftsman's tape, so that the map lies flat and smooth. The best way to tape down a map is shown in figure 9. Re-check alignment to be sure the map has not moved.

   To check alignment, draw a very fine line through a UTM tick on one side of the map, using the T-square. If the line passes exactly through the tick of equal value on the opposite side of the map, then the map is properly aligned.

2. Draw a horizontal line along the T-square through the point to be measured, extending through the left or right edge of the map, whichever is closer.

3. Using the T-square and triangle, draw a vertical line through the point, extending through the top or bottom edge of the map, whichever is closer.

4. Remember to label each point and both of its projections (the points at which the lines in steps 2 and 3 cross the map edges).

5. For each point to be measured, copy the zone number from the map onto the worksheet.

6. Copy onto the worksheet the printed portion of the easting value of the nearest blue UTM tick mark to the left, west of, the point's projection on the top or bottom map edge. If the value of the tick is not printed on the map, it can easily be found by counting from nearby ticks. Establish the distance between ticks by checking against the map scale.

7. Using the proper corner of the coordinate counter, align the ends of the appropriate measuring scale with the tick marks to the left and right of the point's projection on the top or bottom map edge. Be sure that the values on the measuring scale increase from left to right. Read the distance from the tick on the left to the point's projection, and enter this figure in the heavily underlined portion of the easting space on the worksheet.

8. Copy onto the worksheet the printed portion of the northing value of the blue UTM tick nearest below, south of, the point's projection on the left or right map edge. (See step 6 for values not printed on the map.)

9. Using the same corner of the counter, place the zero point on the tick below the point's projection. Be sure that the values on the measuring scale increase going upward, north (see figure 10). Read the distance from the lower (southern) tick to the point's projection, and enter this figure in the heavily underlined portion of the northing space on the worksheet.

10. Check the measurements and copied values of eastings and northings by carefully remeasuring at least once.

Method III

The third method for deriving UTM grid references should be used when maps have UTM grid ticks, but are drawn to scales that do not match any of the four scales on the UTM coordinate counter. There are three versions of Method III, the first somewhat less reliable than the second, but requiring fewer tools, the third using proportional dividers.

The first two versions require a straightedge and a measuring scale that divides its units of measure into 10ths. Generally, the most satisfactory type of measuring scale will be a triangular engineer's scale, such as the Dietzgen 21636. A metric engineer's scale will also work.

Note: Method III is geometrically similar to the method commonly used for deriving latitude and longitude values in the Geographic Coordinate System.

Version 1

This version is useful when no drafting table and T-square are available, and when only one point on a map must be measured. When a drafting table and T-square are available, or when several points must be measured on the same map, version 2 should be used. For each point to be measured, follow these steps:

1. Locate the point on the map.
2. Draw four UTM grid lines to form a complete grid square surrounding the point. Whether or not a T-square is used, the straightness of the lines drawn is crucial to this method.
3. Choose a measuring scale, minimum 10 units long with 10 subdivisions per unit, on which 10 units is *longer* than the distance between UTM grid ticks.
4. Align the measuring scale so that:
   a) the zero point is along the western grid line,
   b) the 10-unit point is on the eastern grid line, and
   c) the edge of the scale passes through the point to be measured.

   Adjust the alignment carefully—accuracy of measurement depends on precise alignment (see figure 11).
5. Read the scale, and write the distance between zero and the point in units and 10ths on a piece of scrap paper.
6. Repeat steps 4 and 5, but with the zero point on the northern grid line and the 10-unit point on the southern grid line.
7. Determine the measuring scale units.

If the distance between ticks is	then each unit represents	and each 10th represents
1,000 m	100 m	10 m
5,000 m	500 m	50 m
10,000 m	1,000 m	100 m

   This will be true for both eastings and northings.
8. Write the easting and northing values on a worksheet, placing the printed and measured digits in their proper places.

Version 2

This version requires a drafting table, T-square, and triangle, in addition to the measuring scale mentioned in version 1. Although the set-up of the map on the drafting board is critical and it takes longer than version 1, this version makes measurement of several points on the same map quicker and more accurately. Follow these steps:

1. Align the UTM grid ticks on the map with the T-square, as in Method II. Tape the map down securely (see figure 9), and check the alignment, adjusting it if necessary. In most cases the T-square will not be parallel to the map edges.
2. Draw lines connecting grid ticks of equal value to construct a grid square around each point to be measured.
3. Choose any measuring scale on which 10 units, each divided into 10ths, span a distance greater than the distance between ticks.
4. For each grid square, align the zero point of the scale with the western grid line, and the 10-unit point of the scale with the eastern grid line. Mark the points on these two lines, and connect them with a diagonal straight line. **Note that this need not be done within, or even near, the grid square itself, but may be done wherever convenient between the lines.**
5. Similarly, draw a diagonal line 10 units long between the north and south grid lines, wherever convenient.
6. Using the T-square and triangle, project the point to the diagonal line just drawn between the east and west grid lines. This is equivalent to projecting the point to the border of the map, as in Method II. Label the point and its projection on the diagonal line.
7. Using the T-square, project the point to the diagonal line just drawn between the north and south grid lines. Label the projection on the diagonal line.
8. Use the measuring scale to measure the distance from the western grid line, along the diagonal line from steps 4 and 6, to the point's projection on the diagonal line. Note the measurement on scrap paper.
9. Use the measuring scale to measure the distance from the southern grid line along the diagonal line from steps 5 and 7, to the point's projection on the line. Note this measurement on scrap paper.
10. Determine the measuring scale units, as in step 7 of version 1.
11. Write the easting and northing values on a worksheet, placing the printed and measured digits in their proper places.

Method IV

When a site is so far south or west within a quadrangle that there are no grid ticks to the south or west of it, and therefore, no grid lines to measure from, Method IV is a simple way to determine eastings and northings.

In figure 12, the point to be measured is so close to the southwest corner of the map sheet that no UTM ticks are printed to the south or west of it. Draw lines connecting the nearest pair of UTM ticks to the north and east of the site. Using the coordinate counter, measure distances from these lines to the site. This involves turning the coordinate counter 180° from its normal position (see figure 12).

In the figure, the site is about 680 meters west of the nearest grid line to the east, and about 850 meters south of the nearest grid line to the north. To obtain the easting and northing values, subtract the measured distances from the UTM values associated with the grid lines:

	388,000 mE			3,167,000 mN
	− 680			− 850
Easting =	387,320 mE		Northing =	3,166,150 mN

Comparable methods may be worked out for points near the western and southern neat lines. For some only one subtraction will be needed. Check the logic of each measurement carefully, remembering that easting values always increase to the east and northing values always increase to the north.

One could construct extended grid lines and measure from them without subtraction. However, drawing the extensions frequently introduces mechanical errors, which are reflected in the UTM values. In practice, Method IV seems to give better results, and is recommended.

Note: This method may be used at any map scale, if the correct measuring scale on the coordinate counter is used.

Method V

This method is used to derive the UTM grid reference for a point when the map in which it is found does not carry UTM grid ticks. It is somewhat tricky, and involves looking up the UTM grid references of the corner points along the neat lines where tick marks would have been printed, then continuing the normal gridding process (Method I or II). It should be used with caution because of the many steps that might introduce mechanical errors.

Tables with UTM references for corner points of USGS quadrangles are found in Department of the Army Technical Manual TM 5–241–11, *Universal Transverse Mercator Grid Tables for Latitudes 0°-80°* (Washington, DC: Headquarters, Department of the Army, 1959).

A. Set-up (two examples are given as figures 14-16)

1. Find the zone number of each map corner point.
   a) By reference to other maps showing this information for the same area
   b) By calculation:
      1) Western Hemisphere
         (a) Divide longitude of point by 6.
         (b) Drop the fraction if there is a remainder; that is, round the result downward. 1.65 becomes 1
         (c) Subtract result in (b) from 30 giving the zone number.
      2) Eastern Hemisphere
         (a) Divide longitude of point by 6.
         (b) If there is a remainder, raise result to the nearest whole number; that is, round upward. 1.35 becomes 2
         (c) Add result in (b) to 30 giving the zone number.
2. Note the longitude of the central meridian (CM) for the zone (see figure 13).
3. Note the latitude and longitude of the corner point.
4. Calculate the angular difference between the longitude of the CM and the longitude of the point by subtracting the smaller from the larger. This gives reference figure Δλ (angular difference).

1. Longitude of CM		2.	
	145° 60′ 00″		166° 00′ 00″
Longitude of point.			
Δλ	145° 30′ 00″	Δλ	165° 00′ 00″
	0° 30′ 00″	Δλ	1° 00′ 00″

B. UTM determination for each map corner point

1. Locate the proper table in *Universal Transverse Mercator Grid Tables for Latitudes 0°-80°* (Department of the Army Technical Manual TM 5–241–11), according to the latitude of the point.
2. Locate the proper line in the table by matching Δλ, the angular difference calculated above, with the values given in the left column of the table.
3. Determine whether the corner point is east or west of the CM
   a) Western Hemisphere
      1) east if point's longitude is less than that of the CM
      2) west if point's longitude is greater than that of the CM.
   b) Eastern Hemisphere
      1) east if point's longitude is greater than that of the CM.
      2) west if point's longitude is less than that of the CM.
4. To find the easting of the corner point, look in the column "West of CM" or "East of CM," according to step B 3 above, and write the figure found in the line determined in step B 2. This is the easting, shown in the table to the nearest 10th of a meter.
5. To find the northing of a corner point, continue across the same line, and write the figure found in the "N" (northing) column.
6. Round off easting and northing to the nearest 10, 50, or 100 meters, depending on map scale. In calculation or a series of measurements, the least precise factor determines the precision of the result. Because you will only be able to measure the UTM reference with limited precision, to the nearest 10 meters on a 1:24,000-scale map, there is no advantage in retaining decimal places beyond the limits of your own sight.

C. Drawing the grid

1. After determining the UTM references of the corner points of the map, measure from each corner to where the nearest tick mark would be if it had been printed along the neat line. That is, set the coordinate counter over each corner point, running along each neat line in turn. For example, the counter should be set so that the easting

measurement on the counter is directly upon the corner point, and the zero point is along the neat line.

Be sure to choose the proper side of the measuring scale so that the numbers increase going east and north. Make an accurate mark on the neat line at the zero point of the scale. This is a close approximation of where the nearest UTM grid tick would have been placed if printed.

2. Count along the neat line, using the coordinate counter, measuring, marking, and labeling the values of the points at which ticks would have been printed. On the north and south neat lines find points with easting values, so that a line through them will pass near enough to the site to give an easting reading. In the east and west neat lines, find points with equal northing values, so that a line through them will pass near enough to the site to give a northing reading.
3. There is a shortcut for counting off large distances, such as might be encountered for a site near the middle of a quadrangle. Carefully cut the map scale from a spare quadrangle map printed to the same scale as the map containing the point. Or, using the map scale, mark off a long distance such as 10,000 meters on the edge of a piece of paper or index card. Dividers may also be used. Use this to set off large distances along the neat line. This is a more accurate method than repeated small measurements with the coordinate counter.
4. Using a pair of the newly drawn ticks with equal values, align the map and tape it down.
5. Check and adjust the alignment, which is crucial in this method.
6. Using equal-valued pairs of the new tick marks, draw grid lines as in Method I around each point to be measured.
7. Continue from step 3 of Method I.

Rounding and the Degree of Precision

In general, it is best to measure site locations to the finest degree of precision possible with a given map and measuring tool. It is inadvisable to round measurements to a coarser degree of precision because this destroys a certain amount of information.

On the ground, one can measure distances with as much precision as the eye can see. Measuring ground distances from their representations on maps, however, imposes limits on precision. Map scale is a factor, compressing ground distances into map lengths difficult to distinguish by eye: one meter on the ground equals 1/24 millimeter on a 1:24,000-scale map. There are also limits in the precision of printing, so that even if one could see the map equivalent of an on-the-ground meter, the fine details of lines and points may not be printed accurately enough on a map to give an exact measurement.

