STATE PLANE COORDINATES
Washington State

Washington State Land Surveyors Association

Larry Signani

13 March 2007

SURVEY TYPES

- Surveys can be grouped into two categories:
- 1. Plane Surveys
- 2. Geodetic Surveys

A survey of a small area in which the area surveyed is considered flat except for topographic variations, is termed a plane survey and this branch of surveying is called Plane Surveying,.

When a survey covers a large portion of the earth, the curvature of the earth has to be considered. Surveys of this type cannot be mapped on plane sheets of paper without distortions. These are called Geodetic Surveys, the position of points are indicated either by spherical coordinates , namely Latitude and Longitude, or by Plane Coordinates after projecting onto a plan surface, E.G., State Plane Coordinates

SURVEY TYPES

- Plane Surveys
- assume earth's surface is flat plane
- use X-Y coordinates
- easy procedures and computations
- sufficient for most surveys

- Geodetic Surveys
- accurately represent earth's shape
- use spheroid coordinates (Latitude, Longitude)
- more complex, expensive, difficult computations

GEOCENTRIC AND GEOGRAPHICAL

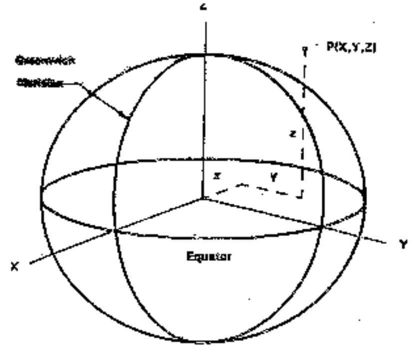


Figure 1. Geocentric Coordinate System

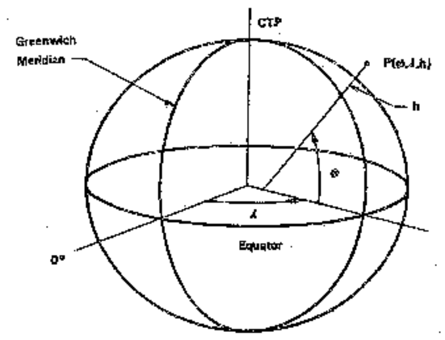
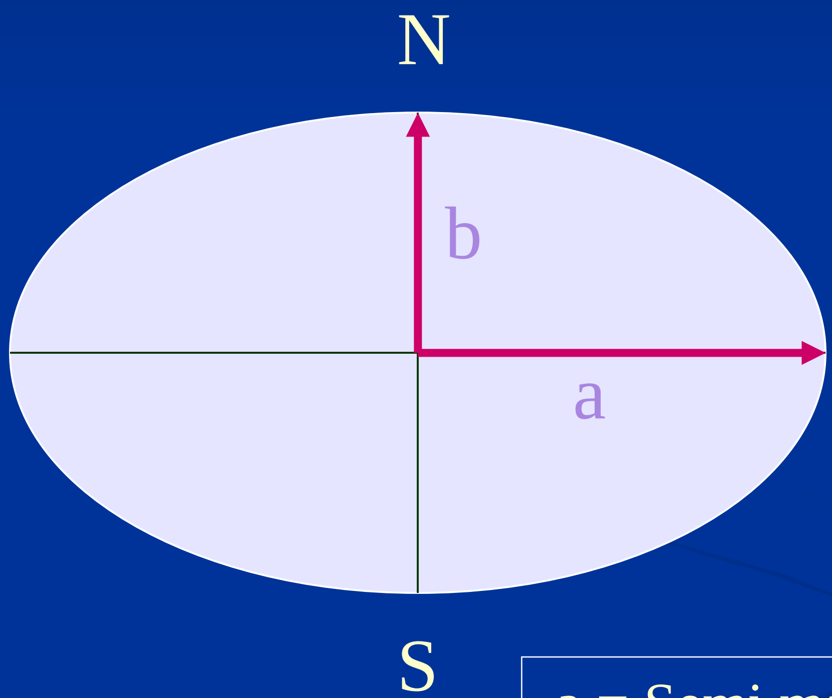


