Using State Plane and Project Datum Coordinates

A basic approach for relating state plane coordinates and project datum coordinates for projects in Kentucky

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KENTUCKY
TRANSPORTATION
CABINET

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Second Edition
Date: 1/08/2004

GPS Surveying methods becoming more common

Since the Kentucky Transportation Cabinet is now using GPS on a regular basis to control all kinds of projects, the state plane coordinate system is now becoming more in use. In the past it was cumbersome to bring state plane coordinates to a project site because of the distances and the terrain the survey crew had to endure. But now, with GPS surveying methods, obtaining state plane coordinates on project sites is becoming commonplace. Basically, we obtain latitudes and longitudes from GPS. These are then converted to state plane coordinates during the post processing process. It is these state plane coordinates that form our basis for our surveys and mapping. This manual will provide a very simple approach in reviewing and using the state plane coordinate system in Kentucky.

Why use a state plane coordinate system?

The system provides a common datum for all surveys. In theory, if all surveys were done on state plane coordinates (and done correctly) all property boundaries and highway right of way lines would match without the problems of overlaps and gaps. The system can also provide a real location of where the project is on the earth and therefore can be valuable for GIS (Geographic Information Systems) databases that are becoming more common. The system also provides a more dependable reference for azimuths than the magnetic north and at the same time overcome the problem of converging true north azimuths. Again, use of the system allows for more continuity in the use of surveys for planning by governmental agencies and public utility companies. This leads to greater efficiency in all phases of land use and planning.

Some terms that you need to be familiar with when dealing with GPS and state plane coordinates are listed below:

1) Map Projections
2) Central Meridian
3) Geoid
4) Datums
5) Scale Factor, Elevation Factor, Combination (Grid) Factor, Project Datum Factor
6) Ellipsoid
7) Heights and Elevations

Map Projections

The earth because of its "roundness" in geodetic terms is referred to a spheroid and uses an ellipse rotated about its minor axis as a mathematical model. This is called the ***ellipsoid***. The means to transform positions on a spheroid to coordinates on a plane are done in the mathematics of map projections. A *projection* is simply a means of transferring points on one surface to corresponding points on another surface. A *map projection* is a projection where one of the surfaces is a spheroid and the other is a surface that can be developed into a plane. Since the earth is round and maps are flat, projections must be used if a map is to accurately depict a significant part of the earth's surface.

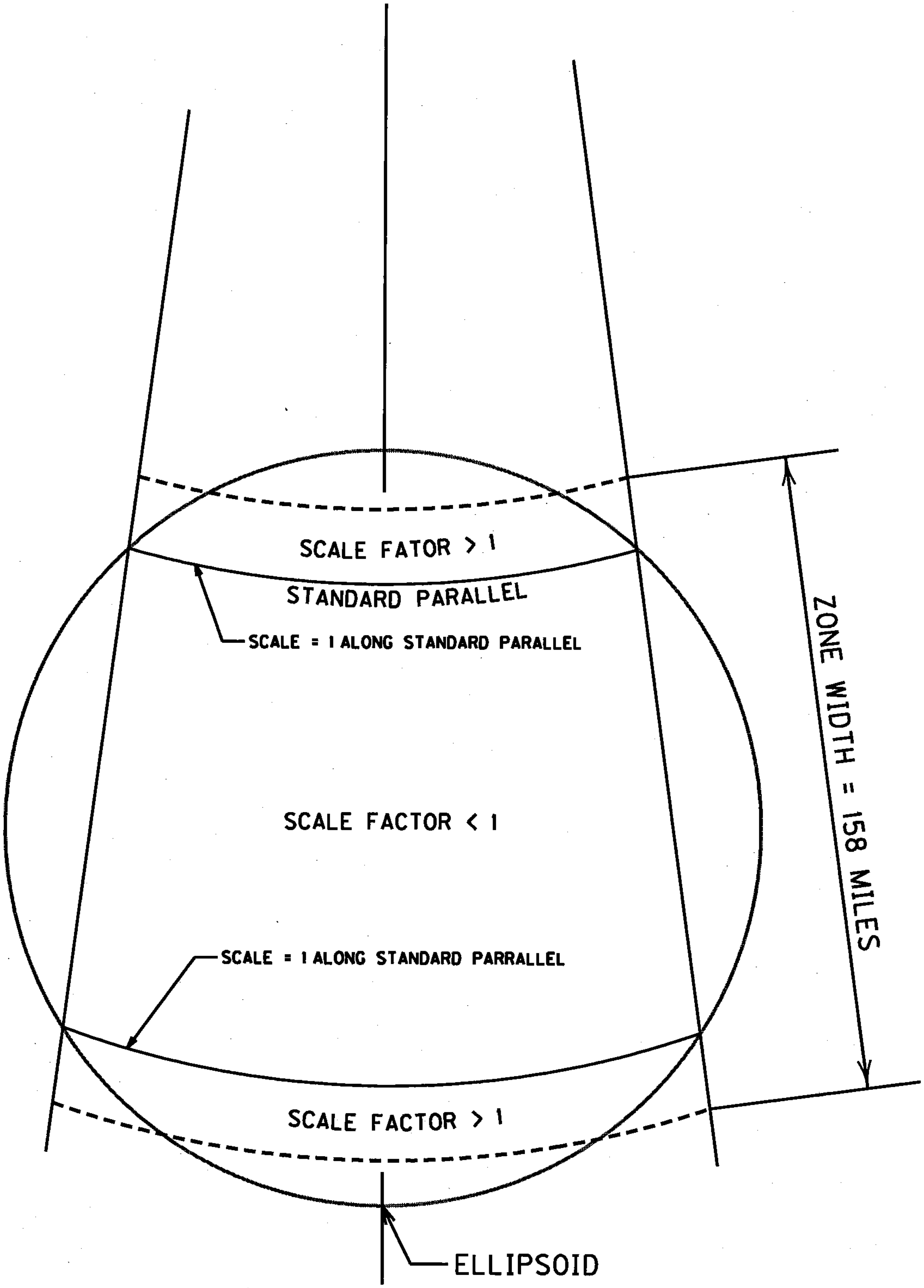
There are many types of projections but the one that we will deal with is called the Lambert conformal conical projection (See **Figure 1**) because this is the projection system that is used for the state of Kentucky. This system is used primarily (but not always) for states that are longer in the east-west direction compared to the north-south direction.