For these reasons and others, including an increasing tendency for human error at high levels of precision, the table shown in the discussion of the coordinate counter also suggests the practical limits of precision for interpretation of USGS quadrangle maps. It will usually be unproductive, and may be misleading, to attempt measurements more precise than those indicated by the table. These practical limits have the effect of forcing the user to round measurements off to 10-, 25-, 50-, or 100-meter precisions, depending on the quadrangle scale.

When dealing with measurements from source maps at a variety of scales, take into account the degree of precision of each source and its effect on the use of UTM information. For example, consider a hypothetical site as its UTM reference might be measured at several map scales:

If the site were plotted on a new map at a very distant scale, say 1:250,000, the differences between these measurements would not be visible. At a closer scale, the choice of source measurement would influence placement on the map. At 1:24,000 in an urban area, the point as measured from a 1:250,000 map might be a block or more out of place. At closer scales, the displacement from true position due to rounding would be even more noticeable. Automated measurement and plotting will not resolve the discrepancies. Automation may eliminate mistakes, but it cannot improve on the inherent imprecision of the source map, nor can it enhance the degree of precision of recorded information.

For maximum accuracy, be sure that source map measurements are at least as precise as maps to be plotted from the data. When multiple points derived from sources of different precision are plotted together, decide whether accurate placement is critical enough to warrant annotating the map to show the precision of each point. One method of annotation is to use a different map symbol for each degree of precision. For example, represent measurement B as 10-meter precision by a cross (+), D at 50-meter precision by a star (*), E at 100-meter precision by a point(.).

If a decision is made that all points in a survey file will be recorded at the precision of the least precise measurement in the file, the resulting UTM references may still give problems in interpretation. It might be decided, for example, that all sites in a survey will have UTM references measured to the nearest 100 meters, since some sites are shown on 1:250,000 scale quadrangles, on which 100 meters is the smallest distance readily resolved by eye. When plotting maps at

Measurement	Map Scale	UTM Reference Z	E	N	Measured to the Nearest	
A	.....	17	632842	4273518	1 meter	(on-the-ground measurement)
B	1:24,000	17	632830	4273520	10 meters	
C	1:62,500	17	632850	4273525	25 meters	
D	1:125,000	17	632850	4273500	50 meters	
E	1:250,000	17	632800	4273500	100 meters	

the 1:250,000 scale, this will cause no problem: one would not be able to see the difference between on-the-ground measurements to the nearest meter and the same references rounded to the nearest 100 meters. If, however, a map of points measured at 100-meter precision were plotted at 1:24,000, all the points scattered through a group of 100-meter squares would be plotted only at the nearest corner points of the squares. The dislocation would be quite evident at 1:24,000. If the points represented corner points of an historic district, the mismatch of precision between measurements and plotting would seriously distort the shape of the plotted area, as in figure 18.

Results of UTM reference measurements made by a digitizer may also be misleading because of precision problems (see Digitizing). Most digitizers measure to the nearest 100th of an inch; some measure at even greater precision. These precisions may be translated by using the scale factor into the on-the-ground distances they represent. If the digitizer measures with greater precision than that with which the source map is printed, then the reference values reported at the digitizer's precision may be inaccurate beyond the limits of precision of the map. In other words, the limit of precision of a measurement is set by the map or measuring tool, whichever has the least (coarsest) precision.

Digitizing

Machinery and computer programs exist that can be used to automate measurement of UTM references. This method, known as digitizing, is most commonly applied to scientific and engineering problems where thousands of points must be measured and recorded. The source documents may be maps, engineering drawings, seismographic traces, etc. The purpose of the measurements may vary, as may the units of measure and the coordinate systems. In common with all applications, however, is a procedure briefly outlined below.

1. Operator secures a source document on the digitizer's surface, which resembles a drafting board. Depending on the system, the document may have to be precisely aligned with a pre-established set of axes.
2. A pointer is placed over two or three points on the document whose coordinates are already known. The coordinate values of each known point are typed into the machinery. This sets the system to measure in the same units, and with the same origin and axes, as the source document.
3. The operator moves the pointer to any other point(s) on the document and the coordinates are automatically measured and calculated, and then displayed by a printer or other device. They may also be recorded for further computer processing.
4. Depending on the equipment being used and on how it has been programmed (digitizing systems contain small computers or are connected with larger ones), measured coordinates may be converted mathematically to other measurement schemes, or areas contained within closed figures may be computed.

Note: Even if a USGS map lacks UTM ticks, the UTM references of its corner points are generally known, and may be used as the set-up points for a digitizer. Then any other points on the same map may be measured directly and reliably, avoiding the difficult and error-prone Method V. Ideally, the operator could enter the corner points in any coordinate system and the equipment would convert them to UTM to set up the digitizer if necessary. Values for measured points would be output in any coordinate system. These conversions depend on the capacity of the computer associated with the digitizer, however, and may not be available with all equipment.

Digitizing systems have become extremely sophisticated and expensive; some have capabilities for automated storage and retrieval of data, and for plotting. Others are part of much larger computer graphics systems, whose capabilities far exceed the need for simple measurement. Because of variety of available systems and the rapid growth of technology, any detailed recommendations given here would quickly become outdated. In principle, however, for situations where manual measurement is a burden, managers should investigate large engineering, planning, and utility offices to see what systems exist and if arrangements could be made to use them.

Computerizing UTM Data

The most compelling reason for gathering reliable location data about historic and archeological sites is not to permit retrieval of a particular site's location from a file, but rather to assure that there is adequate, usable information to influence the processes of land-use planning. At all levels, from the individual development project to the regional master plan, the environmental impact of proposed plans cannot be studied without a thorough inventory of cultural resources, including data on their locations.

When dealing with large areas, or areas containing hundreds of sites, the management of inventory data is cumbersome. The amount of labor needed to locate, extract, and synthesize information from the survey files is overwhelming. Computerized data expedites the flow of information to planners in a form most likely to receive their consideration. For example, with properly automated location data, it is possible to search a state's inventory files for the sites within 100 meters of a proposed path. Verbal information about sites of concern can be printed in the order and format best suited to the planners' needs, and maps or map overlays can be plotted automatically to show spatial relationships between the highway, the site, and other environmental features. As planning proceeds, the impact of alternate proposals may be similarly studied.

Further possibilities occur in other fields. Studies have been undertaken to test the value of environmental information in predicting the locations of archeological sites. The statistical correlation of environmental data with accurate location and cultural data for known sites is the key to such studies. Because of the complexity of the methods used, computer processing is necessary.

The generalized data format that follows will record enough data to fix the location of any point unambiguously. It provides sufficient information for performing geographic searches, and for formatting data to drive an automated plotter. The format is based on the full, numerical form of UTM notation with significant digits to the nearest meter. It accounts for multipoint, complex, and discontinuous sites, and those whose recorded boundary points do not form closed figures. The abbreviated forms of notation (see Variant Forms) are not recommended for automation because they require translation before mathematical computations can be performed, and may be ambiguous over large areas that cross zone boundaries. The recommended format is:

Pen	**Identification**	**UTM Reference**	**(Fields)**
	Featurepoint	Zone Easting Northing	(Subfields)

The format is used once for each point recorded.

The zone, easting, and northing subfields are the standard UTM reference information for a single point. Should a site contain multiple, separate features, such as a series of mileposts, the feature subfield may be used to give a unique label to each feature. All points describing the same feature would contain the same value in the feature subfield. If there are multiple points within the same feature, each is labeled in order, using the point subfield. The convention used here is to begin labeling with the northeasternmost point, and to proceed clockwise. For the feature and point subfields letters or numbers may be used but numbers are recommended. The Pen field indicates whether an automatic plotter's pen should be raised or left on the paper before moving from one point to the next. By this means distinctions may be made between site features. Any binary (two-value) code may be used.

Using this format, the UTM data for the compound site in figure 6g would be coded as three features: the first a closed figure with three points, the second an unclosed figure with five points, and the third a closed figure with four points.

The letter D stands for pen down, U for pen up. The feature number remains constant for all points in the same feature. The point number is unique for each point within a feature, but the series of point numbers may start anew for each feature. In this example z, e, and n symbolize whatever UTM values are measured for each point.

Not included in this format is an indicator to show whether a site feature forms a closed figure; that is, whether a plotter pen should connect the last point of a feature with the first. This may be done by repeating a figure's first point immediately after the last with a pen code indicating pen down on the next-to-

last point. It may also be shown by a closure field for each feature, instructing the plotter pen to return to the beginning point of a feature before moving to the next feature. The choice of these or other methods should be made by a programmer.

Depending on local needs, the format shown may be varied and editorial rules may be imposed. As long as variations are used consistently within the same file and can be translated back into the general format, compatibility between inventories can be maintained. For example, the format calls for three digits to record feature numbers; in many cases it may be determined that only two digits are necessary. If data recorded with two digits were to be merged with data having three digits, a leading zero could be added by the computer in a simple pre-processing step. Similarly, if one inventory used I and O to indicate pen up and pen down, while another used U and D, one set of codes could easily be converted to the other for common use. Letters may be used instead of numbers to label features or points. If programming is more convenient with the pen field following the UTM field, this rearrangement will not defeat the format, since the data could easily be reformatted as necessary to put the fields in another order.

In searching files of UTM data, the UTM reference field would be examined by the computer to determine whether a point lies within the area in which the inquirer is interested. If a map overlay were to be plotted, the UTM reference would also supply the X-Y coordinate data needed to position the point properly in relation to the map and to other plotted points. The pen, feature, and point subfields would be used in plotting to distinguish between features and to keep points in order.

When maps or overlays are plotted, scale will influence clarity. If the plot is at a distant scale (shows a large area), the symbols designating nearby points may overlap. To prevent this, some users may wish to record a single, central point for each site regardless of the site's extent, in addition to the several individual points describing the site in greater detail. For each plotting problem it must then be decided whether the single-point or multipoint representation would be clearer. The central point may be tagged with X or another symbol in the pen field to distinguish it from boundary points, or boundary points may be relegated to a separate data category. In either case, if the central point is used, it must be present in the record for each site, even if the complete list of UTM points for a site consists of only a single point. In files where most sites are represented by single points, this will result in much redundant data.

Extended UTM Grids

Local variants on the UTM system may include, where the area of interest spans a zone boundary, extension of the grid from one zone into an adjacent zone. All measurements of points in the second zone are made in terms of the original zone's grid. With respect to the proper UTM grid of the second zone, the extended grid becomes distorted, and this effect increases with the distance from the original zone. Extension of grids beyond zone boundaries is not, therefore, recommended where UTM information may be used with information from beyond the original zone. This would happen in multistate situations, where large-scale planning may span zone boundaries. In figure 19, state A measures its zone 17 sites on a grid extended westward from zone 18, while states B and C measure their zone 17 sites on the grid for zone 17 proper. The boundary between A and B is a river along which a major flood-control project is planned. Inventory records of zone 17 sites in B and C will have UTM measurements incompatible with those measured by A on the extended grid, and therefore inventory files for B and C cannot be searched or plotted in common with A unless a mathematical conversion process is introduced. For example, the bridge marked in the diagram would have quite different UTM references as measured by states A and B. Someone trying to place the site on a map would have to know from which state the reference came and which state's grid was being used to draw the map. One state's UTM references would not be compatible with the other state's grid.

Variant Forms of UTM Notation

There are several variants of the UTM notational form, useful for specialized situations. All are derived from the full, numerical (general) form described in this text, and all can be translated, to a limited degree, back into the general form. The variant forms are not recommended for automated searching of UTM references or automated map plotting because those functions require numerical notation and are adversely affected by rounding. Variants are also not recommended when:

1. Data may be used in conjunction with UTM data in the general form;
2. Inventories cross zone boundaries;
3. Inventories derive location data from overlapping quadrangles at different map scales, or from non-USGS map sources; or
4. Inventories contain sites close together.

Digitized measurements cannot be made directly in variant forms.

The variant forms make use of the anterior digits, the small, raised digits at the left end (most significant digits) of grid values printed next to tick marks. Anterior digits represent hundreds of thousands of meters. In the UTM reference 17 ^{6}32840 ^{42}73525, the ^{6} and ^{42} are anterior digits, representing 600,000 and 4,200,000 meters, respectively.