Figure 2. Geographical Coordinate System

LATITUDE & LONGITUDE

LATITUDE AND LONGITUDE

THE ELLIPSOID MATHEMATICAL MODEL OF THE EARTH

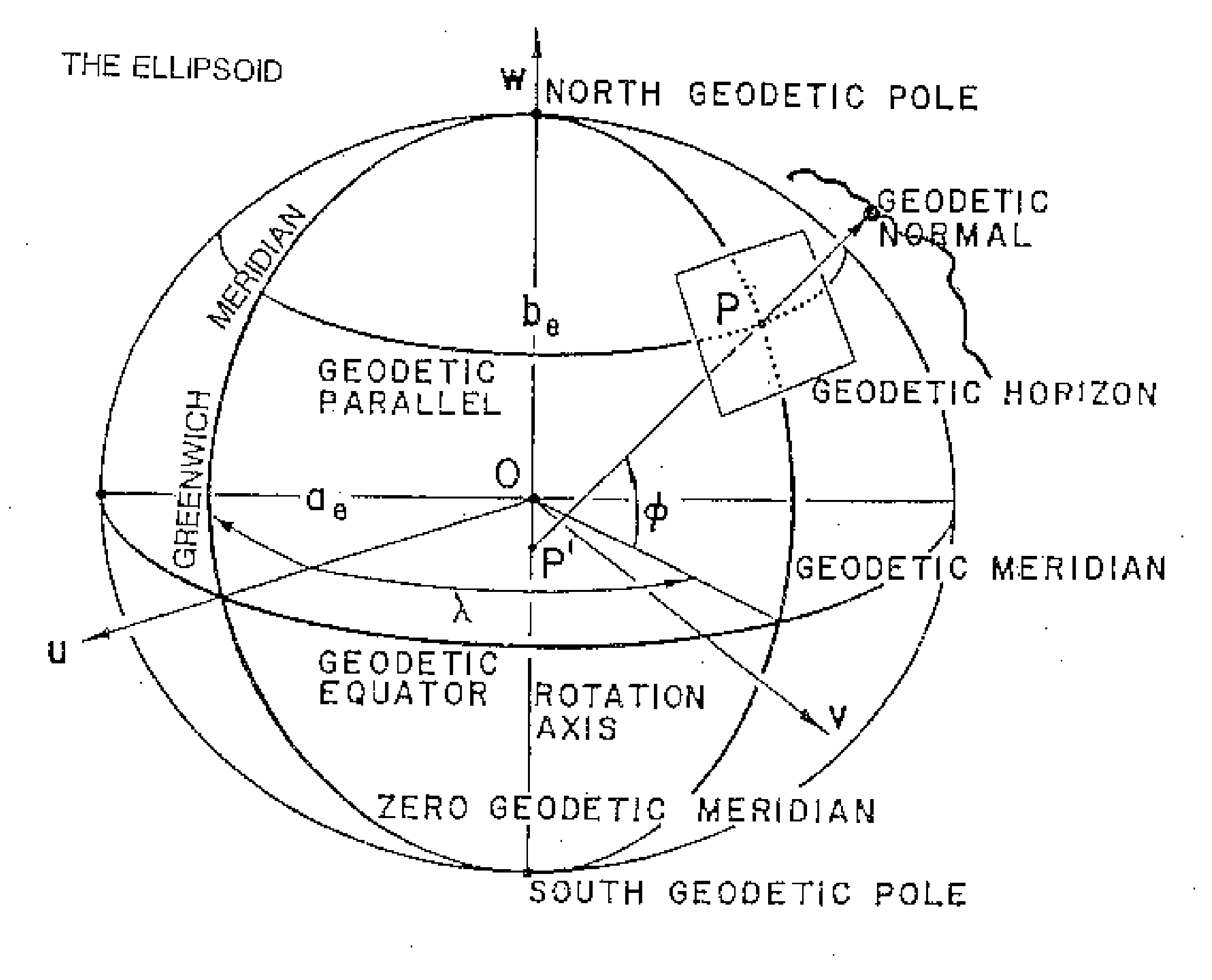


a = Semi major axis

b = Semi minor axis

$f = \frac{a-b}{a}$ = Flattening

THE ELLIPSOID



UNITED STATES ELLIPSOID DEFINITIONS

BESSEL 1841
a = 6,377,397.155 m 1/f = 299.1528128

CLARKE 1866
a = 6,378,206.4 m 1/f = 294.97869821

GEODETIC REFERENCE SYSTEM 1980 - (GRS 80)
a = 6,378,137 m 1/f = 298.257222101

WORLD GEODETIC SYSTEM 1984 - (WGS 84)
a = 6,378,137 m 1/f = 298.257223563

THE ELLIPSOID

(1738)6,397,3006,363,806.283191FranceEverest

(1830)6,377,563.3966,356,256.909299.3249646BritainBessel

(1866)6,378,206.46,356,583.8294.9786982North AmericaClarke

(1880)6,378,249.1456,356,514.870293.465France, AfricaHelmert

(1969)6,378,1606,356,774.719298.25South AmericaWGS-72

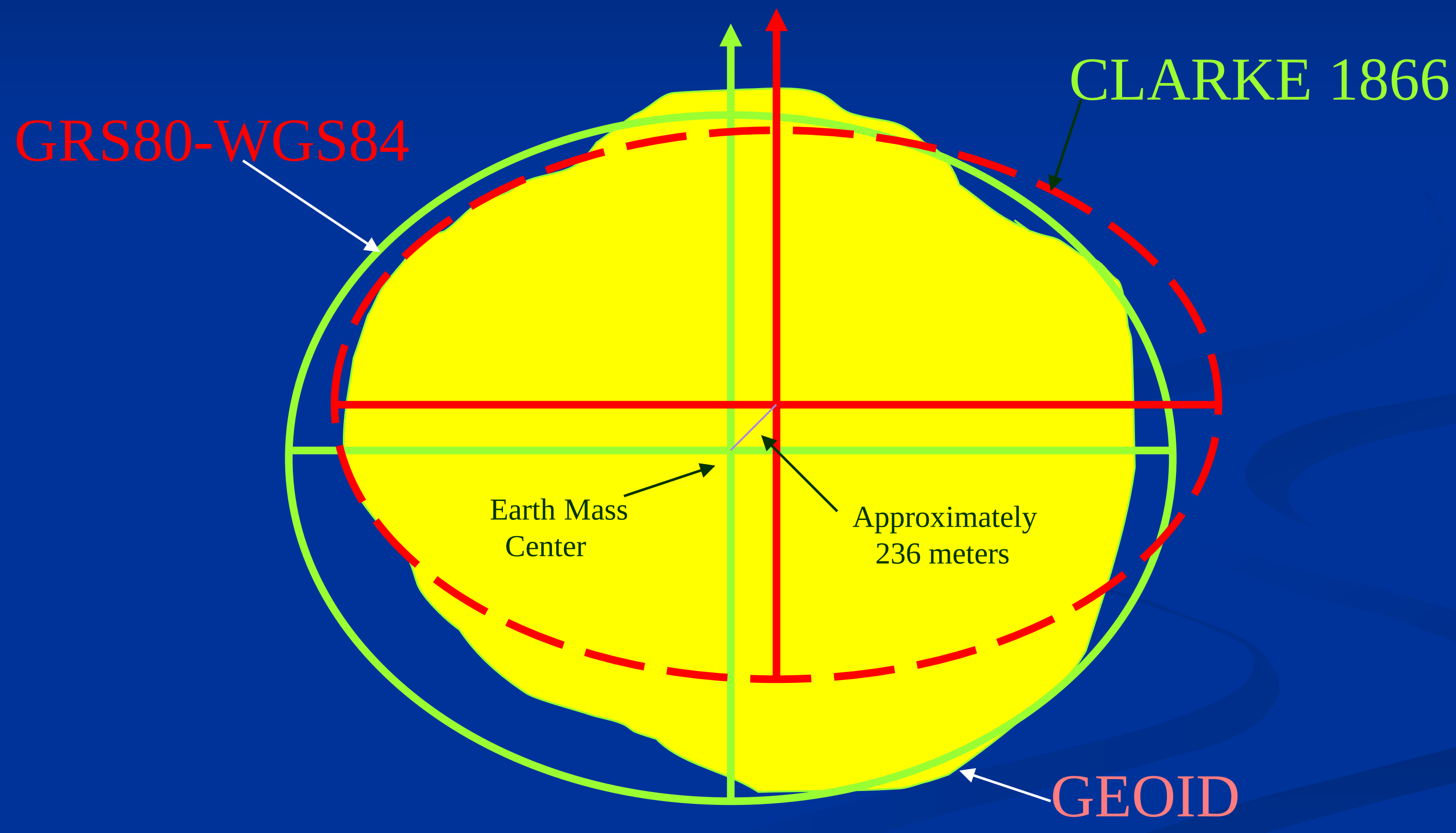
(1972)6,378,1356,356,750.52298.26USA/DoDGRS-80

(1979)6,378,1376,356,752.3141298.257222101NAD 83

(1982)6,378,1376,356,752.3298.257024899N AmericaWGS-84

(2003)6,378,136.66,356,751.9298.25642Global ITRS

THE GEOID AND TWO ELLIPSOIDS



DATUMS

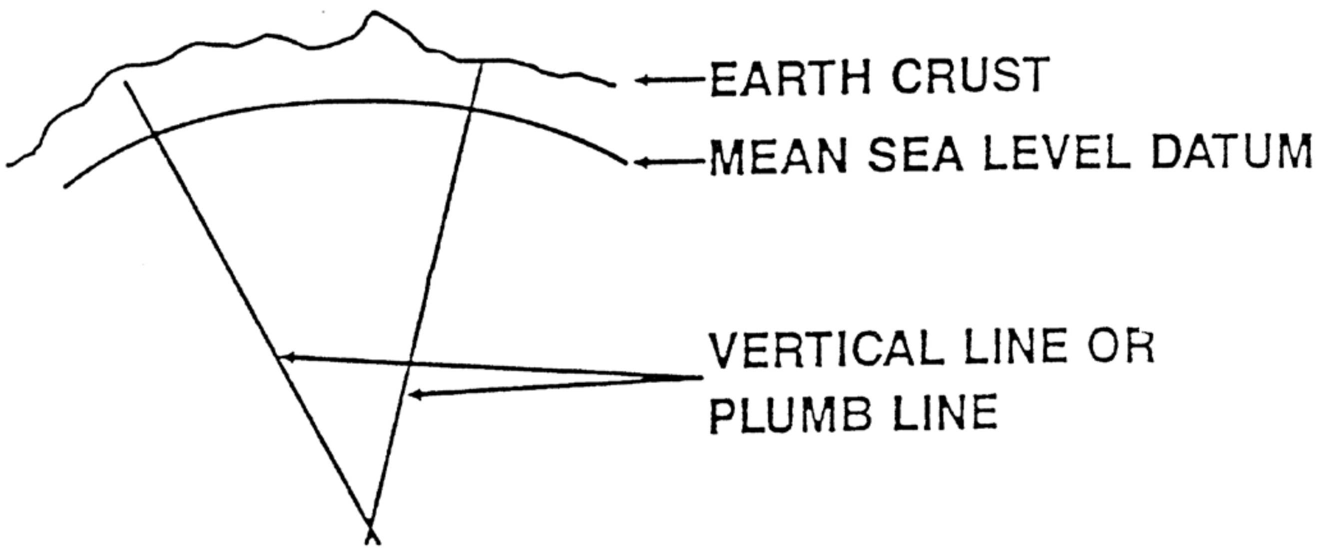
A set of constants specifying the coordinate system used for geodetic control, i.e., for calculating coordinates of points on the Earth. Specific geodetic datums are usually given distinctive names. (e.g., North American Datum of 1983, European Datum 1950, National Geodetic Vertical Datum of 1929)

DATUM

US Army Corp
of Engineers

GEODESY OVERVIEW

DATUM:
ANY LEVEL OR CURVED SURFACE (REAL OR IMAGINARY) TO WHICH MARKS ARE REFERENCE TO.