From **Figure 2** you will notice that the Lambert projection for Kentucky contains two *zones,* **North Zone & South Zone**. The boundary between the zones follow county lines for convenience but either zone can be used when you are working close to this area.

Kentucky has also adopted a new zone called the **Single Zone** (See Appendix A). Currently all three zones can be used but may be going to the Kentucky Single Zone entirely in the near future. Some state agencies are already using the Single Zone exclusively.

Central Meridian

Also from **Figure 2** you will notice that each zone contains a *Central Meridian.* This meridian or longitude line is placed near the middle of each zone. At the intersection of this meridian and a chosen standard parallel (latitude line) is referred to as the origin for each zone. For the North Zone the origin coordinates are Northing 0.0 and Easting 500,000.00. For the South Zone the origin coordinates are Northing 500,000.00 and Easting 500,000.00. These are just arbitrary coordinates assigned by NGS when the NAD83 system was developed. Be aware that these are metric coordinates.



CONFORMAL CONICAL PROJECTION

(LAMBERT PROJECTION)

FIGURE 1

KENTUCKY SPCS – NORTH AND SOUTH ZONES

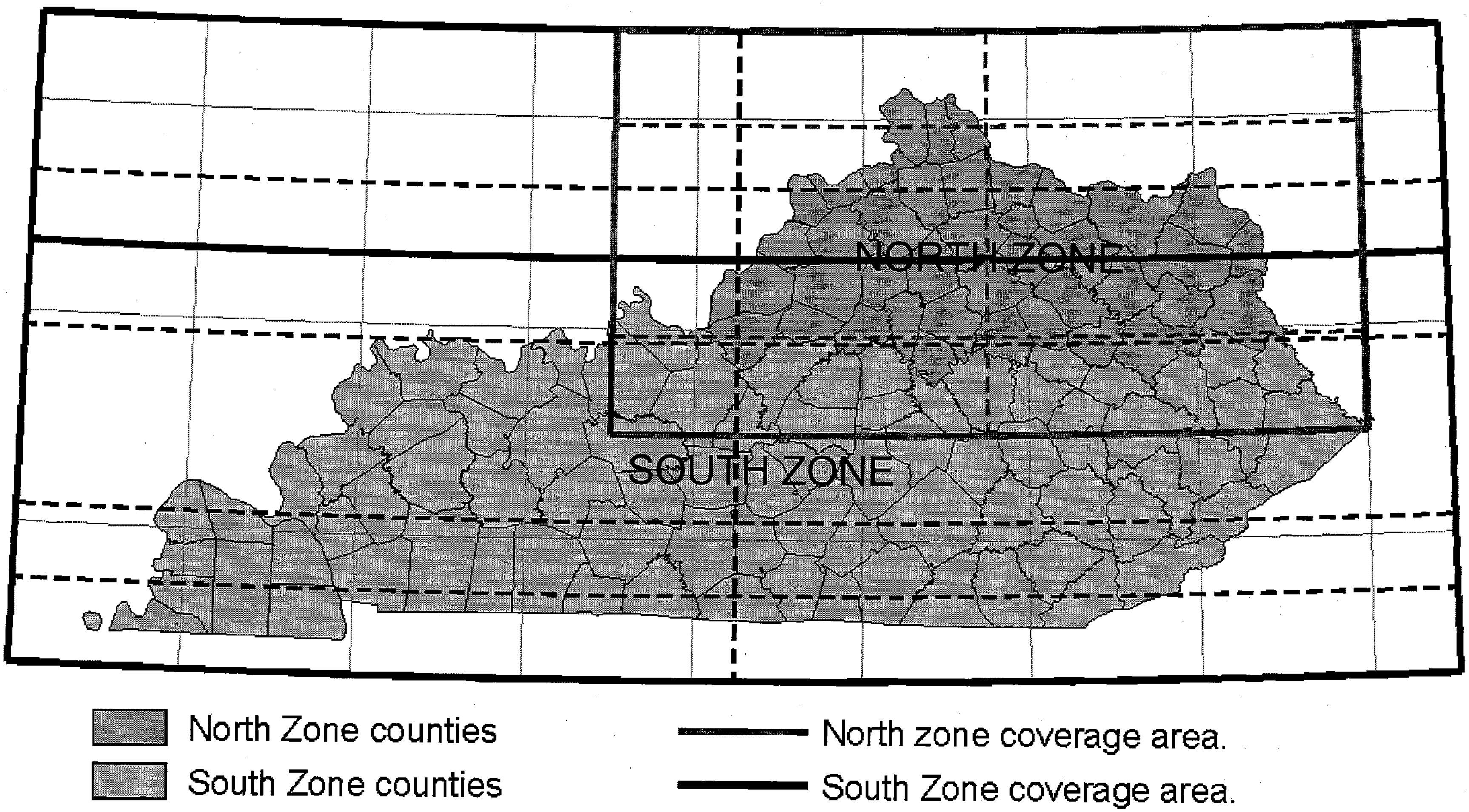


FIGURE 2

Geoid

The shape of any earth datum, such as "sea level", is not a perfect spheroid due to variations in the direction of gravity. This irregular shape is called the ***geoid***. The geoid is an equipotential surface, perpendicular to the direction of gravity at all points. The plumb line or the vertical (defined by gravity) is affected by land masses and the density of crustal rock near the surface. This causes the geoid to *undulate* or to be "bumpy" or wavy. This undulation or separation from the ellipsoid is known as the geoid height. In the former NAD27 system these were assumed to coincide and was just called "sea level". See **Figure 3** or **Figure 3A**

Datums

A datum is a reference frame from which other quantities are based. The datum we use for *horizontal* control (N,E) is based on the GRS80 ellipsoid and is called the North American Datum of 1983. **(NAD83)**. Since Kentucky now has a **HARN** (**H**igh **A**ccuracy **R**eference **N**etwork) a new adjustment has been completed and we now refer to the horizontal datum as NAD83/1994 since the final adjustment was completed in 1994.