The simplest class of variant notation is based on rounding data to the 10-, 100-, 1,000-, or 10,000-meter degrees of precision. For example:

17 632842 4273518 (general form, to the nearest meter)

may be reduced to:

17 6328 42735 (100-meter precision)

by dropping the rightmost or least significant two digits of the easting and northing. This may cause problems in applying UTM data, as discussed in Rounding and the Degree of Precision.

Another variant prefixes the easting and northing with the quadrangle name, dropping the zone number and anterior digits. While this form somewhat simplifies locating a site on a particular map, it produces ambiguities because quadrangles at different scales may have identical names. It is also a difficult notation to automate if UTM data is to be used for the purpose listed above. It is useful for small, personal files and for local surveys. For example, the general form of UTM reference for the northwest corner of the Executive Office Building, Washington, DC located in the Washington West Quadrangle, is: 18 323120 4307260. This reduces to Washington West 23120 07260, according to this method.

References in this form are difficult to plot on maps other than the USGS quadrangles on which they are measured. The quadrangle name, substituting for anterior digits, gives no clue to placement on, say, a state highway map or a broader-scale USGS quadrangle.

A variant form based on military usage is popular in Europe and Canada, but has the disadvantage of requiring reference tables for conversion to and from the general form. Except in areas limited to a single 100-km square on the UTM grid, it cannot readily be used for automated searching or plotting. Each UTM zone is divided into strips running east and west, usually 8 degrees of latitude wide. The strips are identified by a single alphabetic digit, according to the chart in figure 20. Within each strip in a zone, the area is divided into 100-km squares, each identified by a two-digit alphabetic code. The code for a square is derived from the zone number and the anterior digits of the eastings and northings within the square, according to the following tables provided by Peter Stott.

Determination of 100-km Square Designations for the UTM Kilometer Grid System

The designation for each 100-km square is a two-letter combination determined from the zone number and the small figures immediately preceding the large grid reference figures in the map margins. Using the tables below, it will be seen that the easting value of 500 km, that is, small figure 5 in the top margin, in zone 18 will become W. A northing value of 4500 km in the same zone will become A.

Like the six-digit figure itself, the easting value must always precede the northing value; thus the 100-km square for the Delaware Aqueduct is designated by the two-letter combination WA.

Using this form, the two-letter code substitutes for the anterior digits, and the easting and northing values are run together. The complete UTM reference for Executive Office Building would be:

18S UU 2312007260

where 18S gives the zone number and strip letter, necessary because the 100-km square designations repeat in each strip (see figure 20). It is customary to abbreviate references even further in this form by rounding eastings and northings, so that the six-digit form, 18S UU 231072, represents three digits each for easting and northing measurements, or 100-meter precision.

While these variants offer certain advantages for small-scale recording projects, the full numerical form of UTM reference is recommended for general use. It requires only a map with tick marks, a straightedge, a sharp pencil, and a coordinate counter, and uses no external reference tables. Because the reference in general form must be measured before conversion to a variant form, it should be no more difficult for the user to record. References in general form may be plotted by hand or computer on any map with UTM ticks, since the reference is a complete measurement from an original point along established axes. It is suggested that the quadrangle name and scale be recorded, but separately from the UTM reference, which is independent of map and scale.

Table A: Easting Values

Hundreds of km	Zones: 7, 10, 13, 16, 19, 22. . .	Zones: 8, 11, 14, 17, 20. . .	Zones: 9, 12, 15, 18, 21. . .
1	A	J	S
2	B	K	T
3	C	L	U
4	D	M	V
5	E	N	W
6	F	P	X
7	G	Q	Y
8	H	R	Z

Table B: Northing Values

Even numbered zones	Hundreds of km	Odd numbered zones
L	35	F
M	36	G
N	37	H
P	38	J
Q	39	K
R	40	L
S	41	M
T	42	N
U	43	P
V	44	Q
A	45	R
B	46	S
C	47	T
D	48	U
E	49	V
F	50	A
G	51	B
H	52	C
J	53	D
K	54	E
L	55	F
M	56	G
N	57	H
P	58	J
Q	59	K
R	60	L

Other USGS Map Series

In areas lacking 7.5-minute topographical maps with UTM ticks, and in cases when latitude/longitude determinations are inconvenient, two other series of USGS map products may be helpful in determining UTM references. One, an orthophotoquad, is defined by USGS as a monocolor orthographic photograph or photomosaic in quadrangle format with minimal cartographic enhancement. The other, an orthophotomap (topographic) shows photographic imagery with topographic map detail.

Orthophotoquads have the appearance of high-altitude photographs at the same scale (1:24,000) as topographic quadrangle maps in the 7.5-minute series. Published orthophotoquads are printed in black and white, with the UTM grid superimposed. Diazo prints of advance (pre- publication) copies are available for orthophotoquads in certain stages of preparation. Advance copies have ticks for UTM, latitude and longitude, and state plane coordinate systems along the edges. Because all ticks on advance copies are printed in black, use care in choosing the correct ticks for measurement.

Very few names or symbols of topographic features are shown on published orthophotoquads, none on advance copies. The photographic rendering of ground features on orthophotoquads may, however, make site location easier than it would be in areas where few natural or man-made landmarks are shown in topographic maps.

To find out what areas have orthophotoquad coverage, request a free copy of the latest edition of the map, "Status of Orthophotoquad Mapping," from one of the two USGS Branch of Distribution offices (see Sources). At present, USGS has no plans for orthophotoquad coverage of Alaska, American Samoa, Guam, Panama Canal Zone, Puerto Rico, or the Virgin Islands. Quarterly updates for each state, called advance material indexes, are available from the four USGS regional mapping centers, (see Sources).[1] Advance copies of orthophotoquads are available only at these centers. Orthophotoquads and new or revised topographic maps are also reported when they are published in *New Publications of the Geological Survey*, published monthly and available free from the Branch of Distribution office in Arlington, VA, (see Sources).

An orthophotomap can be thought of as a photographic image covering a standard 7.5-minute quadrangle area, enhanced with drawn-in and labeled map features like those found in the topographic map series. Unlike the orthophotoquads, the orthophotomaps are printed with artificially constructed color representing the ground character, often with surprisingly beautiful results. Orthophotomaps are printed with all of the standard ticks; UTM ticks are blue. Availability is shown on the order forms and state indexes to topographic maps, where the designation OM following a quadrangle name indicates an orthophotomap. State indexes to topographic maps, order forms, and orthophotomaps are all available from the Branch of Distribution offices. Orthophotomaps have been prepared only for limited areas of the country.

The National Register of Historic Places will accept orthophotoquads in either advance or published form, on which UTM references to a site have been measured, if accompanied by a USGS topographic map, if necessary, at a different scale, on which the site location has also been marked. The topographic map is needed to relate the site to map features by name. Orthophotomaps are acceptable without accompanying topographic maps.

According to USGS, all published maps, including topographic quadrangles, orthophotoquads, and orthophotomaps are available from the Branch of Distribution offices either by mail order or over-the-counter; they are also available in small quantities at certain over-the-counter sales offices. Prices from commercial distributors may be higher. Unpublished (advance) versions of topographic maps and orthophotoquads are priced as shown on the advance material indexes for each state, and are available only at the four mapping centers.

Sources

A. Branch of Distribution, US Geological Survey, 1200 S. Eads Street, Arlington, VA 22202
—for areas east of the Mississippi River, including Minnesota, Puerto Rico, and the Virgin Islands

B. Branch of Distribution, US Geological Survey, Box 25286, Federal Center, Denver, CO 80225
—for areas west of the Mississippi River, including Alaska, Hawaii, Louisiana, Guam, and American Samoa

C. Eastern Mapping Center, US Geological Survey, Reston, VA 22092
—Alabama, Connecticut, Delaware, District of Columbia, Florida, Georgia, Indiana, Kentucky, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Vermont, Virginia, and West Virginia

D. Mid-Continent Mapping Center, US Geological Survey, Box 133, Rolla, MO 65401
—Arkansas, Illinois, Iowa, Kansas, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Nebraska, North Dakota, Oklahoma, South Dakota, and Wisconsin

E. Rocky Mountain Mapping Center, US Geological Survey, Federal Center, Denver, CO 80225
—Alaska, Colorado, Montana, New Mexico, Texas, Utah and Wyoming

F. Western Mapping Center, US Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025
—Arizona, California, Hawaii, Idaho, Nevada, Oregon, and Washington

[1]The reverse side of each advance material index shows what new advance and published topographic quadrangle maps have become available in the most recent quarter. Several advance stages of unpublished topographic maps may be available many months before published versions go on sale. A free nationwide index map, "Topographic Mapping: Status and Progress of Operations, 7.5- and 15-minute series," is available free from Branch of Distribution offices.

Vocabulary

accuracy Freedom from error. A measurement may be accurate but imprecise (correct to the nearest 10 miles). See *precision*.

central meridian The meridian (longitude) line bisecting each UTM zone, located 6° apart beginning at 3° east and west longitude, that is, at 3°, 9°, 15°, . . ., 177°. See *zone*.

coordinate counter Measuring tool for use with the UTM grid system, also known as a romer.

coordinates Two or more measurements, combined to define uniquely the location of a point. Cartesian coordinates are based on linear rather than angular distances from two intersecting axes, with distances from one axis being measured in a direction parallel with the other. Grid systems are usually rectangular cartesian systems with the axes meeting at right angles; the UTM grid is an example. It is possible to have coordinate systems of more than two dimensions. The point where the axes intersect, where the coordinates measure 0 on each axis, is the *origin* of the system. In the UTM system, each zone is assigned a separate grid, with its origin on the equator, 500,000 meters west of the central meridian of the zone. See *false easting*.

easting A segment of the UTM reference of a point, a measure of the metric distance between the point and the central meridian of the UTM zone in which the point is located. See *false easting* and *reference*.

false easting An arbitrary value of 500,000 meters assigned to the central meridian of each UTM zone, as a convenience to avoid negative easting values. This places the origin (zero point) of the UTM grid outside the zone, 500,000 meters west of the intersection of the central meridian and the equator.

false northing An arbitrary value of 10 million meters assigned to the equator when dealing with locations in the Southern Hemisphere.

neat line Printed map edge.

northing A segment of the UTM reference of a point, the metric distance between the point and the equator. See *false northing*.

precision The degree of refinement of a measurement; the minuteness of the units of measure. A measurement may be precise but inaccurate (measured to a fine degree but wrong). See *accuracy*.

quadrangle Literally, a figure with four straight sides. In the United States, a territory corresponding to a USGS atlas sheet; loosely, a USGS map of a quadrangle.

reference A statement indicating the location of a point on the earth's surface. A reference may be based on political geography, known topographic features, or some local or worldwide system of measure. The UTM grid and geographic coordinates (latitude/longitude) are examples of the latter.

romer. See *coordinate counter*.

scale The relationship between distances on the ground and their representation on a map. Scale is commonly expressed as an equivalence 1″ = 1 mile or as a ratio 1:63360. A given distance on the ground will appear larger on a large-scale map than on a small-scale map. The terms large-scale and small-scale are frequently confused, however. For this reason, this publication uses the terms distant scale to indicate a large distance and close scale to indicate a close-up view.

USGS United States Geological Survey.

zone A 6°-wide division of the earth's surface along longitude, pole-to-pole, lines, numbered consecutively running eastward from zone 1 (between 180° and 174° west longitude) to zone 60 (between 174° east longitude and 180°).