VERTICAL DATUMS

MEAN SEA LEVEL DATUM OF 1929

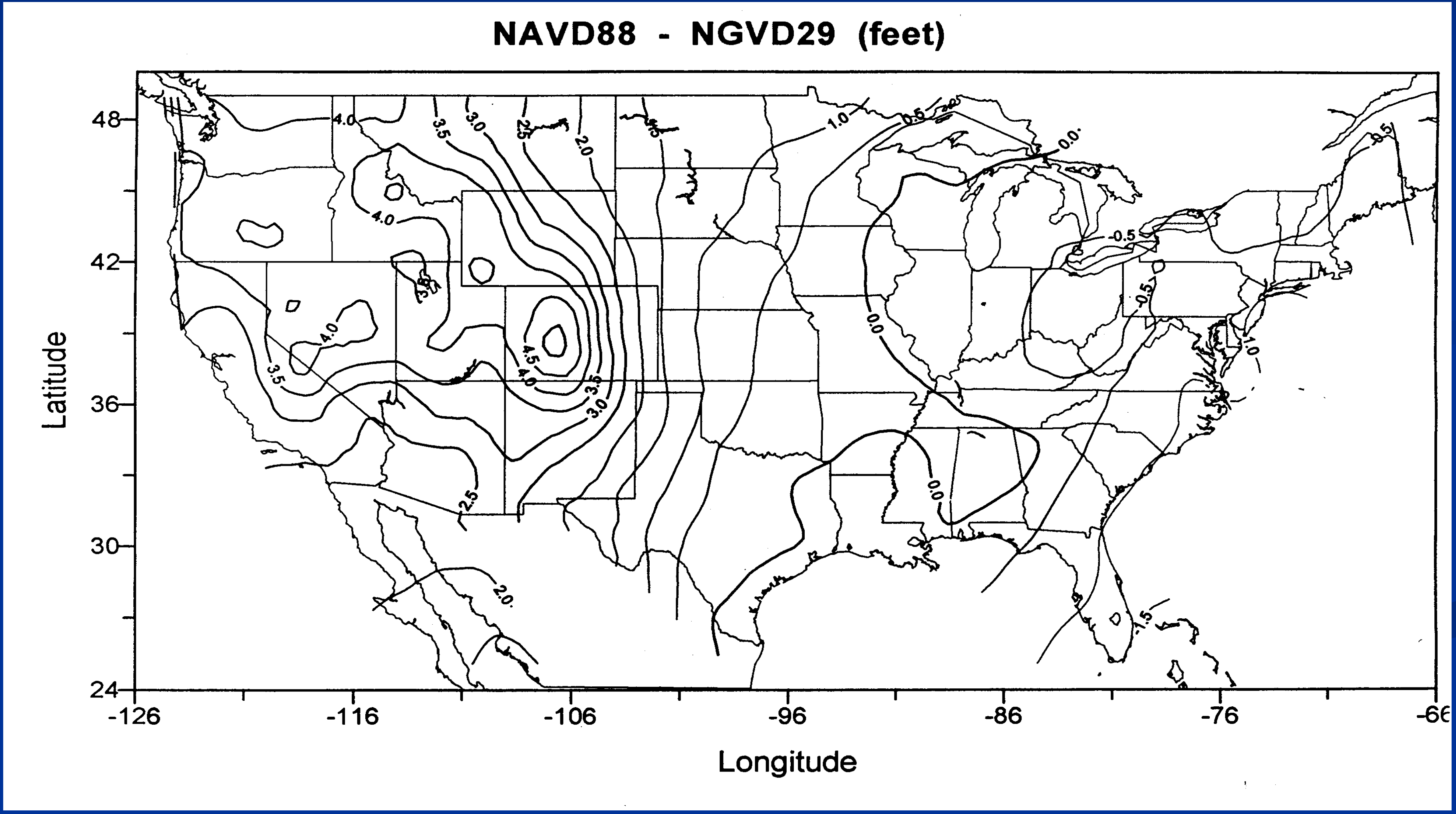
NATIONAL GEODETIC VERTICAL DATUM OF 1929

(As of July 2, 1973)

NORTH AMERICAN VERTICAL DATUM OF 1988

(As of June 24, 1993)

NGVD 29 and NAVD 88



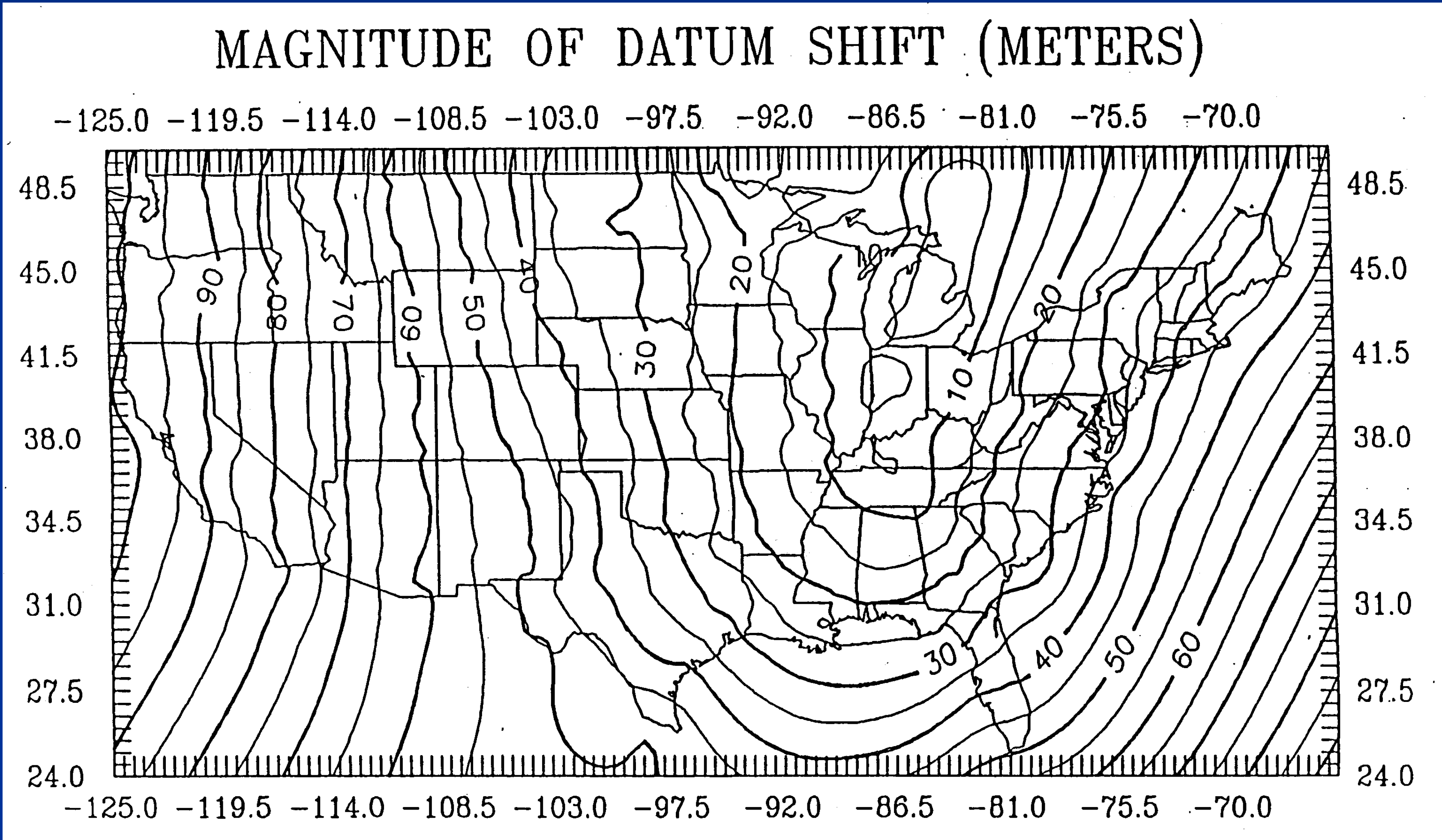
COMPARISON OF VERTICAL DATUM ELEMENTS

	NGVD 29	**NAVD 88**
DATUM DEFINITION	26 TIDE GAUGES IN THE U.S. & CANADA	FATHER'S POINT/RIMOUSKI QUEBEC, CANADA
BENCH MARKS	100,000	450,000
LEVELING (Km)	102,724	1,001,500
GEOID FITTING	Distorted to Fit MSL Gauges	Best Continental Model