For vertical control, the datum used is the geoid ("sea level") and is called the North American Vertical Datum of 1988 (**NAVD88**). Both of these datums use metric coordinates.

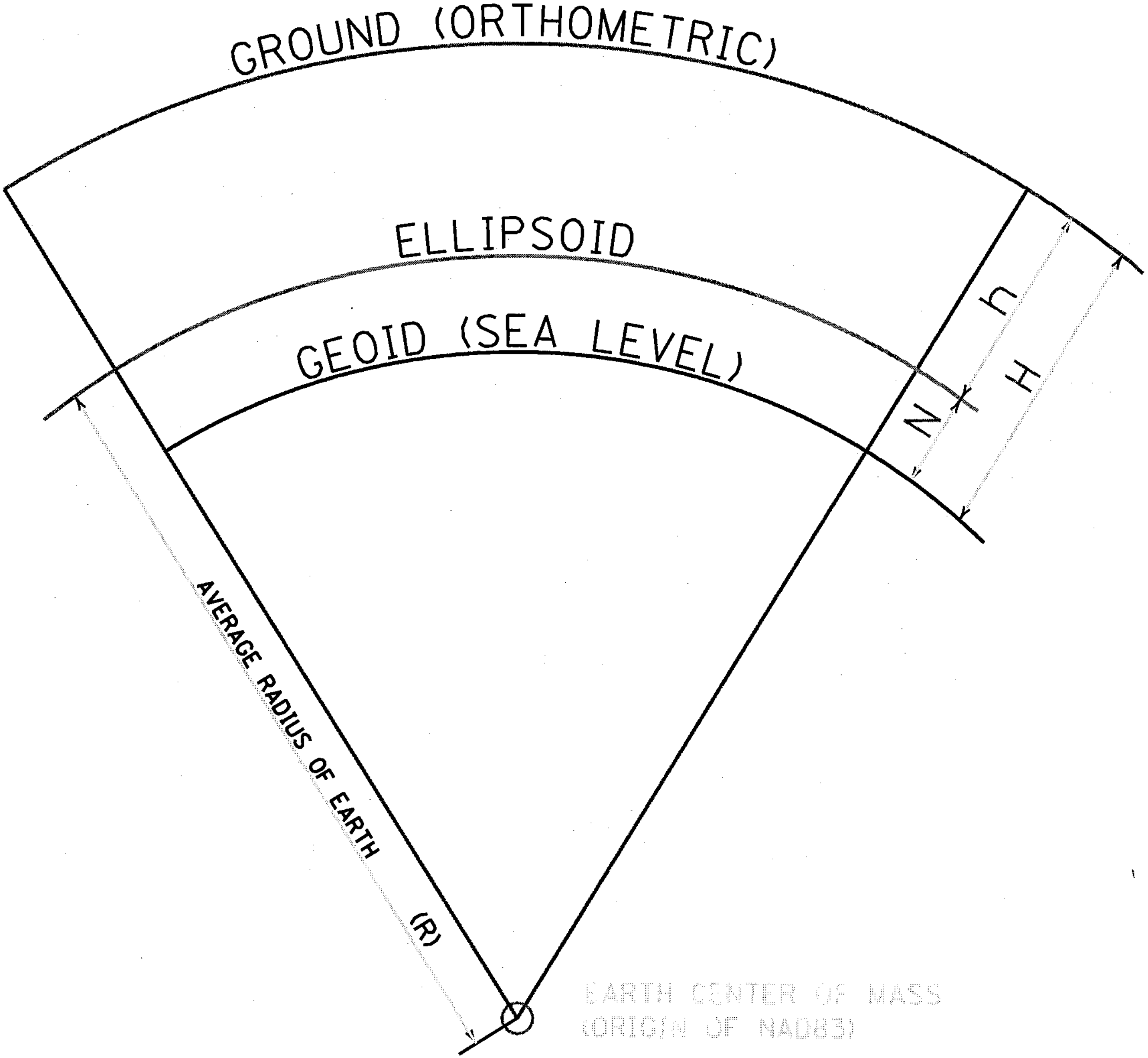
Scale Factor

The lines where the projection surface intersects the ellipsoid are called *standard lines*. Along them the scale is the same on the ellipsoid as on the projection surface. The *scale factor* is the ratio of a length on the projection surface to the length on the ellipsoid. The scale factor can be obtained from software such as **CORPSCON** if the state plane coordinates or a latitude and longitude is known. For all practical purposes, scaling from a quad sheet to obtain these values will be close enough. For the Lambert projection the scale factor is a function of the latitude as it changes in a North-South direction and stays constant in the east-west direction. From **Figure 1** you will notice that the scale factor is less than 1.00 for most of each zone but does get greater than 1.000 just on the "outer edges" of the zone width. At the Standard Parallels the scale factor is equal to 1.0000.

Elevation Factor

Elevation, geoid height, and elevation factor are shown in **Figure 3**. The geoid height is the vertical distance of the geoid above the ellipsoid and is the reference for elevations or *orthometric heights*. Elevations, being referred to the geoid, should be corrected to the ellipsoid to achieve the