Figure 1. *UTM coordinate counter (facsimile not exact size).*

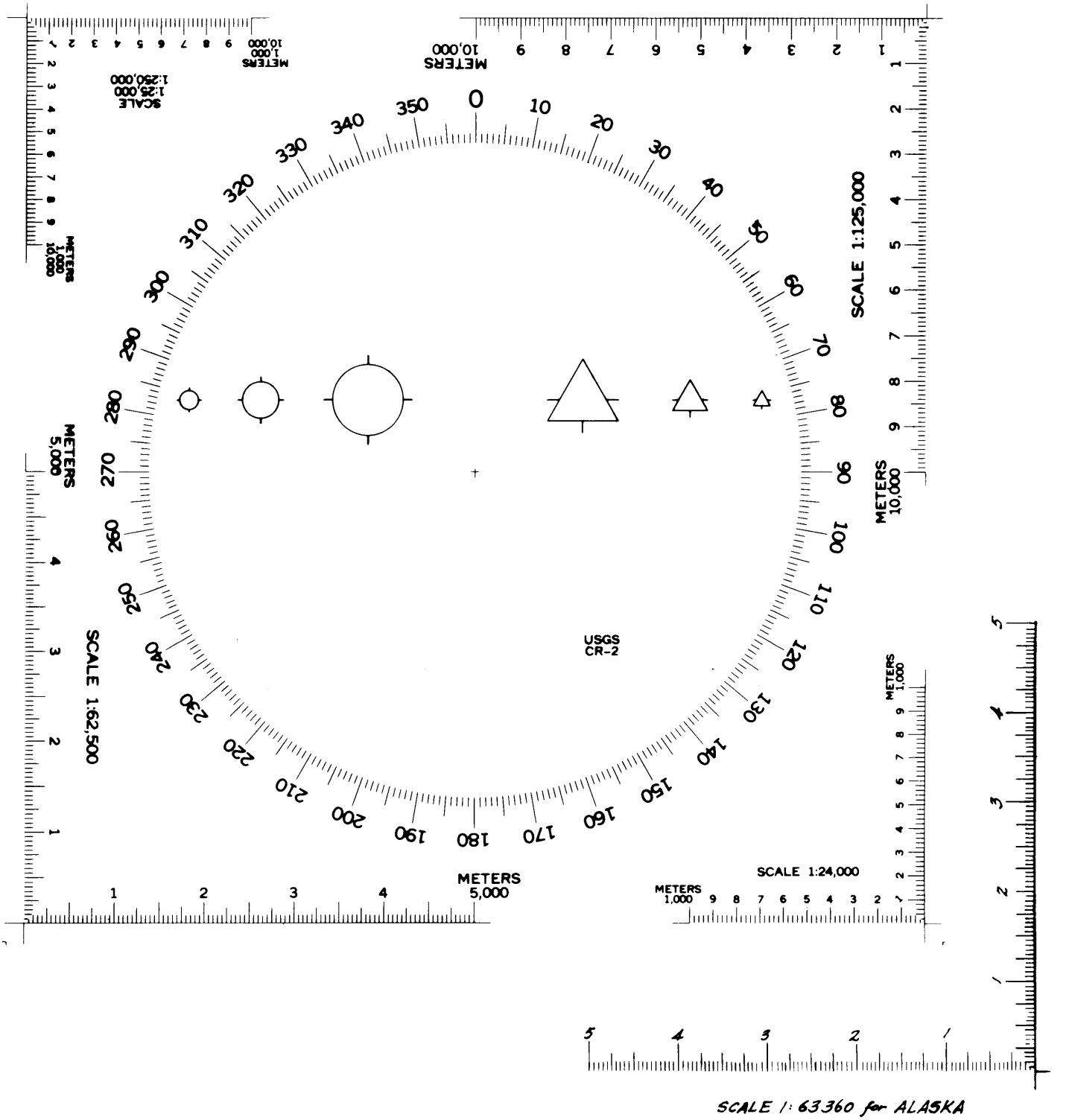


Figure 2. *UTM zones in the contiguous USA.*

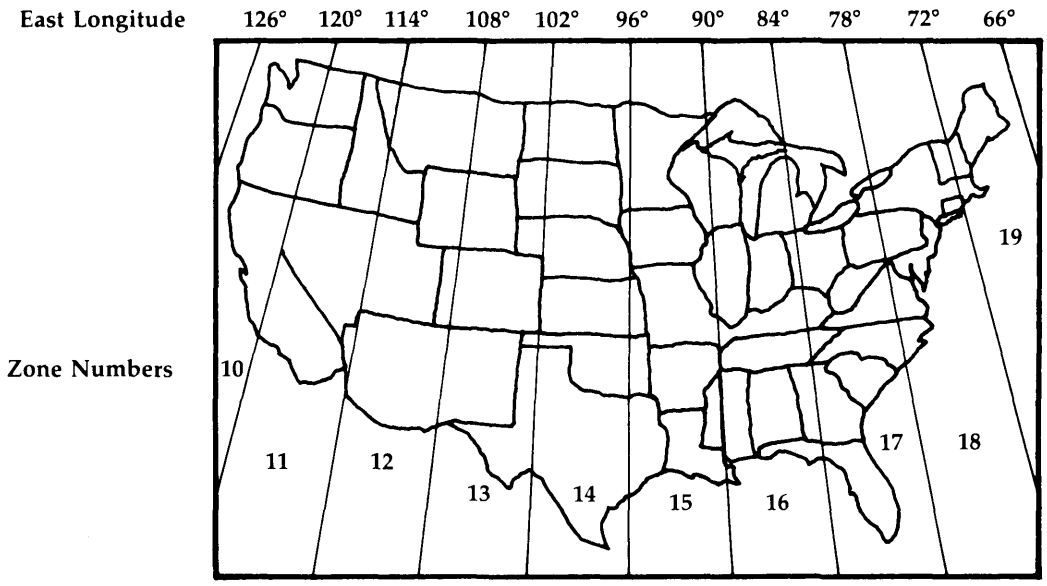


Figure 3. *A UTM zone (shape exaggerated).*

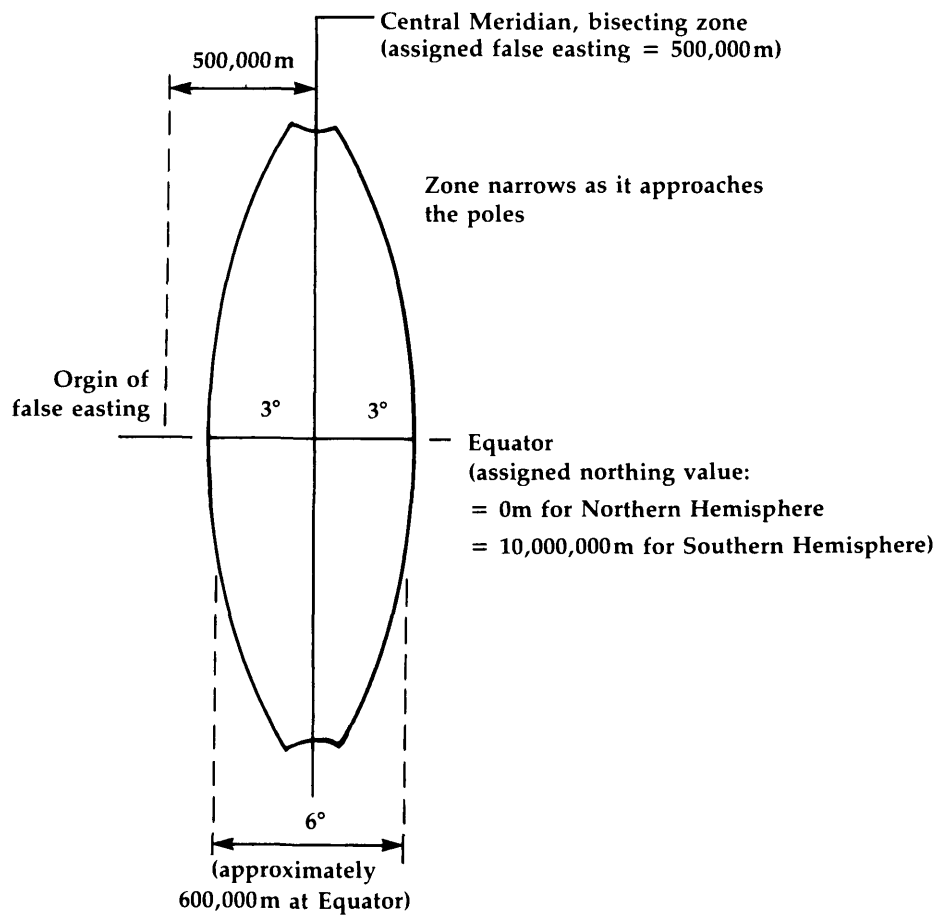


Figure 4. *A UTM worksheet.*

UTM Worksheet

Zone	Easting	Northing	Zone	Easting	Northing	Zone	Easting	Northing
Zone	Easting	Northing	Zone	Easting	Northing	Zone	Easting	Northing
Zone	Easting	Northing	Zone	Easting	Northing	Zone	Easting	Northing

Figure 5. *Labeling points clockwise from northeasternmost point.*

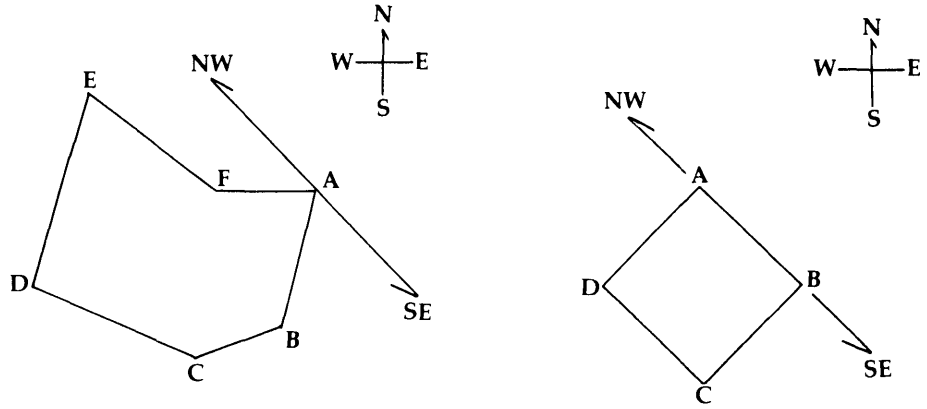
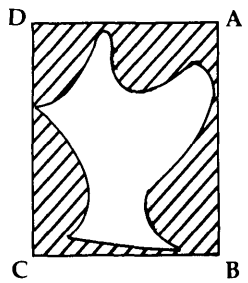
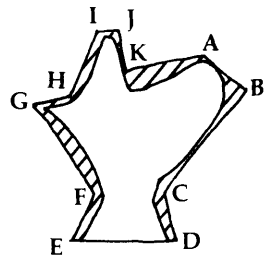


Figure 6. *Problem sites.*

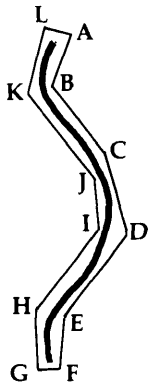
a) Complex site represented by rectangle ABCD: extraneous area is shaded.



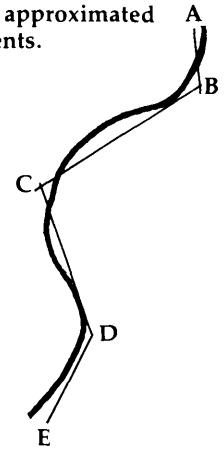
b) Complex site represented by additional points: extraneous area is reduced.



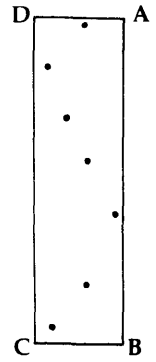
c) Extensive site enclosed by line segments.



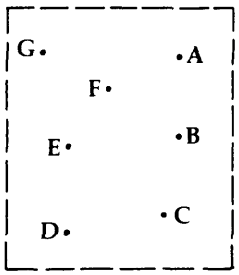
d) Unclosed site approximated by line segments.



e) Discontinuous site treated as single feature, enclosed by rectangle.



f) Discontinuous site treated as series of features, each a single point.



g) Compound site with three features.