COMPARISON OF DATUM ELEMENTS

	NAD 27	NAD 83
ELLIPSOID	CLARKE 1866 a = 6,378,206.4 m 1/f = 294.9786982	GRS80 a = 6,378,137. M 1/f = 298.257222101
DATUM POINT	Triangulation Station MEADES RANCH, KANSAS	NONE EARTH MASS CENTER
ADJUSTMENT	25k STATIONS Several Hundred Base Lines Several Hundred Astro Azimuths	250k STATIONS Appox. 30k EDMI Base Lines 5k Astro Azimuths Doppler Point Positions VLBI Vectors
BEST FITTING	North America	World-Wide

NAD 27 and NAD 83



HIGH ACCURACY REFERENCE NETWORKS

"GPSABLE"

Clear Horizons for Satellite Signal Acquisition

EASY ACCESSIBILITY

Few Special Vehicle or Property Entrance Requirements

REGULARLY SPACED

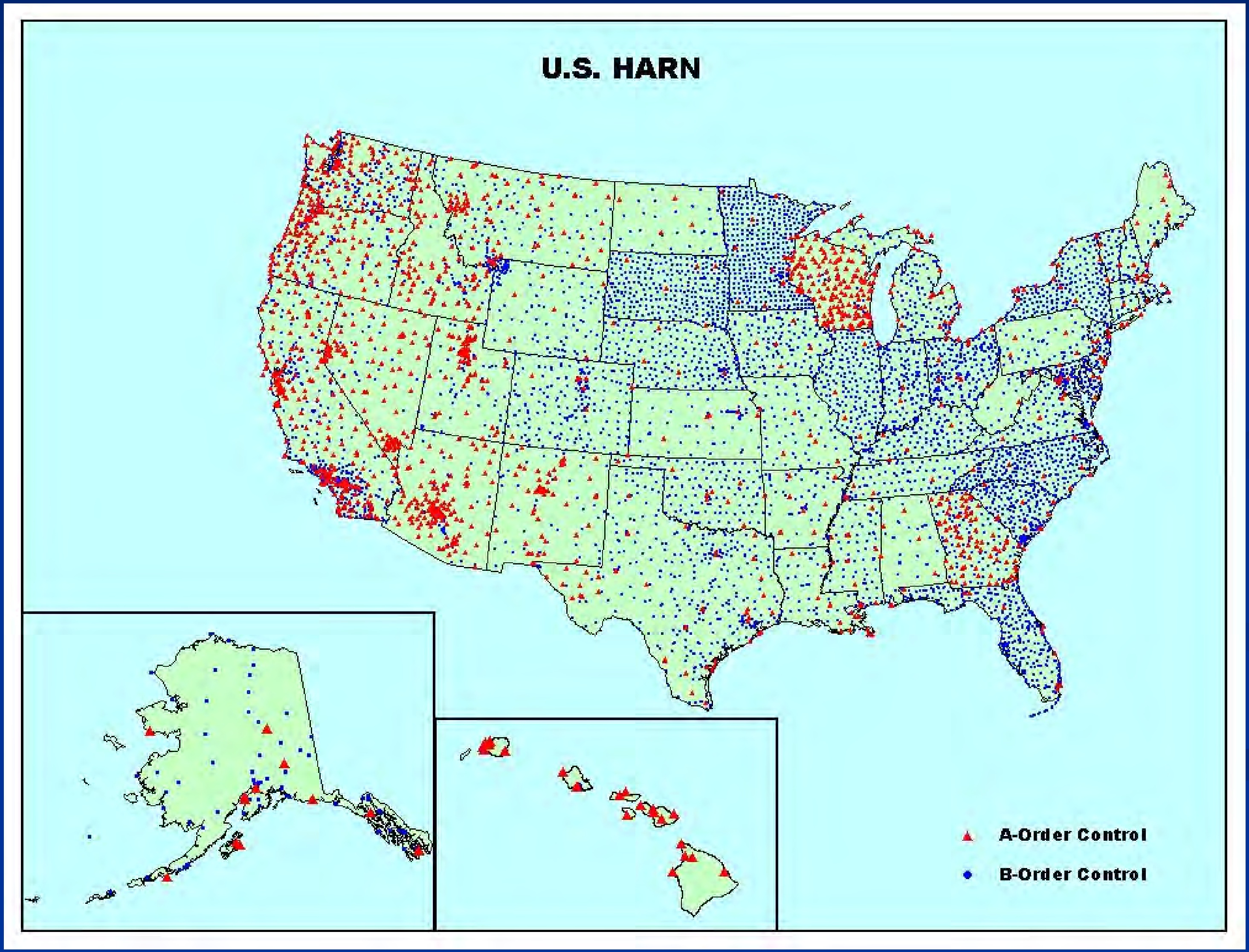
Always within 20-100 Km

HIGH HORIZONTAL ACCURACY

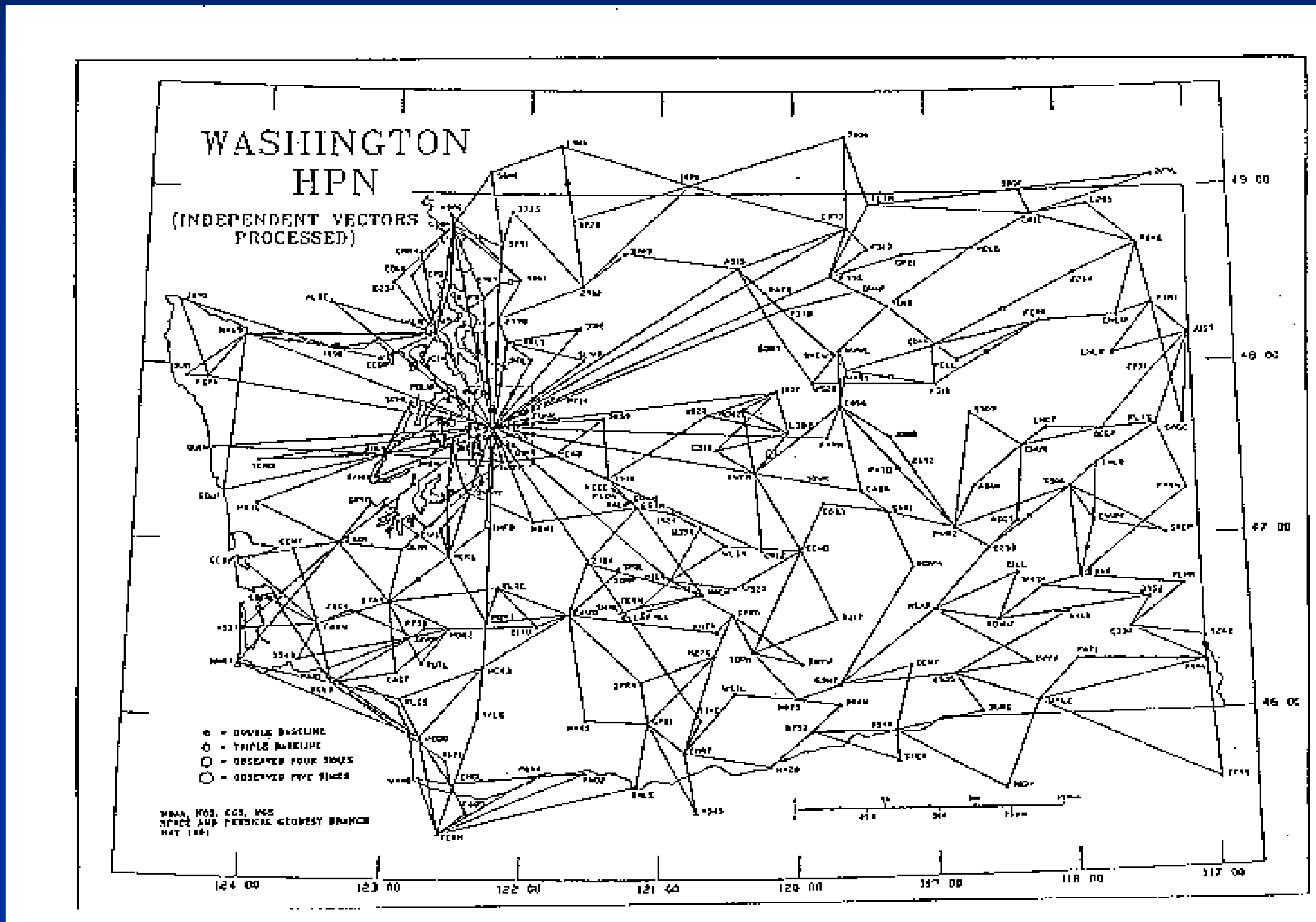
A-Order (5 mm + 1:10,000,000)