NORTH AMERICAN DATUM 1983 (NAD83)



$$\text{ELEVATION FACTOR} = \frac{R}{R+N+H}$$

N = GEOID HEIGHT
h = ELLIPSOID HEIGHT
H = ORTHOMETRIC HEIGHT

FIGURE 3

Lambert Ground, Grid, and Ellipsoid

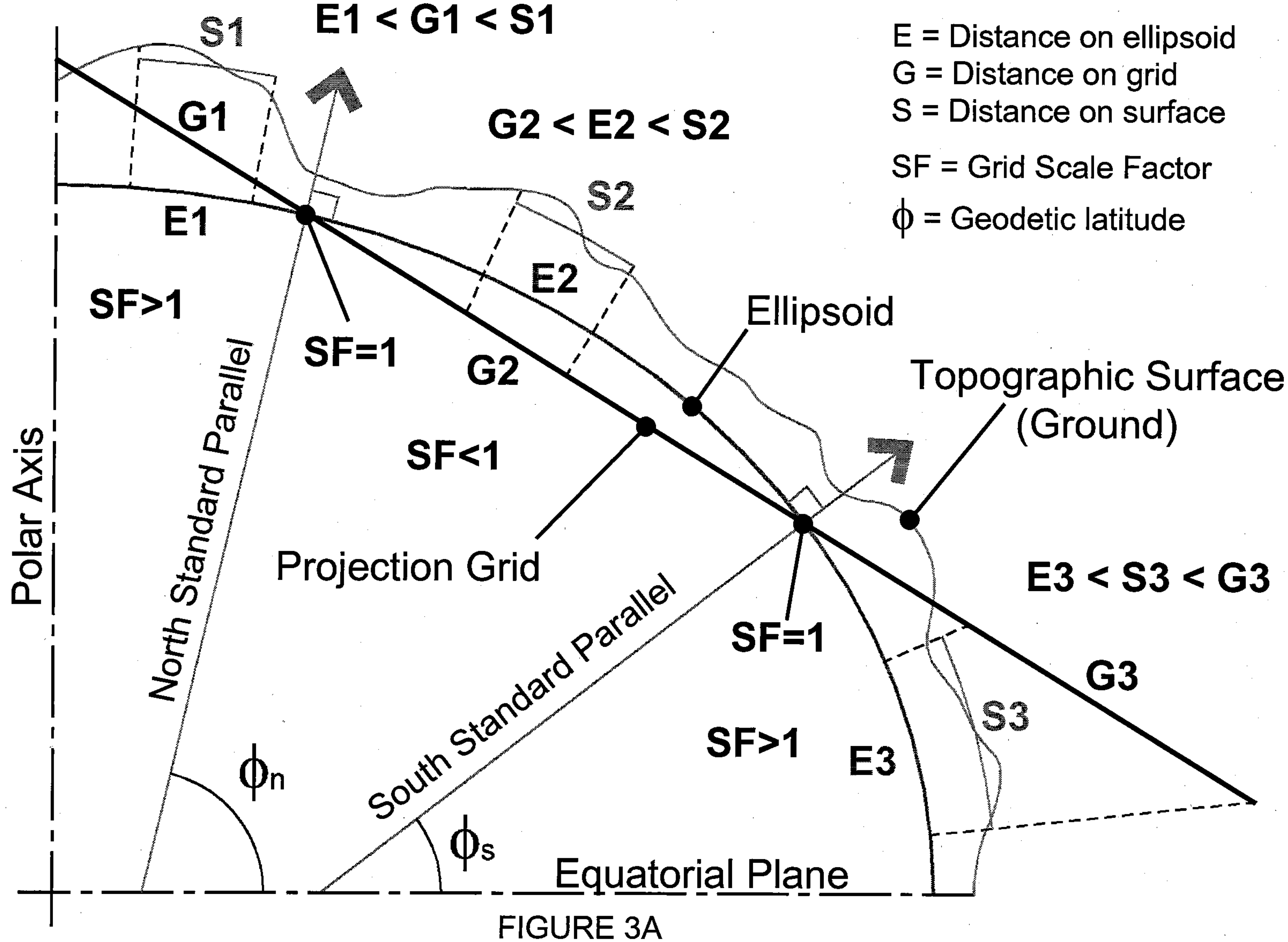


FIGURE 3A

precision desirable in determining the elevation factors. The elevation factor is determined by the following equation:

EF = R/(R+H+N) (Elevation Factor) **Equation #1**

From Figure 3 it can also be seen that h = H + N
H = mean height above the geoid (orthometric height)
h = ellipsoid height
N = mean geoid height of the survey line (will be negative)
R = mean radius of the earth (20,906,000 feet)

Because the geoid is below the ellipsoid in the Continental U.S. these geoid heights will be published a negative.

Combination or Grid Factor

The grid factor is simply the product of the elevation factor and the scale factor and is calculated as follows:

GF = SF x EF **Equation #2**

where SF = scale factor and EF = elevation factor

When surveying with state plane coordinates in the field you are essentially "running on the grid". In other words, all the horizontal distances you are obtaining in the field (on the ground) are being reduced to the grid by the combination factor that may be entered in the data collector. This should not be a new concept to a surveyor since slope distances had to be reduced to horizontal distances before any coordinate calculation could take place.
When you calculate an inverse (get distance) between state plane coordinates you are getting grid distances and grid azimuths.

Project Datum Factor

The project datum factor is simply the reciprocal of the combination factor.

The equation is: **PDF = 1/GF.** **Equation #3**

Simply put, this takes the state plane coordinates which are on the grid, back "up" to ground coordinates. This can be clearly seen from **Figure 3A.** It is very important to realize that when the state plane coordinates are "raised" back to the ground they are no longer state plane coordinates but now are known as ***project coordinates or mapping coordinates***. When you calculate an inverse between project coordinates you get what is referred to as a project (ground) distance and a project azimuth. The project distance is simply the distance you should get when you take a distance reading from the total station in the field. This is how most contractors and construction personnel want the survey done because of actually staking "on the ground". But with the use of this project datum factor we can always get back to state plane coordinates, if desired.