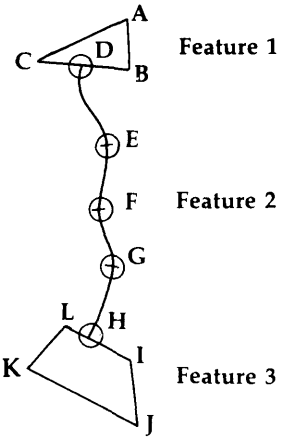


Figure 7. *Coordinate Counter set at the Wisconsin Historical Society (Method I).*

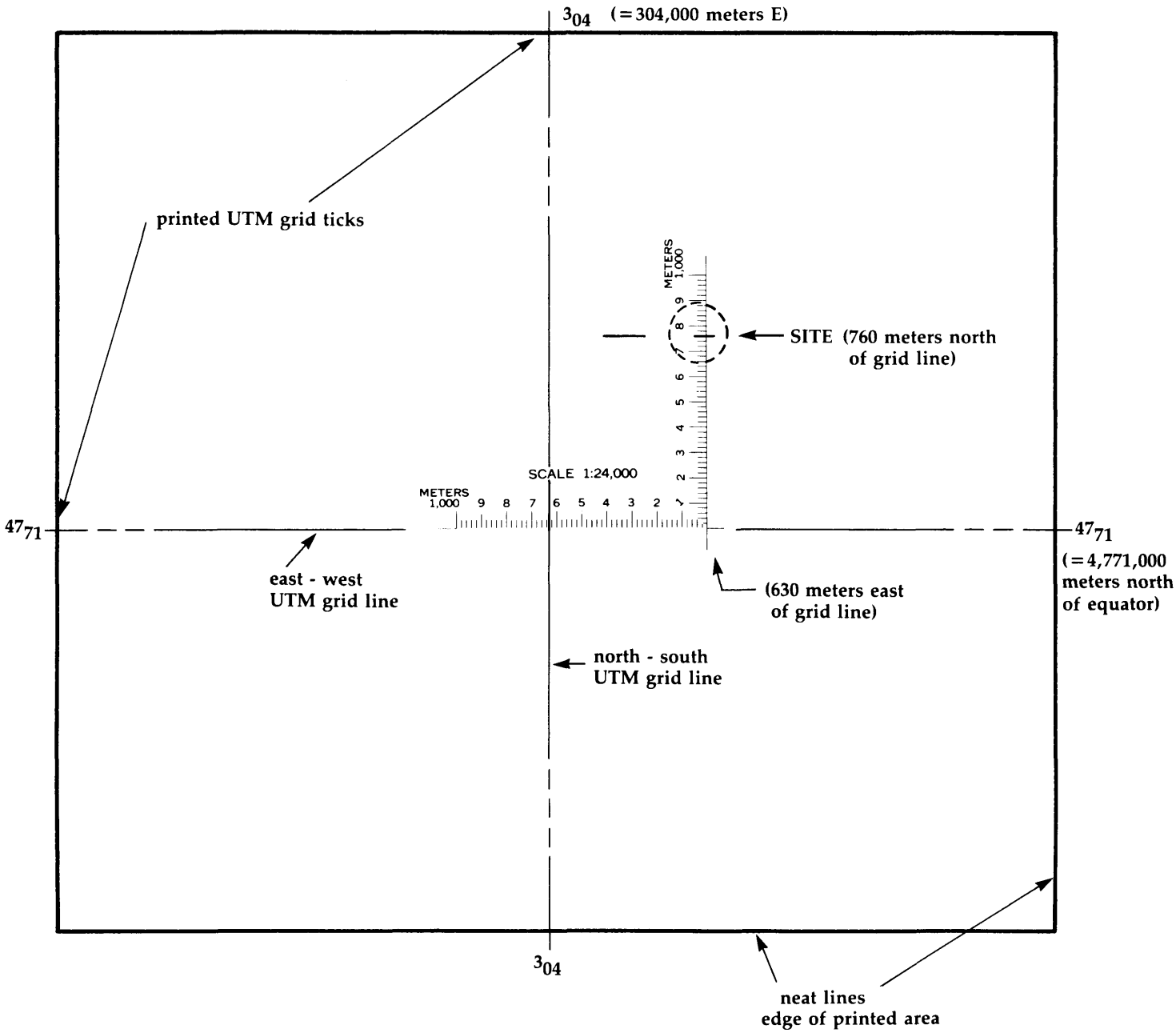
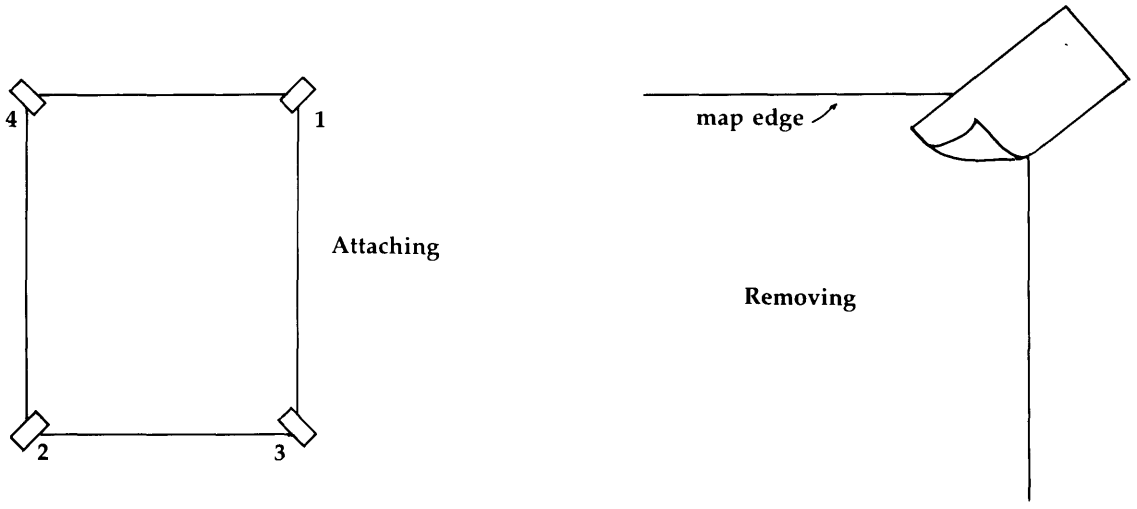


Figure 8. *UTM worksheet with two references from Madison WI.*

Figure 9. *Securing map to drafting table.*



Attaching the map

a) Be sure that the drafting surface is smooth and free of dirt, eraser grit, paper clips, etc.

b) Align the map carefully with the T-square, and check the alignment.

c) Using draftsman's or masking tape, put a short piece of tape at each map corner, along the map's diagonal lines.

d) Flatten the tape in corner 1 onto the drafting surface. Be sure not to let the map move.

e) Hold the map with one hand, and with the other smooth the map away from corner 1 toward corner 2. Check alignment and fasten corner 2.

f) Similarly, smooth the map between corners 3 and 4, and fasten each.

Removing the map

a) Loosen and roll up one corner of a piece of tape. Use a corner that is on the map surface.

b) Pull slowly on the rolled-up corner, pulling the tape outward, over itself.

c) Repeat for each corner.