B-Order (8mm + 1:1,000,000)

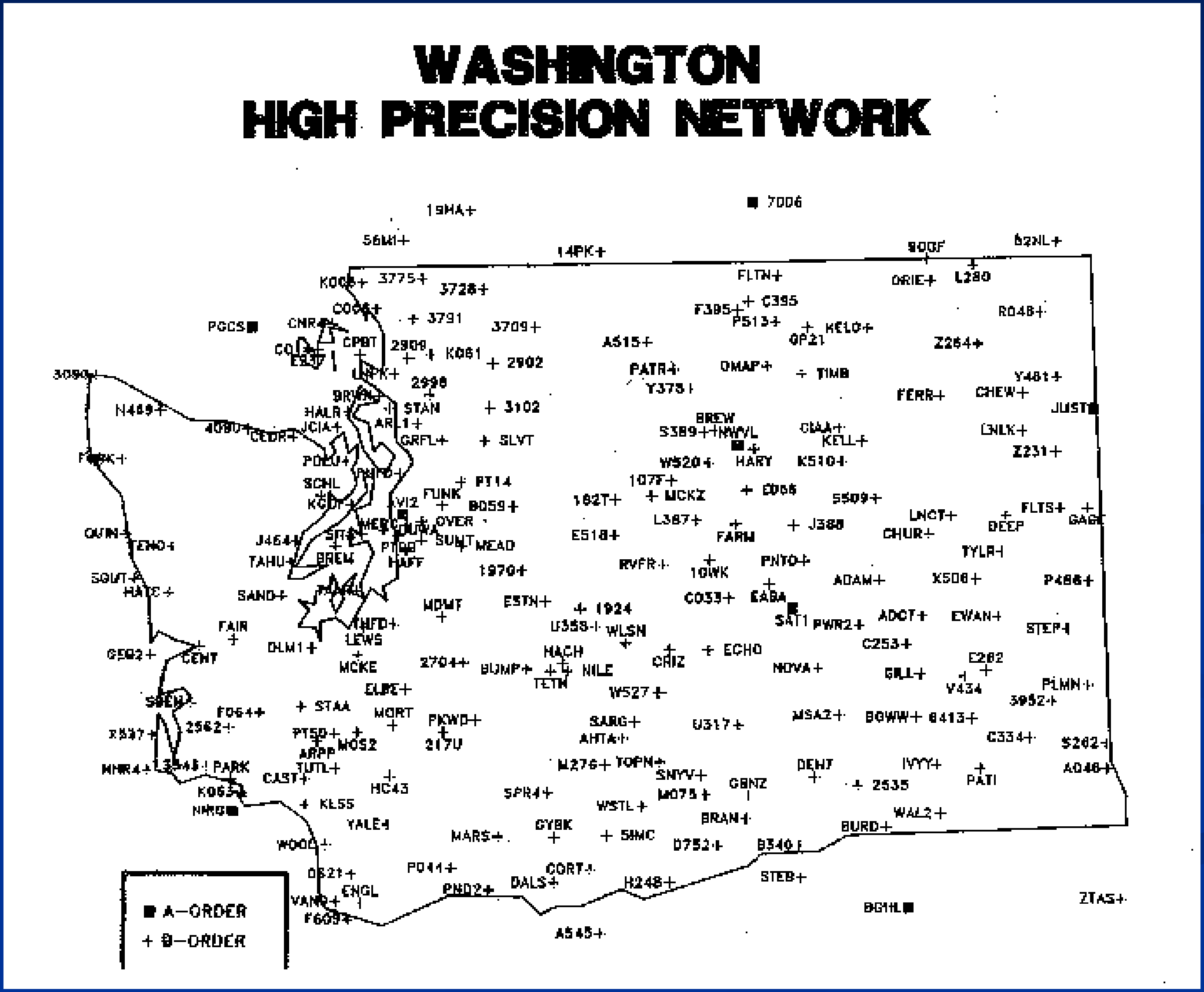
HIGH ACCURACY REFERENCE NETWORKS



HARN



HARN


WASHINGTON
HIGH PRECISION NETWORK
■ A–ORDER
+ B–ORDER
7006
19MA
56MI
14PK
BOGF
B2NL
FLTN
ORIE
L280
3775
3728
C395
F395
P513
KELO
R048
PGCS
3791
3709
A515
Z264
K061
2902
PATR
OMAP
TIMB
3090
2998
Y481
FERR
CHEW
N449
STAN
3102
BREW
JUST
4090
CEDR
GRFL
SLVT
NWVL
KELL
CNLK
Z231
HARY
K510
PT14
107F
MCKZ
E066
5509
FUNK
B059
182T
L387
J388
LNCT
FLTS
DEEP
OVER
E518
FARM
CHUR
QUIN
J464
SUNT
MEAD
TYLR
TAHU
BREM
RVFR
10WK
PNTO
ADAM
X506
P488
SAND
1970
C033
EABA
SGUT
HATC
MDMT
ESTN
1924
SAT1
PWR2
ADOT
EWAN
STEP
FAIR
U358
WLSN
C253
G592
CENT
DLM1
LEWS
HACH
ECHO
E262
MCKE
2704
BUMP
NILE
CRIZ
NOVA
GILL
PLMN
TETH
W527
V434
3952
F064
STAA
MORT
PKWD
SARG
U317
MSA2
BOWW
6413
X537
2562
PT50
MOS2
217U
AHTA
C334
S262
ARPP
M276
TOPN
DENT
IVYY
NHR4
PARK
TUTL
SNYV
GBNZ
2535
PATI
A046
CAST
HC43
SPR4
M075
K063
KL55
WSTL
WAL2
YALE
GYBK
BRAN
BURD
WOOD
MARS
SIMC
D752
B340
O821
PO41
CORT
STEB
ENGL
PND2
DALS
H248
VANO
F609
BGHL
ZTAS
A545