Heights and Elevations

There are usually many questions about the elevations we get from GPS. What we actually get from GPS is ellipsoid heights. These are actually on the ellipsoid model. This ellipsoidal height is then added to the geoid height to finally derive at an orthometric height or elevation. Remember from an earlier discussion, that the geoid is "bumpy" and "wavy" or undulates and is not consistent. The geoid heights are derived from a model that is known as a geoid model or what is referred to as Geoid03. This Geoid03 model is the latest that has been produced from NGS. Because more and more data is being collected as time continues, these models will continue to change and be updated. Most of us are familiar with a triangulated surface from a DTM model. The triangles will "corner" at known elevation points with other elevations between these points being interpolated. This is essentially what the geoid model is, just over a much larger area (the state). It is because of this interpolation that we get an approximate geoid height and therefore refer to the elevation as a ***GPS derived elevation***, which is only as good as the geoid height, measured at that point. This is why we say GPS derived elevations are approximate. GPS can actually give good elevations if there are enough (at least 4) known benchmarks included in the control network. But for most small networks this may not be the case and the resulting elevations will only be GPS derived unless differential levels are run to the points.

The equation that relates the geoid height and the ellipsoid height is :
(Refer back to Figure 3 and Figure 3A)

$$\mathbf{h = H + N}$$

h = ellipsoid height
N = geoid height
H = orthometric height

Example: GPS was used on control point A147. Find the orthometric height (elevation) of A147 if the ellipsoid height = 754.76 feet and the geoid height = -105.12 meters.

Solution: Using the equation above it can be written as:

$$754.76 = H + (-105.12) \text{ or } (754.76 + 105.12)$$

$$\mathbf{H = 859.88\ feet}$$

Therefore, the orthometric height (elevation) = **859.88** feet.

This would be considered a GPS derived elevation unless differential levels were run to the point.

Review of Equations used for process of obtaining project datum factor

Because we require our aerial consultants to use the same process, the following statements again describe how the process of relating state plane coordinates and project datum coordinates is to be done. This is from a memo that was sent to them. The manuscripts we get from the aerial consultants are in .dgn format and should be on project datum.

The recommended method of determining positions on the project datum (for localized areas where *average* elevation and *average* scale factors can be used without a significant loss of accuracy in modeling the entire project's plane projection) is as follows:

- determine the true Kentucky state plane position of each project control point
- determine the project scale factor (**SF**) from the most centralized control point for the project. This is to be a permanent control point. (i.e. concrete)
- determine the project elevation factor (**EF**) from an average elevation of all control points used on the project.
- from the scale factor and elevation factor, determine the combined factor **CF = (SF x EF).**
- calculate the project datum factor as the reciprocal of the combined factor **PDF = (1 /CF)** -- this factor will be used to scale or stretch the mapping to the project datum.
- holding 0.0,0.0 fixed, move or shift each control position from state plane to project datum.
- provide both the Kentucky state plane coordinate position and the project datum position for each point used as project control.

Mathematically, the shift for each individual point could be represented by

the following equations:

$Npd = [No+(Nsp-No)] * PDF$
$Epd = [Eo+(Esp-Eo)] * PDF$

Since No and Eo are 0.0, the equations simplify to:
$Npd = Nsp * PDF$
$Epd = Esp * PDF$

where:
Npd = northing on project datum
Epd = easting on project datum
Nsp = northing on a state plane projection
Esp = easting on a state plane projection
No = northing of held point
Eo = easting of held point
PDF = project datum factor (the reciprocal of the combined factor)

It can be seen that as long as some basic rules are followed converting state plane coordinates to project or ground coordinates should not be a problem. We (Transportation Cabinet) need to be performing our surveys using the project datum method unless conditions require you to use state plane coordinates while surveying. For example, you may be required to do some staking on a project where monuments have been set by others and all you have is state plane coordinates. You could in turn calculate the factors to perform a project datum survey but they may be slightly different than the ones that were used when the control work was done. This could affect the accuracy of your survey compared to the previous survey.

It should be realized, the only information really needed to convert from state plane coordinates and project coordinates are:

1) the coordinates of the control (state plane or project datum)
2) the project datum factor

If the project datum factor is not known then you would need to obtain the scale factor and the elevation factor and then use these to calculate your project datum factor. Again, the scale factor can be determined if the latitude and longitude is known. For all practical purposes, scaling from a quad sheet to obtain the latitude and longitude will be close enough.

In summary:

If you are converting <u>from state plane coordinates to project datum coordinates</u> you need to **<u>multiply</u>** the state plane coordinates by the project datum factor.

If you are converting <u>from project datum coordinates to state plane coordinates</u> then you need to **<u>divide</u>** the project datum coordinates by the project datum factor.

Using State Plane and Project Datum Coordinates with the Sokkia SDR33 data collector

Since we use the SDR33 data collector, the methods below describe how this process can be used on it.

Surveying with State Plane Coordinates on the SDR33

When creating a new job, make sure the Sea Level correction is set to **NO** (using the other corrections should be OK) and key in the appropriate scale factor. This factor will be the **Combination Factor that you calculated.** Key it in as the scale factor in the SDR33. Now, when you shoot a slope distance in the field the data collector will convert it to the grid automatically and you will be obtaining state plane coordinates as you survey. (Assuming you start with state plane coordinates)

Surveying with Project Datum Coordinates on the SDR33

Project Datum simply means using actual ground distances instead of grid distances as in state plane coordinates. When creating a new job, make sure the Sea Level correction is set to **NO** (using the other corrections should be OK), Key in or upload the project datum coordinates calculated and key in 1.0000000 as the scale factor. You will now be surveying with project datum coordinates. Be aware that this is the same procedure you use when you use assumed coordinates. The only difference between project datum coordinates and assumed coordinates is that the project datum coordinates you are obtaining can easily be converted to state plane coordinates.

Example

This example uses a project that was done in Kenton County in District 6. This project was tied to one HARN point and to one CORS point. The HARN point is located at the District 6 Office and is designated **KY06** and the CORS station is in Erlanger and designated **ERLA**. The control network is shown in **Figure 4** and the coordinate listing is shown in **Figure 5**. Using the rules and equations on the following pages, we will step through the process necessary to calculate a project datum factor.

EXAMPLE (cont.)

Step 1) Determine the state plane coordinates of each control point. (Coordinates are shown in **Figure 5**) They were obtained from GPS.

Step 2) Determine the "central point" of the project. In this example we will choose Control Point #3 (shown in **Figure 4**) as being the central point.