Figure 10. *Measuring northing of Old Spring Tavern WI. (Method II).*

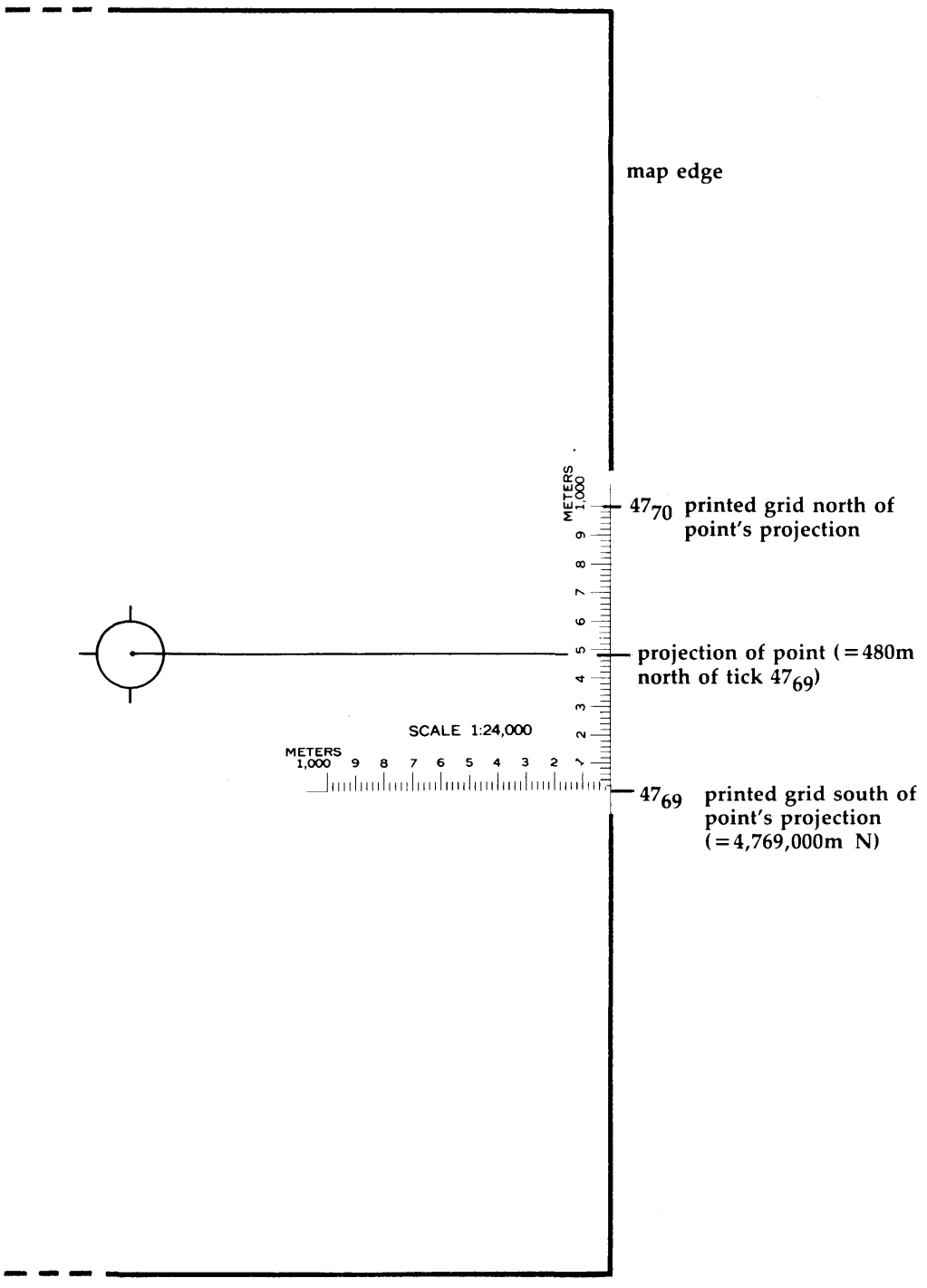


Figure 11. *Dividing the space between two grid lines (Method IIIA).*

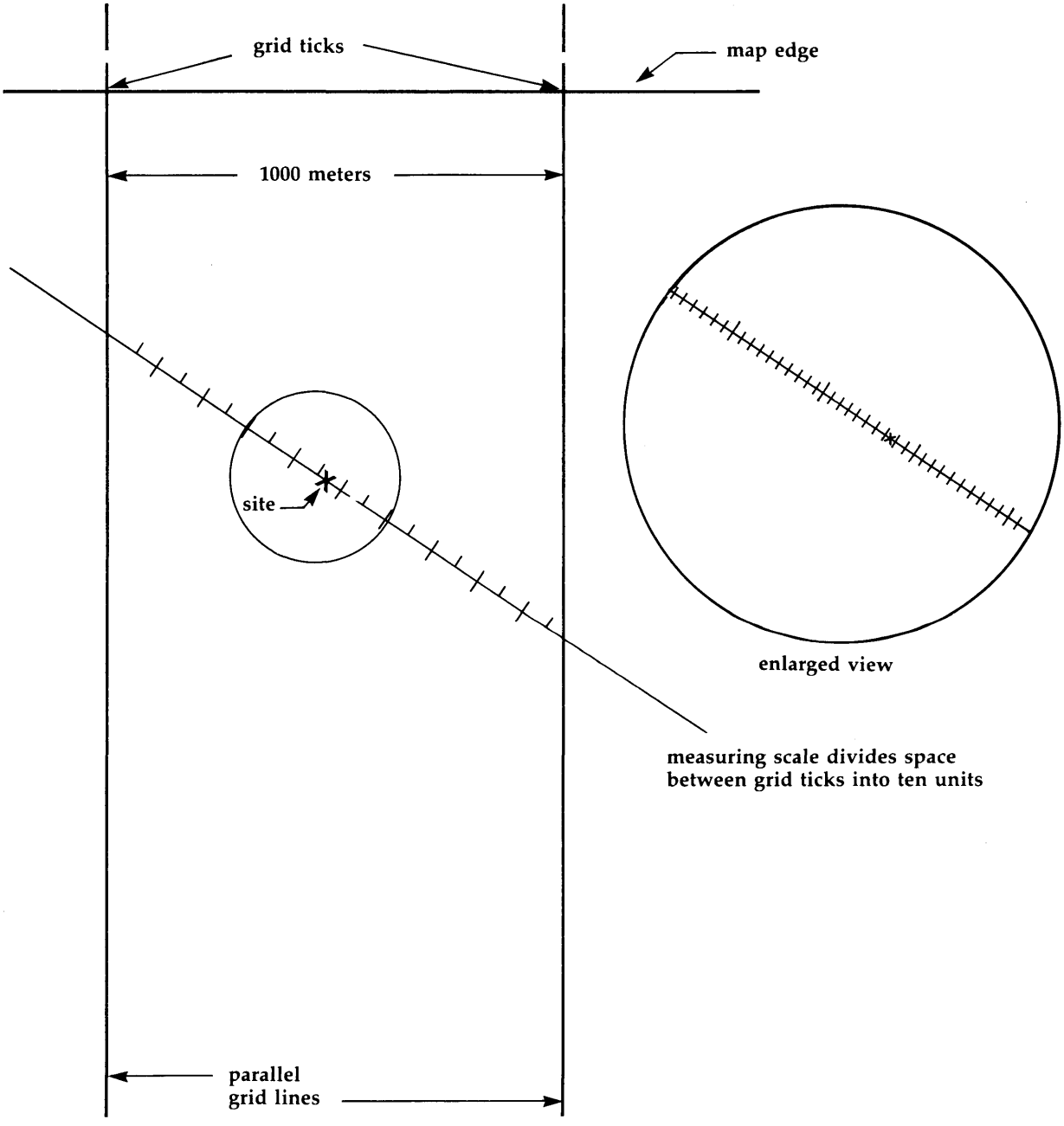
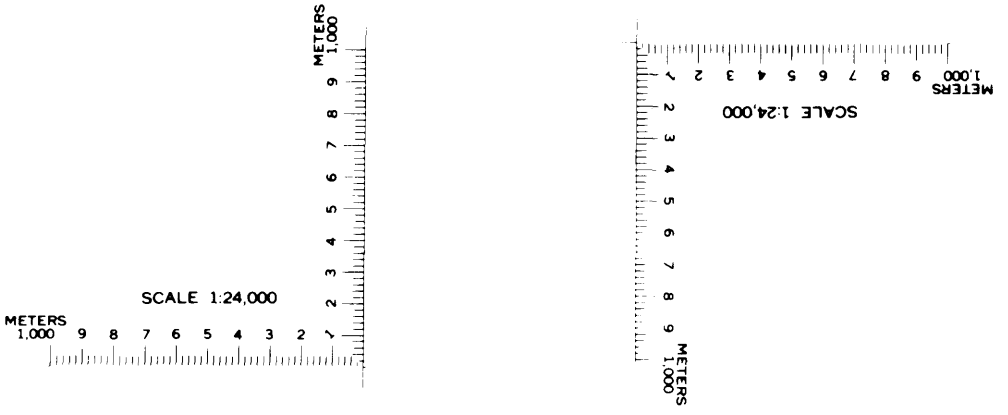


Figure 12. *Measuring UTM reference near SW corner of map.*

Move the coordinate counter from this position to this position.



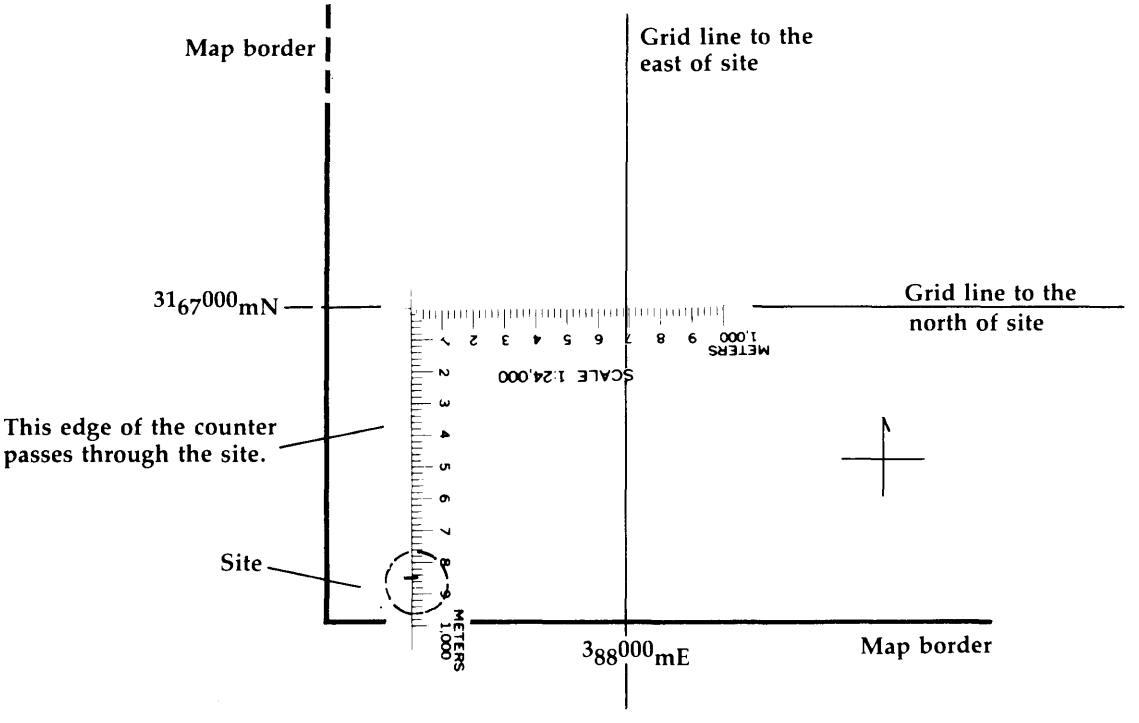


Figure 13. *Central Meridians for UTM zones.*

Zone Number	CM (Longitude)	Zone Boundaries (Longitude)	Zone Number	CM (Longitude)	Zone Boundaries (Longitude)
1	W 177°	W 180°–174°	31	E 3°	E 0°– 6°
2	171°	174°–168°	32	9°	6°– 12°
3	165°	168°–162°	33	15°	12°– 18°
4	159°	162°–156°	34	21°	18°– 24°
5	153°	156°–150°	35	27°	24°– 30°
6	147°	150°–144°	36	33°	30°– 36°
7	141°	144°–138°	37	39°	36°– 42°
8	135°	138°–132°	38	45°	42°– 48°
9	129°	132°–126°	39	51°	48°– 54°
10	123°	126°–120°	40	57°	54°– 60°
11	117°	120°–114°	41	63°	60°– 66°
12	111°	114°–108°	42	69°	66°– 72°
13	105°	108°–102°	43	75°	72°– 78°
14	99°	102°– 96°	44	81°	78°– 84°
15	93°	96°– 90°	45	87°	84°– 90°
16	87°	90°– 84°	46	93°	90°– 96°
17	81°	84°– 78°	47	99°	96°–102°
18	75°	78°– 72°	48	105°	102°–108°
19	69°	72°– 66°	49	111°	108°–114°
20	63°	66°– 60°	50	117°	114°–120°
21	57°	60°– 54°	51	123°	120°–126°
22	51°	54°– 48°	52	129°	126°–132°
23	45°	48°– 42°	53	135°	132°–138°
24	39°	42°– 36°	54	141°	138°–144°
25	33°	36°– 00°	55	147°	144°–150°
26	27°	30°– 24°	56	153°	150°–156°
27	21°	24°– 18°	57	159°	156°–162°
28	15°	18°– 12°	58	165°	162°–168°
29	9°	12°– 6°	59	171°	168°–174°
30	W 3°	W 6°– 0°	60	E 177°	E 174°–180°

Figure 14. *Method V, steps A and B, example 1.*

Example 1

Find the UTM reference for the NE corner of the Jackson, LA, USGS quadrangle (7.5 minute).

Geographic coordinates (read from map corner): Latitude N 30° 52′ 30″
Longitude W 91° 07′ 30″

A. Set-up

1. Zone number: 91° ÷ 6 = 15.2
   rounding downward 15.2 becomes 15
   30 − 15 = 15 (Zone Number).
2. Central meridian for zone 15: 93°
4. Angular difference (Δλ):

CM	93° 00′ 00″	=	92° 59′ 60″
point	91 07 30	=	91 07 30
	Δλ		1 52 30

B. UTM determination

1. Locate the table for Lat. = 30° 52′ 30″ (see figure 15)
2. Locate the line in table for = 1° 52′ 30″ (Δλ)
3. Point is east of CM (91° 07′ 30″ is less than 93°)
4. Easting (from table) = 679,250.9 meters
   rounded to: 679,250 meters (10-meter precision)
5. Northing (from table) = 3,417,070.9 meters
   rounded to: 3,417,070 meters (10-meter precision)

C. Result: UTM reference = Z15 E1679250 N3417070.

Figure 15. *UTM Reference table for corner point in Figure 14*

UTM Grid Coordinates • Clarke 1866 Spheroid

Meters

Latitude 30°30′00″

Δλ	West of CM E	East of CM E	N
0°00′00″	500,000.0	500,000.0	3,374,009.5
07 30	488,004.7	511,995.3	3,374,016.2
15 00	476,009.3	523,990.7	3,374,036.1
22 30	464,013.9	535,986.1	3,374,069.3
30 00	452,018.5	547,981.5	3,374,115.8
37 30	440,022.9	559,977.1	3,374,175.5
45 00	428,027.1	571,972.9	3,374,248.6
52 30	416,031.2	583,968.8	3,374,334.9
1 00 00	404,035.1	595,964.9	3,374.434.6
07 30	392,038.8	607,961.2	3,374,547.5
15 00	380,042.2	619,957.8	3,374,673.7
22 30	368,045.4	631,954.6	3,374,813.2
30 00	356,048.2	643,951.8	3,374,966.0
37 30	344,050.7	655,949.3	3,375,132.1
45 00	332,052.9	667,947.1	3,375,311.5
52 30	320,054.6	679,945.4	3,375,504.2
2 00 00	308,056.0	691,944.0	3,375,710.2
07 30	296,056.9	703,943.1	3,375,929.6
15 00	284,057.3	715,942.7	3,376,162.2
22 30	272,057.2	727.942.8	3,376,408.2
30 00	260,056.6	739,943.4	3,376,667.4
37 30	248,055.4	751,944.6	3,376,940.0
45 00	236,053.7	763,946.3	3,377,225.9
52 30	224,051.3	775,948.7	3,377,525.2
3 00 00	212,048.3	787,951.7	3,377,837.8
07 30	200,044.6	799,955.4	3,378,163.8
15 00	188,040.2	811,959.8	3,378,503.1
22 30	176,035.1	823,964.9	3,378,855.7
30 00	164,029.3	835,970.8	3,379,221.8