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
DATABASE =  ,PROGRAM = datasheet, VERSION = 7.58
1        National Geodetic Survey,   Retrieval Date = MARCH 10, 2008
 DG9672 ***********************************************************************
 DG9672  DESIGNATION -  ARC
 DG9672  PID         -  DG9672
 DG9672  STATE/COUNTY-  WA/THURSTON
 DG9672  USGS QUAD   -  TUMWATER (1994)
 DG9672
 DG9672                        *CURRENT SURVEY CONTROL
 DG9672  ___________________________________________________________________
 DG9672* NAD 83(1986)-  47 00 26.     (N)    122 54 34.     (W)     SCALED
 DG9672* NAVD 88     -        53.014  (meters)     173.93   (feet)  ADJUSTED
 DG9672  ___________________________________________________________________
 DG9672  GEOID HEIGHT-         -21.36  (meters)                      GEOID03
 DG9672  DYNAMIC HT  -          53.024 (meters)     173.96   (feet)  COMP
 DG9672  MODELED GRAV-     980,809.7   (mgal)                        NAVD 88
 DG9672
 DG9672  VERT ORDER  -  SECOND    CLASS I
 DG9672
 DG9672.The horizontal coordinates were scaled from a topographic map and have
 DG9672.an estimated accuracy of +/- 6 seconds.
 DG9672
 DG9672.The orthometric height was determined by differential leveling
 DG9672.and adjusted in July 2005.
 DG9672
 DG9672.The geoid height was determined by GEOID03.
 DG9672
 DG9672.The dynamic height is computed by dividing the NAVD 88
 DG9672.geopotential number by the normal gravity value computed on the
 DG9672.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
 DG9672.degrees latitude (g = 980.6199 gals.).
 DG9672
 DG9672.The modeled gravity was interpolated from observed gravity values.
 DG9672
 DG9672;                   North         East     Units  Estimated Accuracy
 DG9672;SPC WA S     -   188,850.      316,810.     MT  (+/- 180 meters Scaled)
 DG9672
 DG9672                          SUPERSEDED SURVEY CONTROL
 DG9672
 DG9672.No superseded survey control is available for this station.
 DG9672
 DG9672_U.S. NATIONAL GRID SPATIAL ADDRESS: 10TET068059(NAD 83)
 DG9672_MARKER: F = FLANGE-ENCASED ROD
 DG9672_SETTING: 50 = ALUMINUM ALLOY ROD W/O SLEEVE (10 FT.+)
 DG9672_STAMPING: ARC 2004
 DG9672_MARK LOGO: WADT
 DG9672_PROJECTION: RECESSED 16 CENTIMETERS
 DG9672_MAGNETIC: O = OTHER; SEE DESCRIPTION
 DG9672_STABILITY: B = PROBABLY HOLD POSITION/ELEVATION WELL
 DG9672_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
 DG9672+SATELLITE: SATELLITE OBSERVATIONS - October 28, 2004
 DG9672_ROD/PIPE-DEPTH: 7.7  meters
 DG9672
```

The NGS Data Sheet

See file [dsdata.txt] for more information about the datasheet.

```
DATABASE =  ,PROGRAM = datasheet, VERSION = 7.58
1        National Geodetic Survey,   Retrieval Date = MARCH 10, 2008
 SY1599 ***********************************************************************
 SY1599  DESIGNATION -  A 461 RESET
 SY1599  PID         -  SY1599
 SY1599  STATE/COUNTY-  WA/THURSTON
 SY1599  USGS QUAD   -  TUMWATER (1994)
 SY1599
 SY1599                         *CURRENT SURVEY CONTROL
 SY1599  ___________________________________________________________________
 SY1599* NAD 83(1991)-  47 02 05.68216(N)    122 53 12.08665(W)     ADJUSTED
 SY1599* NAVD 88     -        20.889  (meters)      68.53   (feet)  ADJUSTED
 SY1599  ___________________________________________________________________
 SY1599  X           -  -2,364,592.757 (meters)                     COMP
 SY1599  Y           -  -3,656,966.266 (meters)                     COMP
 SY1599  Z           -   4,644,410.470 (meters)                     COMP
 SY1599  LAPLACE CORR-          -9.56  (seconds)                    DEFLEC99
 SY1599  ELLIP HEIGHT-          -0.560 (meters)          (08/17/92) ADJUSTED
 SY1599  GEOID HEIGHT-         -21.53  (meters)                     GEOID03
 SY1599  DYNAMIC HT  -          20.893 (meters)      68.55  (feet)  COMP
 SY1599  MODELED GRAV-     980,802.9   (mgal)                       NAVD 88
 SY1599
 SY1599  HORZ ORDER  -  FIRST
 SY1599  VERT ORDER  -  FIRST     CLASS II
 SY1599  ELLP ORDER  -  FOURTH    CLASS II
 SY1599
 SY1599.The horizontal coordinates were established by GPS observations
 SY1599.and adjusted by the National Geodetic Survey in August 1992.
 SY1599
 SY1599.The orthometric height was determined by differential leveling
 SY1599.and adjusted in June 1991.
 SY1599
 SY1599.The X, Y, and Z were computed from the position and the ellipsoidal ht.
 SY1599
 SY1599.The Laplace correction was computed from DEFLEC99 derived deflections.
 SY1599
 SY1599.The ellipsoidal height was determined by GPS observations
 SY1599.and is referenced to NAD 83.
 SY1599
 SY1599.The geoid height was determined by GEOID03.
 SY1599
 SY1599.The dynamic height is computed by dividing the NAVD 88
 SY1599.geopotential number by the normal gravity value computed on the
 SY1599.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
 SY1599.degrees latitude (g = 980.6199 gals.).
 SY1599
 SY1599.The modeled gravity was interpolated from observed gravity values.
 SY1599
 SY1599;                    North         East     Units Scale Factor Converg.
 SY1599;SPC WA S     -   191,878.267   318,633.710   MT  0.99994540   -1 44 01.3
 SY1599;SPC WA S     -   629,520.61  1,045,384.10   sFT  0.99994540   -1 44 01.3
 SY1599;UTM  10      - 5,209,049.963   508,608.789   MT  0.99960091   +0 04 58.5
 SY1599
```

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
DATABASE = Sybase ,PROGRAM = datasheet, VERSION = 7.42
1        National Geodetic Survey,   Retrieval Date = FEBRUARY  2, 2007
 SY5645 ***********************************************************************
 SY5645  FBN          -  This is a Federal Base Network Control Station.
 SY5645  DESIGNATION -  FAIR
 SY5645  PID          -  SY5645
 SY5645  STATE/COUNTY-  WA/GRAYS HARBOR
 SY5645  USGS QUAD    -  ELMA (1981)
 SY5645
 SY5645                         *CURRENT SURVEY CONTROL
 SY5645  ___________________________________________________________________
 SY5645* NAD 83(1998)-  47 00 52.55462(N)    123 22 35.28791(W)     ADJUSTED
 SY5645* NAVD 88     -        32.316  (meters)     106.02   (feet)  ADJUSTED
 SY5645  ___________________________________________________________________
 SY5645  X           -  -2,396,679.778 (meters)                     COMP
 SY5645  Y           -  -3,638,005.919 (meters)                     COMP
 SY5645  Z           -   4,642,879.264 (meters)                     COMP
 SY5645  LAPLACE CORR-         10.40   (seconds)                    DEFLEC99
 SY5645  ELLIP HEIGHT-         10.65   (meters)         (03/21/00) GPS OBS
 SY5645  GEOID HEIGHT-        -21.66   (meters)                     GEOID03
 SY5645  DYNAMIC HT  -         32.322 (meters)     106.04  (feet)  COMP
 SY5645  MODELED GRAV-    980,791.2   (mgal)                       NAVD 88
 SY5645
 SY5645  HORZ ORDER  -  A
 SY5645  VERT ORDER  -  SECOND    CLASS II
 SY5645  ELLP ORDER  -  THIRD     CLASS II
 SY5645
 SY5645.The horizontal coordinates were established by GPS observations
 SY5645.and adjusted by the National Geodetic Survey in March 2000..
 SY5645.This is a SPECIAL STATUS position.  See SPECIAL STATUS under the
 SY5645.DATUM ITEM on the data sheet items page.
 SY5645
 SY5645.The orthometric height was determined by differential leveling
 SY5645.and adjusted by the National Geodetic Survey in April 1995..
 SY5645
 SY5645.The X, Y, and Z were computed from the position and the ellipsoidal ht.
 SY5645
 SY5645.The Laplace correction was computed from DEFLEC99 derived deflections.
 SY5645
 SY5645.The ellipsoidal height was determined by GPS observations
 SY5645.and is referenced to NAD 83.
 SY5645
 SY5645.The geoid height was determined by GEOID03.
 SY5645
 SY5645.The dynamic height is computed by dividing the NAVD 88
 SY5645.geopotential number by the normal gravity value computed on the
 SY5645.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
 SY5645.degrees latitude (g = 980.6199 gals.).
 SY5645
 SY5645.The modeled gravity was interpolated from observed gravity values.
 SY5645
 SY5645;                    North         East     Units Scale Factor Converg.
 SY5645;SPC WA S     -   190,863.335   281,347.893   MT  0.99994268   -2 05 22.0
```