Step 3) The scale factor for the position of CP#3 is **1.0000136034**. This was determined by Trimble TGO software although CORPSCON or NADCON could have also been used. The majority of scale factors are less than 1 but you will notice that the scale factor for this project is greater than one. The reason for that is because this project falls above the northern most standard parallel for the Kentucky North Zone where the projection grid actually comes above the ellipsoid. (See Figure 3A)

Step 4) The project elevation is determined by averaging the elevations on the project site. This normally does not include the HARN points because they are typically far away from the project site but since KY06 was so close to the project and could be used as an actual control point, it was decided to include it into the project. From the spreadsheet, the average elevation is determined to be **824.36 feet**. Also, note that the average geoid height over the project is **–111.70 feet**.

Step 5) The elevation factor can now be determined from **Equation 1**. Remember, the radius of the earth is taken as a constant. The radius that is generally accepted is 20,906,000 feet.

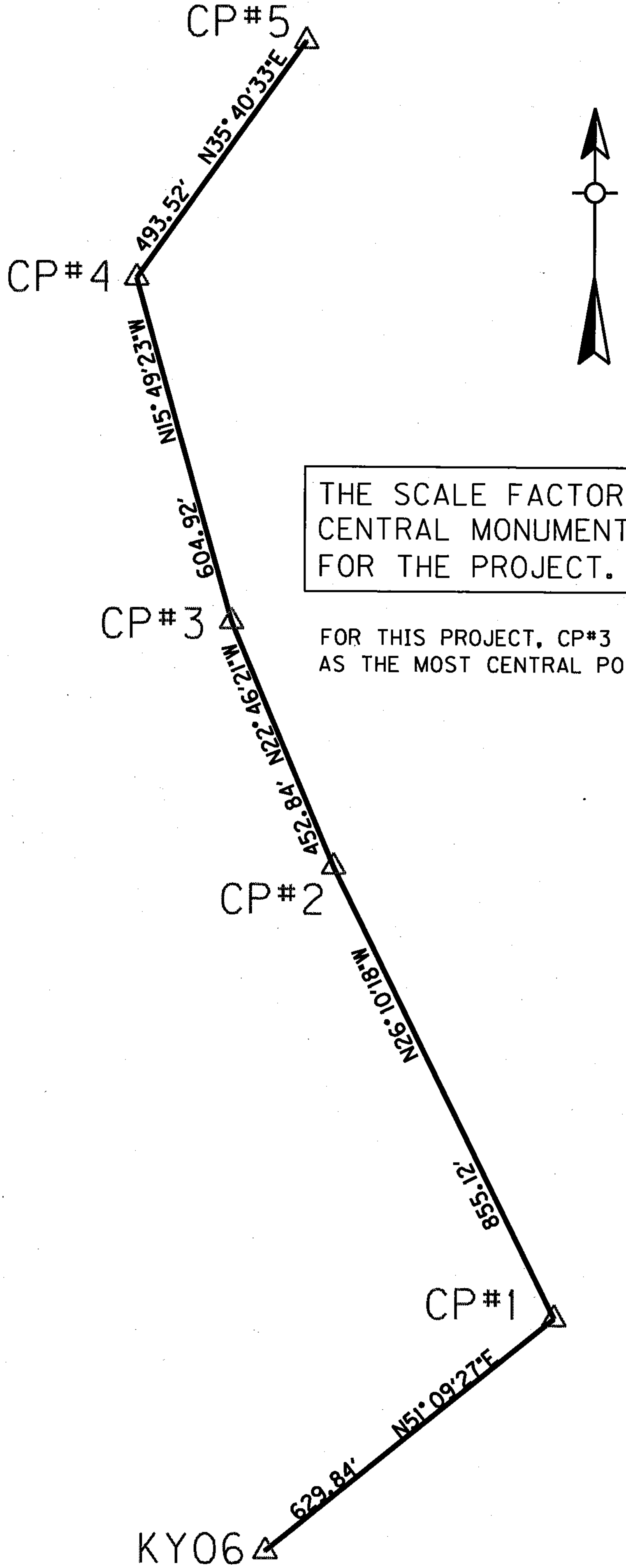
EF = 20,906,000/(20,906,000+824.36-111.70)
EF = 0.9999659124

Step 6) Now that the elevation and scale factors are known we can now calculate the combination or grid factor. From **Equation 2** the grid factor would be:

GF = (1.0000136034)*(.9999659124)
GF = 0.9999795154

Step 7) From Equation 3, the Project Datum Factor (PDF) can now be calculated.

PDF = 1/GF **PDF = 1.0000204851**



THE SCALE FACTOR AT THE MOST CENTRAL MONUMENT IS USED FOR THE PROJECT.

FOR THIS PROJECT, CP#3 WILL BE USED AS THE MOST CENTRAL POINT.

FIGURE 4

PROJECT: KENTON COUNTY (BUTTERMILK PIKE WIDENING)

STATE PLANE COORDINATES US SURVEY FEET
10/23/2003

NAD83/1994 STATE PLANE COORDINATES, KENTUCKY NORTH ZONE

	NORTHING	EASTING	ELEV.	Ellipsoid Ht.	Geoid Ht.	
KY06	562795.820	1547676.960	833.988	722.292	-111.696	1.0000128373
CP01	563190.842	1548167.523	840.483	728.785	-111.699	1.0000130291
CP02	563958.296	1547790.360	839.680	727.980	-111.700	1.0000134007
CP03	564375.840	1547615.076	824.071	712.370	-111.701	1.0000136034
CP04	564957.836	1547450.134	793.116	681.414	-111.702	1.0000138868
CP05	565358.737	1547737.954	814.819	703.115	-111.704	1.0000140832
AVERAGE			**824.360**		**-111.700**	

EF = 0.9999659124
SF = 1.0000136034
CF (EF*SF) = 0.9999795154
RATIO 48,817 Ground to Grid Distortion

PDF **1.0000204851** **<----------------- PROJECT DATUM FACTOR**
(TO PUBLISH ON PLANS)