Latitude 30°45′00″

Δλ	West of CM E	East of CM E	N
0°00′00″	500,000.0	500,000.0	3,401,713.2
07 30	488,035.5	511,964.5	3,401,719.9
15 00	476,070.9	523,929.1	3,401,739.9
22 30	464,106.3	535,893.7	3,401,773.3
30 00	452,141.6	547,858.4	3,401,820.0
37 30	440,176.8	559,823.2	3,401,880.1
45 00	428,211.9	571,788.1	3,401,953.5
52 30	416,246.8	583,753.2	3,402,040.2
1 00 00	404,281.5	595,718.5	3,402,140.3
07 30	392,316.0	607,684.0	3,402,253.8
15 00	380,350.2	619,649.8	3,402,380.6
22 30	368,384.2	631,615.8	3,402,520.8
30 00	356,417.8	643,582.2	3,402,674.3
37 30	344,451.2	655,548.8	3,402,841.2
45 00	332,484.2	667,515,8	3,403,021.5
52 30	320,516.8	679,483.2	3,403,215.1
2 00 00	308,549.0	691,451.0	3,403,422.1
07 30	296,580.7	703,419.3	3,403,642.5
15 00	284,612.0	715,388.0	3,403,876.3
22 30	272,642.8	727,357.2	3,404,123.4
30 00	260,673.0	739,327.0	3,404,383.9
37 30	248,702.8	751,297.2	3,404,657.8
45 00	236,731.9	763,268.1	3,404,945.1
52 30	224,760.5	775,239.5	3,405,245.8
3 00 00	212,788.4	787,211.6	3,405,559.9
07 30	200,815.6	799,184.4	3,405,887.4
15 00	188,842.2	811,157.8	3,406,228.4
22 30	176,868.1	823,131.9	3,406,582.7
30 00	164,893.2	835,106.8	3,406,950.5

Latitude 30°37′30″

Δλ	West of CM E	East of CM E	N
0°00′00″	500,000.0	500,000.0	3,387,861.2
07 30	488,020.1	511,980.0	3,387,867.9
15 00	476,040.1	523,959.9	3,387,887.9
22 30	464,060.0	535,940.0	3,387,921.2
30 00	452,079.9	547,920.1	3,387,967.8
37 30	440,099.7	559,900.3	3,388,027.7
45 00	428,119.3	571,880.7	3,388,100.9
52 30	416,138.8	583,861.2	3,388,187.4
1 00 00	404,158.1	595,841.9	3,388,287.3
07 30	392,177.1	607,822.9	3,388,400.5
15 00	380,195.9	619,804.1	3,388,527.0
22 30	368,214.5	631,785.5	3,388,666.9
30 00	356,232.7	643,767.3	3,388,820.0
37 30	344,250.6	655,749.4	3,388,986.5
45 00	332,268.1	667,731.9	3,389,166.4
52 30	320,285.3	679,714.7	3,389,359.6
2 00 00	308,302.0	691,698.0	3,389,566.1
07 30	296,318.3	703,681.7	3,389,785.9
15 00	284,334.1	715,665.9	3,390,019.1
22 30	272,349.4	727,650.6	3,390,265.7
30 00	260,364.2	739,635.8	3,390,525.6
37 30	248,378.5	751,621.5	3,390,798.8
45 00	236,392.2	763,607.8	3,391,085.4
52 30	224,405.2	775,594.8	3,391,385.4
3 00 00	212,417.6	787,582.4	3,391,698.8
07 30	200,429.4	799,570.6	3,392,025.5
15 00	188,440.5	811,559.5	3,392,365.6
22 30	176,450.8	823,549.2	3,392,719.2
30 00	164,460.4	835,539.6	3,393,086.1

Latitude 30°52′30″

Δλ	West of CM E	East of CM E	N
0°00′00″	500,000.0	500,000.0	3,415,565.5
07 30	488,051.0	511,949.0	3,415,572.2
15 00	476,101.9	523,898.1	3,415,592.2
22 30	464,152.8	535,847.2	3,415,625.7
30 00	452,203,5	547,796.5	3,415,672.5
37 30	440,254.2	559,745.8	3,415,732.7
45 00	428,304.8	571,695.2	3,415,806.3
52 30	416,355.2	583,644.8	3,415,893.2
1 00 00	404,405.3	595,594.7	3.415,993.6
07 30	392,455.3	607,544.7	3,416,107.3
15 00	380,505.1	619,494.9	3,416,234.4
22 30	368,554.5	631,445.5	3,416,374.9
30 00	356,603.7	643,396.3	3,416,528.8
37 30	344,652.5	655,347.5	3,416,696.1
45 00	332,701.0	667,299.0	3,416,876.8
52 30	320,749.1	679,250.9	3,417,070.9
2 00 00	308,796.8	691,203.2	3,417,276.4
07 30	296,844.1	703,155.9	3,417,499.3
15 00	284,890.9	715,109.1	3,417,733.6
22 30	272,937.2	727,062.8	3,417,981.4
30 00	260,983.0	739,017.0	3,418,242.5
37 30	249,028.2	750,971.8	3,418,517.0
45 00	237,072.9	762,927.1	3,418,805.0
52 30	225,117.0	774,883.0	3,419,106.4
3 00 00	213,160.5	786,839.5	3,419,421.3
07 30	201,203.3	798,796.7	3,419,749.5
15 00	189,245.5	810,754.5	3,420,091.3
22 30	177,286.9	822,713.1	3,420,446.5
30 00	165,327.6	834,672.4	3,420,815.1

Grid Coordinates for 7.5 Minute Intersections

Figure 16. *Method V, steps A and B, example 2.*

Example 2

Find the UTM reference for the NE corner of the Neenah, WI, USGS quadrangle (7.5 minute).

Geographic coordinates (read from map corner): Latitude N 44° 15′ 00″
Longitude W 88° 22′ 30″

A. Set-up

1. Zone number: 88° ÷ 6 = 14.7
   rounding downward 14.7 becomes 14
   30 − 14 = 16 (zone number).
2. Central meridian for zone 16: 87°
4. Angular difference (Δλ):

point	88°	22′	30″
CM	87	00	00
Δλ	1	22	30

B. UTM determination

1. Locate table for Lat. = 44° 15′ 00″ (see figure 17)
2. Locate line for = 1° 22′ 30″ (Δλ)
3. Point is west of CM (88° 22′ 30″ is greater than 87°)
4. Easting (from table) = 390,221.1 meters
   rounded to: 390,220 meters (10-meter precision)
5. Northing (from table) = 4,900,343.2 meters
   rounded to: 4,900,340 meters (10-meter precision)

C. Result: UTM reference = Z16 E390221 N4900340.

Figure 17. *UTM reference table for corner point in figure 16.*

UTM Grid Coordinates • Clarke 1866 Spheroid

Meters

Latitude 44°00′00″				Latitude 44°15′00″			
Δλ	West of CM E	East of CM E	N	Δλ	West of CM E	East of CM E	N
0°00′00″	500,000.0	500,000.0	4,871,656.6	0°00′00″	500,000.0	500,000.0	4,899,423.9
07 30	489,977.9	510,022.1	4,871,664.2	07 30	490,020.1	509,979.9	4,899,431.5
15 00	479,955.9	520,044.1	4,871,687.0	15 00	480,040.2	519,959.8	4,899,454.3
22 30	469,933.8	530,066.2	4,871,725.0	22 30	470,060.4	529,939.6	4,899,492.3
30 00	459,911.8	540,088.2	4,871,778.2	30 00	460,080.5	539,919.5	4,899,545.5
37 30	449,889.7	550,110.3	4,871,846.5	37 30	450,100.6	549,899.4	4,899,613.8
45 00	439,867.6	560,132.4	4,871,930.0	45 00	440,120.7	559,879.3	4,899,697.4
52 30	429,845.5	570,154.5	4,872,028.8	52 30	430,140.8	569,859.2	4,899,796.2
1 00 00	419,823.4	580,176.6	4,872,142.7	1 00 00	420,160.9	579,839.1	4,899,910.1
07 30	409,801.3	590,198.7	4,872,271.8	07 30	410,181.0	589,819.0	4,900,039.3
15 00	399,779.2	600,220.8	4,872,416.1	15 00	400,201.0	599,799.0	4,900,183.6
22 30	389,757.0	610,243.0	4,872,575.6	22 30	390,221.1	609,778.9	4,900,343.2
30 00	379,734.9	620,265.1	4,872,750.3	30 00	380,241.1	619,758.9	4,900,517.9
37 30	369,712.7	630,287.3	4,872,940.3	37 30	370,261.1	629,738.9	4,900,707.9
45 00	359,690.5	640,309.5	4,873,145.4	45 00	360,281.1	639,718.9	4,900,913.1
52 30	349,668.2	650,331.8	4,873,365.7	52 30	350,301.1	649,698.9	4,901,133.4
2 00 00	339,646.0	660,354.0	4,873,601.2	2 00 00	340,321.1	659,678.9	4,901,369.0
07 30	329,623.7	670,376.3	4,873,851.9	07 30	330,341.0	669,659.0	4,901,619.8
15 00	319,601.4	680,398.6	4,874,117.9	15 00	320,360.9	679,639.1	4,901,885.8
22 30	309,579.0	690,421.0	4,874,399.0	22 30	310,380.8	689,619.2	4,902,167.1
30 00	299,556.6	700,443.4	4,874,695.4	30 00	300,400.7	699,599.3	4,902,463.5
37 30	289,534.2	710,465.8	4,875,007.0	37 30	290,420.6	709,579.4	4,902,775.2
45 00	279,511.8	720,486.3	4,875,333.8	45 00	280,440.4	719,559.6	4,903,102.1
52 30	269,489.3	730,510.7	4,875,675.8	52 30	270,460.2	729,539.8	4,903,444.2
3 00 00	259,466.7	740,533.3	4,876,033.1	3 00 00	260,479.9	739,520.1	4,903,801.5
07 30	249,444.2	750.555.8	4,876,405.5	07 30	250,499.7	749,500.3	4,904,174.1
15 00	239,421.6	760,974.4	4,876,793.3	15 00	240,519.4	759,480.6	4,904,562.0
22 30	229,398.9	770,601.1	4,877,196.3	22 30	230,539.1	769,460.9	4,904,965.1
30 00	219,376.2	780,623.8	4,877,614.5	30 00	220,558.7	779,441.3	4,905,383.4
37 30	209,353.5	790,646.5	4,878,048.0	37 30	210,578.3	789,421.7	4,905,817.0
45 00	199,330.7	800,669.3	4,878,496.7	45 00	200,597.9	799,402.1	4,906,265.8
52 30	189,307.6	810,092.2	4,878,960.6	52 30	190,617.4	809,382.6	4,906,729.9
4 00 00	179,284.9	820,715.1	4,879,439.9	4 00 00	180,636.9	819,363.1	4,907,209.3

Latitude 44°07′30″			
Δλ	West of CM E	East of CM E	N
0°00′00″	500,000.0	500,000.0	4,885,540.1
07 30	489,999.0	510,001.0	4,885,547.7
15 00	479,998.0	520,002.0	4,885,570.5
22 30	469,997.0	530,003.0	4,885,608.5
30 00	459,996.0	540,004.0	4,885,661.7
37 30	449,995.0	550,005.0	4,885,730.0
45 00	439,994.0	560,006.0	4,885,813,6
52 30	429,993.0	570,007.0	4,885,912.3
1 00 00	419,992.0	580,008.0	4,886,026.3
07 30	409,990.0	590,009.1	4,886,155.4
15 00	399,989.9	600,010.1	4,886,299.7
22 30	389,988.8	610,011.2	4,886,459.3
30 00	379,987.7	620,012.3	4,886,634.0
37 30	369,986.6	630,013.4	4,886,823.9
45 00	359,985.5	640,014.5	4,887,029.1
52 30	349,984.3	650,015.7	4,887,249.4
2 00 00	339,983.1	660,016.9	4,887,485.0
07 30	329,981.9	670,018.1	4,887,735.8
15 00	319,980.7	680,019.3	4,888,001.7
22 30	309,979.5	690,020.5	4,888,282.9
30 00	299,978.2	700,021.8	4,888,579.3
37 30	289,976.9	710,023.1	4,888,891.0
45 00	279,975.5	720,024.5	4,889,217.8
52 30	269,974.2	730,025.8	4,889,559.9
3 00 00	259,972.8	740,027.2	4,889,917.2
07 30	249,971.3	750,028.7	4,890,289.7
15 00	239,969.9	760,030.2	4,890,677.5
22 30	229,968.3	770,031.7	4,891,080.6
30 00	219,966.8	780,033.2	4,891,498.8
37 30	209,965.2	790,034.8	4,891,932.4
45 00	199,963.5	800,036.5	4,892,381.2
52 30	189,961.9	810,038.1	4,892,845.2
4 00 00	179,960.1	820,039.9	4,893,324.5