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
DATABASE =  ,PROGRAM = datasheet, VERSION = 7.58
1        National Geodetic Survey,   Retrieval Date = MARCH 10, 2008
 SY3193 ***********************************************************************
 SY3193  DESIGNATION -  HOSP RM 4 1974
 SY3193  PID         -  SY3193
 SY3193  STATE/COUNTY-  WA/THURSTON
 SY3193  USGS QUAD   -  LACEY (1994)
 SY3193
 SY3193                         *CURRENT SURVEY CONTROL
 SY3193  ___________________________________________________________________
 SY3193* NAD 83(1991)-  47 02 47.82141(N)    122 51 09.07491(W)     ADJUSTED
 SY3193* NAVD 88     -        50.4    (meters)     165.     (feet)  VERTCON
 SY3193  ___________________________________________________________________
 SY3193  LAPLACE CORR-          -9.04  (seconds)                    DEFLEC99
 SY3193  GEOID HEIGHT-         -21.68  (meters)                     GEOID03
 SY3193  HORZ ORDER  -  SECOND
 SY3193
 SY3193.The horizontal coordinates were established by classical geodetic methods
 SY3193.and adjusted by the National Geodetic Survey in December 1991.
 SY3193
 SY3193.The NAVD 88 height was computed by applying the VERTCON shift value to
 SY3193.the NGVD 29 height (displayed under SUPERSEDED SURVEY CONTROL.)
 SY3193
 SY3193.The Laplace correction was computed from DEFLEC99 derived deflections.
 SY3193
 SY3193.The geoid height was determined by GEOID03.
 SY3193
 SY3193;                    North         East     Units Scale Factor Converg.
 SY3193;SPC WA S     -   193,100.914   321,268.335   MT  0.99994703   -1 42 31.9
 SY3193;SPC WA S     -   633,531.92  1,054,027.86   sFT  0.99994703   -1 42 31.9
 SY3193;UTM  10      - 5,210,355.068   511,202.434   MT  0.99960154   +0 06 28.6
 SY3193
 SY3193!             -  Elev Factor  x  Scale Factor =  Combined Factor
 SY3193!SPC WA S     -   0.99999549  x   0.99994703  =   0.99994252
 SY3193!UTM  10      -   0.99999549  x   0.99960154  =   0.99959703
 SY3193
 SY3193                          SUPERSEDED SURVEY CONTROL
 SY3193
 SY3193  NAD 83(1986)-  47 02 47.81920(N)    122 51 09.08485(W) AD(       ) 2
 SY3193  NAD 27      -  47 02 48.46856(N)    122 51 04.58400(W) AD(       ) 2
 SY3193  NGVD 29 (07/19/86)   49.4     (m)          162.      (f) VERT ANG
 SY3193
```

Washington State Department of Transportation

Geographic Services

SURVEY INFORMATION SYSTEM

Report of Survey Mark

GENERAL MONUMENT INFORMATION

Designation:	GP34005-2
Monument ID:	193
State:	WASHINGTON
County:	THURSTON
Region:	OL
Nearest Town:	OLYMPIA
Usgs Quad:	LACEY

T.R.S:	18N, 1W , 18
Corner Code:	
State Route:	005
Mile Post:	107.900
Station:	
Offset:	
Owner:	GS
Bearing:	M

ACCOUNTS INFORMATION

BOOK	PROJECT	INVOICE
224	MS5400	23-05032
233	MS5400	23-05032
55	0L1550	23-92009

Description

THE STATION IS LOCATED IN THE CITY OF OLYMPIA. IT IS LOCATED IN THE NORTHWEST QUADRANT OF THE LILLY ROAD UNDERCROSSING OF SR 005, 8.2 METERS SOUTH OF THE NORTH END OF THE WEST SIDEWALK AND 1.2 METERS WEST OF THE EAST EDGE OF THE SIDEWALK. THE MARK IS A BRASS DISK CEMENTED INTO A DRILL HOLE IN THE CONCRETE SIDEWALK SET LEVEL WITH ITS SURFACE. * NOTE: UPDATED BY G.P.S. CONSTRAINED TO H.P.N. *

CURRENT SURVEY CONTROL

DATUM	LATITUDE	UNIT	LONGTITUDE	UNIT	NETWORK	METHOD	ACCURACY
NAD 83/91	47 02 40.113905	N	122 50 39.990669	W	PRIMARY	GPS	2 CM
	ELLIP HGT						
NAD 83	44.576	M				GPS	5 CM
	ORTHO HGT						
NAVD 88	66.116	M			PRIMARY	DIFF LEVELS	1 CM
SPC ZONE	**NORTHING**	**UNIT**	**EASTING**	**UNIT**	**SCALE**	**CONV.ANGLE**	**COMB.FACTOR**
S	192844.741	M	321874.875	M	0.99994673	-1 42 10.8	

Washington State Department of Transportation

Geographic Services

Survey Information System

Report of Survey Mark

GENERAL MONUMENT INFORMATION

Designation:	GP34005-1	**T.R.S:**	18N, 1W , 17	**ACCOUNTS INFORMATION**		
Monument ID:	192	**Corner Code:**		**BOOK**	**PROJECT**	**INVOICE**
State:	WASHINGTON	**State Route:**	005	224	MS5400	23-05032
County:	THURSTON	**Mile Post:**	108.400	233	MS5400	23-05032
Region:	OL	**Station:**		55	0L1550	23-92009
Nearest Town:	LACEY	**Offset:**				
Usgs Quad:	LACEY	**Owner:**	GS			
		Bearing:	M			

Description

Picture of Monument

THE STATION IS LOCATED IN THE CITY OF LACEY. IT IS LOCATED IN THE BRIDGE DECK NEAR THE APPROXIMATE CENTER LINE OF SLEATER-KINNEY AND SR 005, 12.2 METERS EAST OF THE WEST TRAFFIC BARRIER WALL AND 38 METERS SOUTH OF THE NORTH EXPANSION JOINT. THE MARK IS A BRASS DISK CEMENTED INTO A DRILL HOLE IN THE CONCRETE BRIDGE DECK AND SET LEVEL WITH ITS SURFACE. * NOTE: UPDATED BY G.P.S. CONSTRAINED TO H.P.N. *

CURRENT SURVEY CONTROL

DATUM	LATITUDE	UNIT	LONGTITUDE	UNIT	NETWORK	METHOD	ACCURACY
NAD 83/91	47 02 45.168733	N	122 50 01.449477	W	PRIMARY	GPS	2 CM
	ELLIP HGT						
NAD 83	46.633	M				GPS	5 CM
	ORTHO HGT						
NAVD 88	68.215	M			PRIMARY	DIFF LEVELS	1 CM
SPC ZONE	**NORTHING**	**UNIT**	**EASTING**	**UNIT**	**SCALE**	**CONV.ANGLE**	**COMB.FACTOR**
S	192976.641	M	322692.663	M	0.99994693	-1 41 42.8	

MONUMENTATION HISTORY

DATE	RECOVERED BY	CONDITION
07/01/1993	GEOGRAPHIC SERVICES	MONUMENTED
09/09/1997	GEOGRAPHIC SERVICES	GOOD
05/25/2006	GEOGRAPHIC SERVICES	UPDATED
08/25/2006	GEOGRAPHIC SERVICES	GOOD

SUPERSEDED CONTROL