PROJECT DATUM COORDINATES

(USE THESE FOR KYTC PROJECTS) (THESE GO INTO THE DATA CONTROLLER)

	NORTHING (US FEET)	EASTING (US FEET)	NAVD88 ELEV. (US FEET)
KY06	562,807.349	1,547,708.664	833.988
CP01	563,202.379	1,548,199.237	840.483
CP02	563,969.849	1,547,822.067	839.680
CP03	564,387.401	1,547,646.779	824.071
CP04	564,969.409	1,547,481.834	793.116
CP05	565,370.318	1,547,769.660	814.819

GROUND DISTANCE BETWEEN KY06 & CP01	**629.850 US SURVEY FEET**
GROUND DISTANCE BETWEEN CP01 & CP02	**855.142 US SURVEY FEET**
GROUND DISTANCE BETWEEN CP02 & CP03	**452.853 US SURVEY FEET**
GROUND DISTANCE BETWEEN CP03 & CP04	**604.930 US SURVEY FEET**
GROUND DISTANCE BETWEEN CP04 & CP05	**493.530 US SURVEY FEET**

FIGURE 5

This would be the factor that would be used to convert between state plane coordinates and project datum coordinates for this project. This factor gets published on the Coordinate Control Sheet that goes into the design plan set.

To convert from State Plane Coordinates to Project Datum Coordinates, you multiply the State Plane Coordinates by the Project Datum factor.
To convert from Project Datum Coordinates to State Plane Coordinates, you divide the Project Datum Coordinates by the Project Datum Factor.

Step 8) Now the project datum coordinates can be computed. From **Figure 5** you would now multiply the state plane coordinates (shown at the top of the sheet) by the above calculated project datum factor to obtain the project datum coordinates as shown at the bottom of the sheet.

When Project Datum Coordinates are obtained, there is a shift between the sets of coordinates. (**See Figure 6**). This is because the state plane coordinates are simply multiplied by the project datum factor. This shift is different at each point because of its unique location (coordinate) on the earth. It is because of this shift that adjacent projects cannot be "tied". They would each have a different project datum. This is the major disadvantage of using Project Datum Coordinates. It essentially creates unique coordinate systems that end up being "stand alone" coordinate systems. Therefore, these systems have to be manipulated before ever being able to include them into a GIS database. To do this correctly, a translation and scaling have to take place. This can be very tedious and time consuming.
This would not be the case with State Plane Coordinates. Keeping survey control on a state plane coordinate system would allow projects to be continually tied as the control was extended from one project site to another. This works very well for GIS databases.

Available Spreadsheets

Obviously, these calculations can be easily done in a spreadsheet.
The spreadsheet that can do these calculations is available on the KYTC web site (http://www.kytc.state.ky.us/design/survey/survey.htm) (Look under GPS Downloads) and can be downloaded. It will have values already in it and you can change those to the values of your project.