Latitude 44°22′30″			
Δλ	West of CM E	East of CM E	N
0°00′00″	500,000.0	500,000.0	4,913,308.0
07 30	490,041.3	509,958.7	4,913,315.6
15 00	480,082.6	519,917.4	4,913,338.4
22 30	470,123.8	529,876.2	4,913,376.4
30 00	460,165.1	539,834.9	4,913,429.6
37 30	450,206.4	549,793.6	4,913,498.0
45 00	440,247.7	559,752.3	4,913,581.3
52 30	430,288.9	569,711.1	4,913,680.3
1 00 00	420,330.2	579,669.8	4,913,794.3
07 30	410,371.4	589,628.6	4,913,923.4
15 00	400,412.7	599,587.4	4,914,067.8
22 30	390,453.9	609,546.1	4,914,227.4
30 00	380,495.1	619,504.9	4,914,402.2
37 30	370,536.3	629,463.7	4,914,592.2
45 00	360,577.5	639,422.5	4,914,797.3
52 30	350,618.6	649,381.4	4,915,017.7
2 00 00	340,659.8	659,340.2	4,915,253.4
07 30	330,700.9	669,299.1	4,915,504.2
15 00	320,742.0	679,258.0	4,915,770.2
22 30	310,783.1	689,216.9	4,916,051.5
30 00	300,824.2	699,175.8	4,916,348.0
37 30	290,865.2	709,134.8	4,916,659.7
45 00	280,906.3	719,093.7	4,916,986.6
52 30	270,947.3	729,052.7	4,917,328.7
3 00 00	260,988.3	739,011.7	4,917,686.1
07 30	251,029.2	748,970.8	4,918,058.8
15 00	241,070.2	758,929.8	4,918,446.6
22 30	231,111.1	768,888.9	4,918,849.8
30 00	221,151.9	778,848.1	4,919,268.2
37 30	211,192.8	788,807.2	4,919,701.8
45 00	201,233.6	798,766.4	4,920,150.7
52 30	191,274.4	808,725.6	4,920,614.8
4 00 00	181,315.1	818,684.9	4,921,094.2

Grid Coordinates for 7.5 Minute Intersections

Figure 18. *Effects of rounding and degree of precision.*

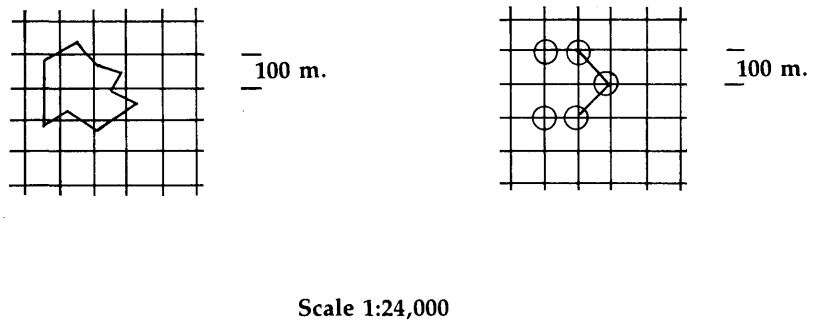
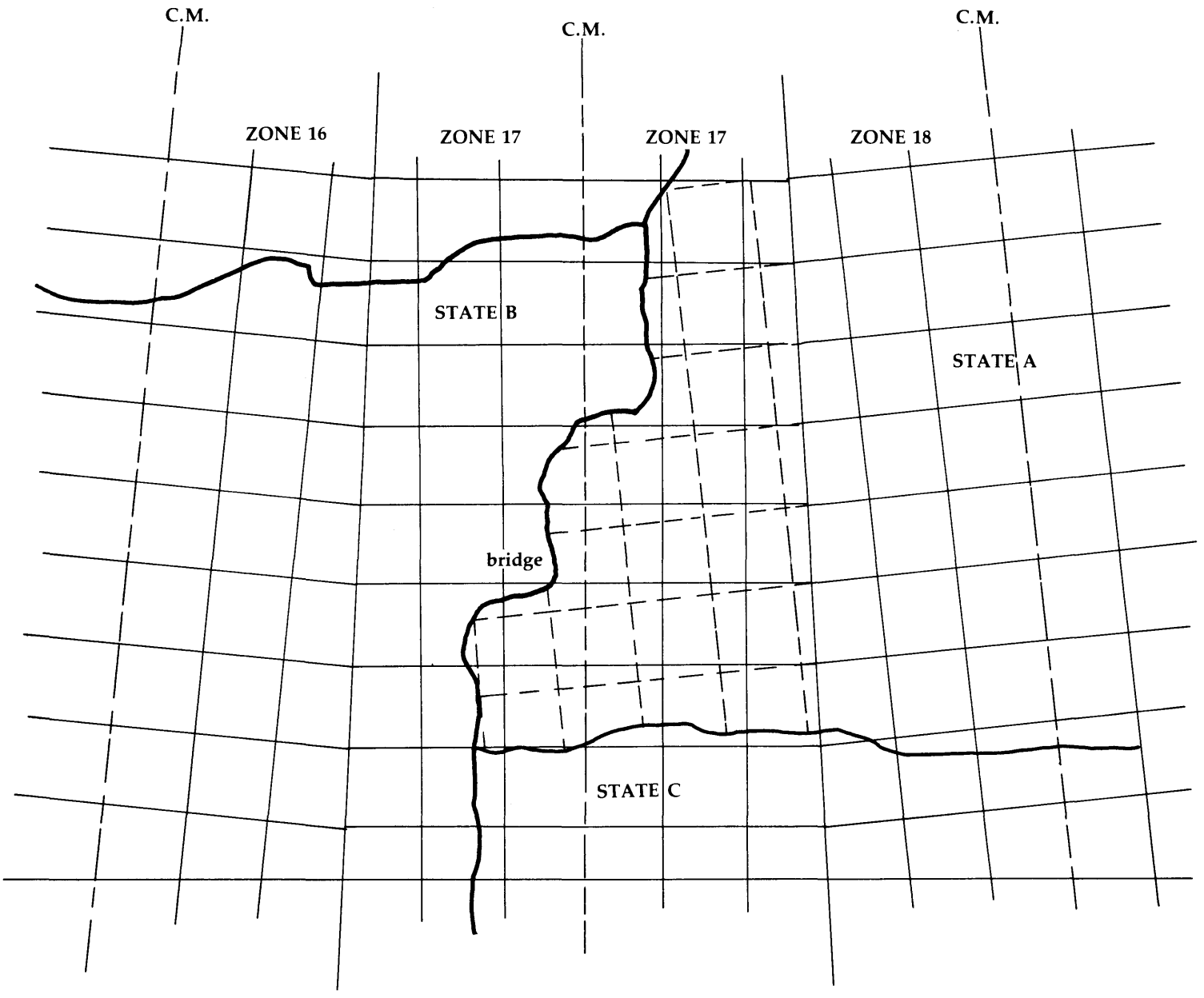


Figure 19. *Zone 18 extended into Zone 17.*



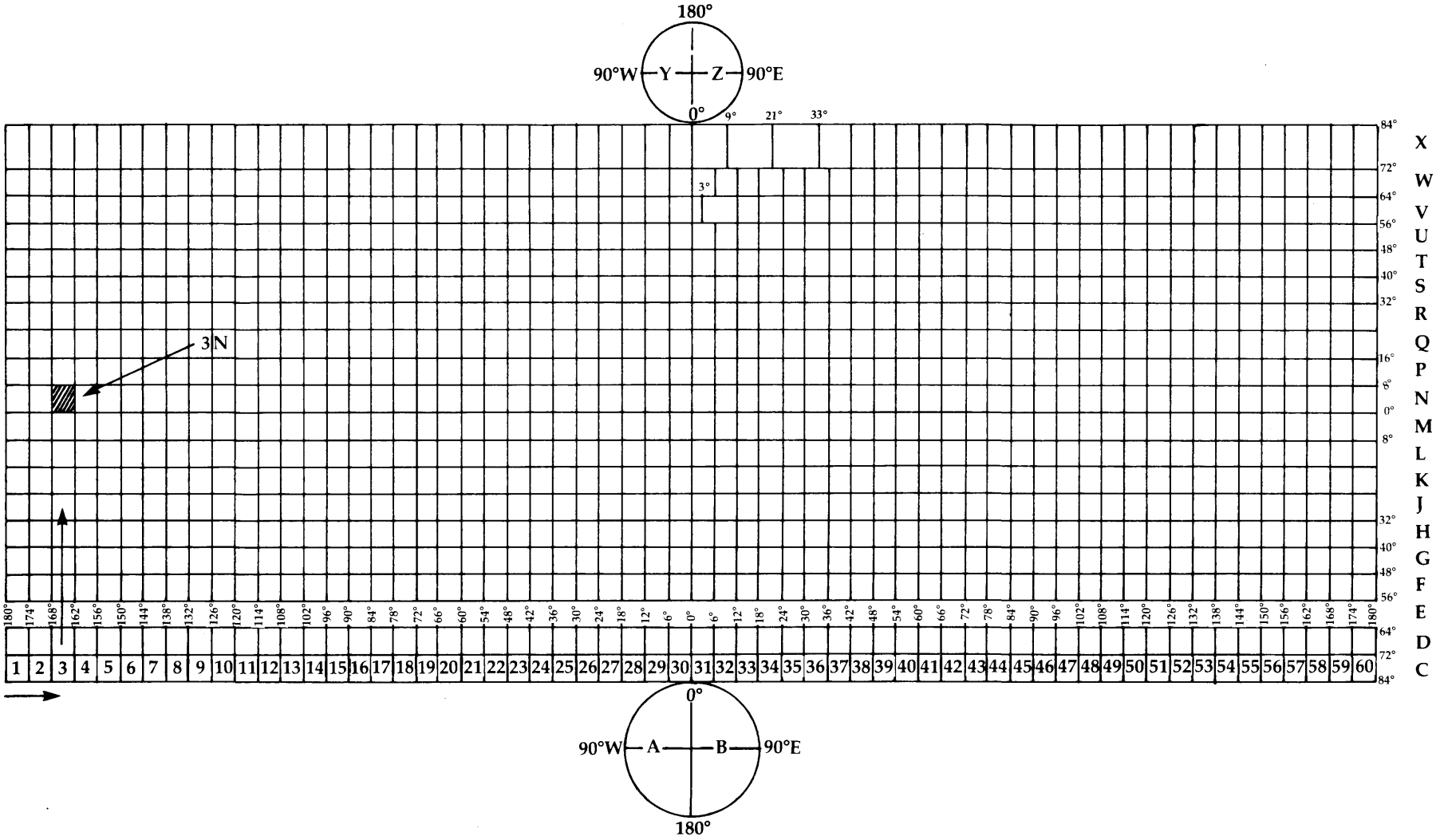


Figure 20. *UTM military grid reference system zone and strip chart.*

Sources of Figures

Mary E. Stea: all figures not otherwise credited.

US Army, Technical Manual TM 5–241–1, *Grids and Grid References* (Washington, DC, Headquarters, Department of the Army, June 1967): figure 20.

———, Technical Manual TM 5 241–11, *Universal Transverse Mercator Grid Tables for Latitudes 0°-80° . . .* (Washington, DC, Headquarters, Department of the Army, December 1959): figures 15, 17.

UTM Coordinate Counter from US Geological Survey, Reston, VA: figure 1.

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