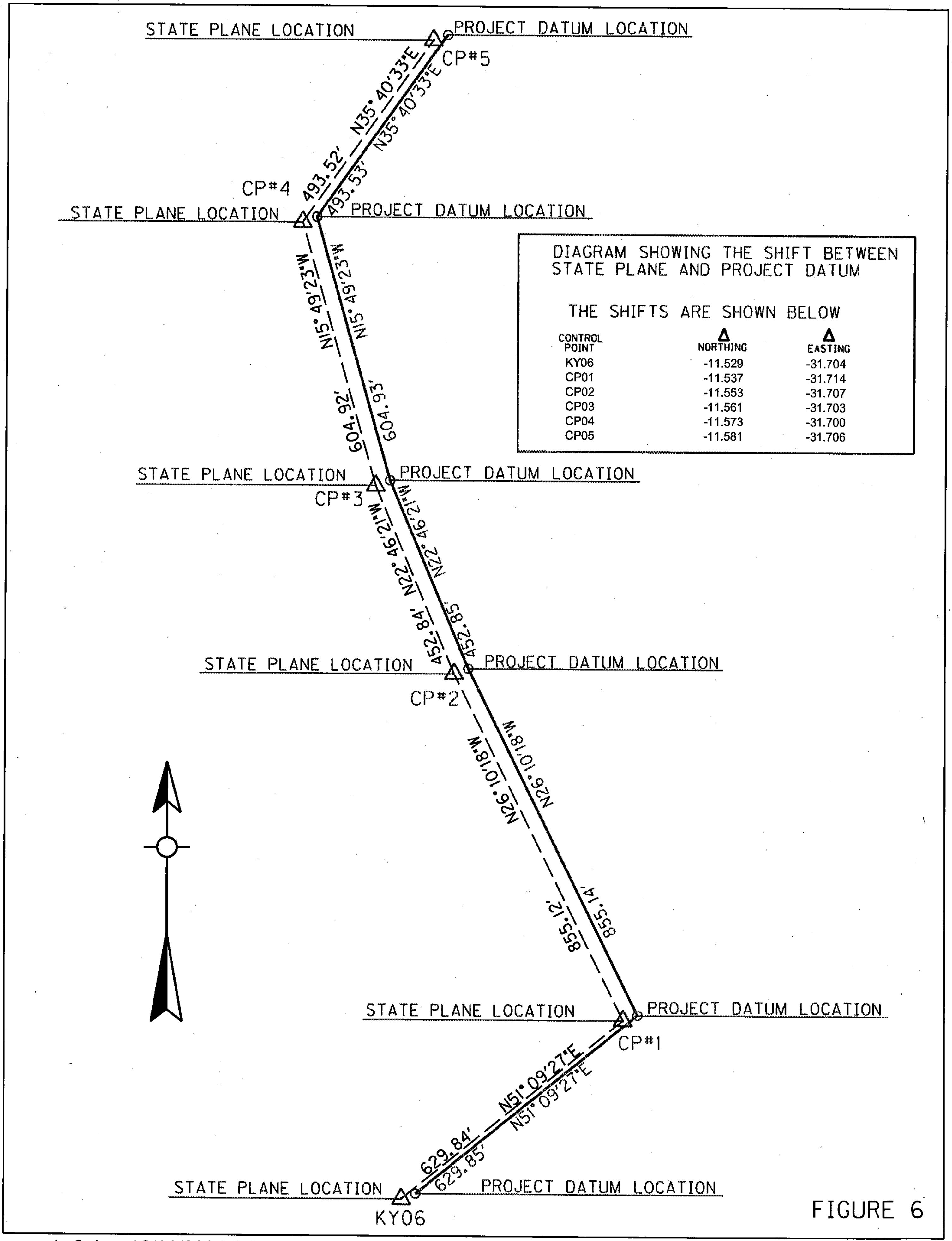


DIAGRAM SHOWING THE SHIFT BETWEEN
STATE PLANE AND PROJECT DATUM

THE SHIFTS ARE SHOWN BELOW

CONTROL POINT	Δ NORTHING	Δ EASTING
KY06	-11.529	-31.704
CP01	-11.537	-31.714
CP02	-11.553	-31.707
CP03	-11.561	-31.703
CP04	-11.573	-31.700
CP05	-11.581	-31.706

FIGURE 6

Department Control Monument Sheet

The following page shows a sample control monument sheet that we require our aerial consultants to fill out for the control they establish for highway projects. It contains all the necessary information that should be needed for that particular monument.

A digital copy can be obtained as follows:

access the KYTC web site (**http://transportation.ky.gov/**)

click on **Forms Library**

click on the name Highway Design to open. Select the **Control Monument Information Sheet** or **tc61514.exe** file

TC 61-514E
04/04

KENTUCKY TRANSPORTATION CABINET
DEPARTMENT OF HIGHWAY
DIVISION OF HIGHWAY DESIGN

CONTROL MONUMENT INFORMATION SHEET

SURVEY COORDINATION

SITE/QUAD	STATION DESCRIPTION (COMPLETE DESCRIPTION REQUIRED) (TYPE, SIZE, DEPTH SET, etc.)				STATION DESIGNATION
LOCALITY/COUNTY					STAMPING ON MARK
DATE SET OR FOUND (DATE, with S or F)	LATITUDE	LONGITUDE	HORIZ. DATUM	ZONE	VERT.DATUM
SET ☐ FOUND ☐	NORTHING (STATE PLANE) (US SURVEY FEET)	EASTING (STATE PLANE) (US SURVEY FEET)	ELEVATION	(CHECK ONLY ONE) GPS DERIVED ☐ DIFF. LEVELS ☐	ORDER ACCURACY
PERSON FILLING OUT FORM	NORTHING (PROJECT DATUM) (US SURVEY FEET)	EASTING (PROJECT DATUM (US SURVEY FEET)	GEOID MODEL	ELLIPSOID HEIGTH	OTHER INFO.
ESTAB. BY AGENCY	PROJECT FACTOR	BACK STATION I.D.	GROUND AZIMUTH & DISTANCE TO BACK STATION		
SCALE FACTOR	ELEVATION FACTOR	AHEAD STATION I.D.	GROUND AZIMUTH & DISTANCE TO AHEAD STATION		
KENTUCKY REGISTERED LAND SURVEYOR IN CHARGE OF MONUMENTATION				KENTUCKY REGISTRATION NO.	

GIVE A COMPLETE SKETCH AND LOCATION DESCRIPTION SO MONUMENT MAY BE RECOVERED BY OTHERS

Coordinate Conversion

International Foot and US Survey Foot Definitions

1) **When converting metric coordinates, be aware of these differences.**
2) **Make sure the data controller is set to US Survey Foot before uploading coordinates that may have been exported from other software (i.e. Inroads Survey)**
3) **Make sure that the coordinates that were exported from another software were US Survey Foot.**

Please be aware there are **two** definitions. They are:

US Survey Foot	**International Foot**
1 meter = 39.37 inches exact	1 inch = 2.54 centimeters

The meters to feet conversion, to **12 significant figures** is:

1 meter = (3937/1200) feet **= 3.28083333333 feet**	1 meter = (1250/381) feet = 3.28083989501 feet

Results in conversion do not differ between the two definitions until the digits reach the 6th or 7th significant figure, depending on the number being converted.

For example, if you had assumed coordinates in metric of 5000.00,10000.00

US Survey Foot Northing would be (5000.00*3.28083333333) = **16,404.17ft.**

International Foot Northing would be (5000.00*3.28083989501) = **16,404.20 ft**.

A difference of only 0.03 feet in this situation

Now if Metric State Plane Coordinates are used.

Northing = 500,000m Easting = 500,000m

Converting these using the US Survey Foot definition:
Northing = 1,640,416.67 ft. Easting = 1,640,416.67 ft.

Converting these using the International Foot definition:
Northing = 1,640,419.95 Easting = 1,640,419.95 ft.

Notice that there is now a difference greater than 3 feet.

It is obvious that the differences become significant when larger numbers are used. Be aware of these differences.

Remember:

The state of Kentucky, and the Transportation Cabinet uses the US Survey Foot Definition

Differences between NAD27 and NAD83

The former NAD27 System was based on US Survey feet. Be aware, when you convert NAD83 metric coordinates to US Survey feet, they are not automatically NAD27 Coordinates. A conversion does not get you from one system to another, but a transformation has to be performed to accomplish this. The software CORPSCON or NADCON from NGS has to be utilized in order for you to accomplish this. Also, be sure you understand your project accuracy requirements before using coordinates obtained from a transformation

Summary

Hopefully, this manual will help answer some of the questions that you may have had about state plane and project datum coordinates. There are several other aspects of the state plane coordinate system that were not covered on this manual. We are only using the system in a limited way, therefore, the full explanation of the state plane coordinate system was not necessary. If you would like to learn more of the state plane coordinate system, the reference listed below is strongly recommended. If you have any questions about this manual or questions in general about this information please contact Perry Semones @ (502) 564-3280.

References

State Plane Coordinates in Modern Surveying Practice
by R.B. Buckner

Kentucky Single Zone Coordinate System
By Bryan Bunch, PLS, PG
Natural Resources Cabinet