DATUM	LATITUDE	UNIT	LONGTITUDE	UNIT	NETWORK	METHOD	ACCURACY
NAD 83/91	47 02 45.168509	N	122 50 01.449824	W	PRIMARY	GPS	2 CM
	ELLIP HGT						
NAD 83	46.637	M				GPS	5 CM

Washington State Department of Transportation

Geographic Services

Survey Information System

Report of Survey Mark

GENERAL MONUMENT INFORMATION

Designation:	GP34005-2	**T.R.S:**	18N, 1W , 18	**ACCOUNTS INFORMATION**		
Monument ID:	193	**Corner Code:**		**BOOK**	**PROJECT**	**INVOICE**
State:	WASHINGTON	**State Route:**	005	224	MS5400	23-05032
County:	THURSTON	**Mile Post:**	107.900	233	MS5400	23-05032
Region:	OL	**Station:**		55	0L1550	23-92009
Nearest Town:	OLYMPIA	**Offset:**				
Usgs Quad:	LACEY	**Owner:**	GS			
		Bearing:	M			

Description

Picture of Monument

THE STATION IS LOCATED IN THE CITY OF OLYMPIA. IT IS LOCATED IN THE NORTHWEST QUADRANT OF THE LILLY ROAD UNDERCROSSING OF SR 005, 8.2 METERS SOUTH OF THE NORTH END OF THE WEST SIDEWALK AND 1.2 METERS WEST OF THE EAST EDGE OF THE SIDEWALK. THE MARK IS A BRASS DISK CEMENTED INTO A DRILL HOLE IN THE CONCRETE SIDEWALK SET LEVEL WITH ITS SURFACE. * NOTE: UPDATED BY G.P.S. CONSTRAINED TO H.P.N. *

CURRENT SURVEY CONTROL

DATUM	LATITUDE	UNIT	LONGTITUDE	UNIT	NETWORK	METHOD	ACCURACY
NAD 83/91	47 02 40.113905	N	122 50 39.990669	W	PRIMARY	GPS	2 CM
	ELLIP HGT						
NAD 83	44.576	M				GPS	5 CM
	ORTHO HGT						
NAVD 88	66.116	M			PRIMARY	DIFF LEVELS	1 CM
SPC ZONE	**NORTHING**	**UNIT**	**EASTING**	**UNIT**	**SCALE**	**CONV.ANGLE**	**COMB.FACTOR**
S	192844.741	M	321874.875	M	0.99994673	-1 42 10.8	

MONUMENTATION HISTORY

DATE	RECOVERED BY	CONDITION
07/01/1993	GEOGRAPHIC SERVICES	MONUMENTED
09/09/1997	GEOGRAPHIC SERVICES	GOOD
08/25/2005	GEOGRAPHIC SERVICES	GOOD
05/25/2006	GEOGRAPHIC SERVICES	UPDATED

SUPERSEDED CONTROL

DATUM	LATITUDE	UNIT	LONGTITUDE	UNIT	NETWORK	METHOD	ACCURACY
NAD 83/91	47 02 40.113905	N	122 50 39.991059	W	PRIMARY	GPS	2 CM
	ELLIP HGT						
NAD 83	44.580	M				GPS	5 CM

Report 1 of 1 Found

Horizontal Monument

Standard Long Report

PIERCE COUNTY PUBLIC WORKS AND UTILITIES 253.798.3221
2401 South 35th Street, 253.798.3271
Tacoma WA 98409-7485 mholden@co.pierce.wa.us

ID No.

Point Designation:	209	History Records:	☐
County/Municipality:	Pierce County	Horizontal Control:	☑
State:	WA	Vertical Control:	☐

NAME

Point Desig. Alias:	GPS209	Geocode:	
Point ID #:	310	BLM Designation:	

HORIZONTAL

NORTHING (ft.):	618658.189187	Coord. System Zone:	4602
EASTING (ft.):	1174215.76468	Horizontal Datum:	NAD 1983/91
NORTHING (m):	188567.393199	Horizontal Method:	Geodetic GPS
EASTING (m):	357901.680879	Horizontal Accuracy:	<=0.050m / 0.164ft.
Latitude:	47° 0' 52.80294 N	Horiz Calc By:	PCM
Longitude:	122° 22' 8.87388 W	Horiz Calc Date:	1992-12-15 00:00:00.0
Scale Factor:	0.999942689352		
Convergence:	-1°21' 27.8		
Combined Grid Factor:	0.999921201092		
Feet Units:	US Survey Foot		

PLSS

Meridian:	Willamette	
Section:	S25T19NR03E	
Horiz. Network Relationship:	Network	

VERTICAL

ORTHO (ft.):	449.269	Vertical Datum:	NGVD29
ORTHO (m):	136.937465075	Vertical Method:	GPS
ELLIP (ft.):	380.766544996	Vertical Accuracy:	<=1.000m / 3.281ft.
ELLIP (m):	116.057875	Vertical Calc By:	PCM
GEOID (ft.):	-68.5024551042	Vert Calc Date:	1992-12-15 00:00:00.0
GEOID (m):	-20.8795900749	Geoid Method:	Derived
		Vert Network Relationship:	Network

MONUMENT

Monument Condition:	Existing or Recovered	Project/Survey #:	1992 GPS
Monument Type:	Donation Land Claim	Field Book #:	
Visit Date:	1992-07-22 00:00:00.0	Page #:	
Visit By:	PCM	Image File Ref:	N/A
Date Set:		Document File Ref:	N/A
Monument Set By:	UNK	PLS ID #:	22353
Cased Monument:	0	PLS_ID_Name:	Wade, Vernon M.

REFERENCE

Mon Description:
Rebar and cap.

Monument Location:
SR 7-26600

Drive-To Descr:
Station is on SR 7 north of 267th St. E. at or on the north line of J. McPhail DLC.

Field Ties:

Comments:
No PLS number recorded on view diagram. Possible NE corner for J. McPhail DLC.

THE GEOID

THE GEOID

THE GEOID IS THE EQUIPOTENTIAL SURFACE OF THE EARTH'S ATTRACTION AND ROTATION WHICH, ON THE AVERAGE, COINCIDES WITH MEAN SEA LEVEL IN THE OPEN OCEAN.

H = HEIGHT ABOVE SEA LEVEL

N = GEOID HEIGHT

h = H+N = ELLIPSOIDAL HEIGHT

THE GEOID: An ellipsoid is defined as a surface of revolution about the minor axis. The geoid is not. It is defined as the sea level surface and is subject to gravitational anomalies which cause it to have an undulating surface. Sometimes it is above the ellipsoid and sometimes below. The separation between the ellipsoid and the geoid, at a given point, is called geoid height. The NAD27 Datum based on the Clarke ellipsoid of 1866 had small geoid heights but the ellipsoid for NAD83 does not fit North America as well. In the conterminous United States the ellipsoid is above the geoid while in Alaska it is below the geoid. Ellipsoidal height is defined as the height of the surface above the ellipsoid. Geoid height is defined as ellipsoidal height minus elevation. In the midwest, the geoid height is approximately -30 meters which places it below the ellipsoid

GRID AZIMUTH COMPUTATION

$\alpha_g = \alpha_A$ + Laplace Correction - γ

$= 253^{o}\ 26'\ 14.9''$ (Observed Astro Azimuth)

$\underline{\qquad + \ (-\ 0.1)}''$ (Laplace Correction)

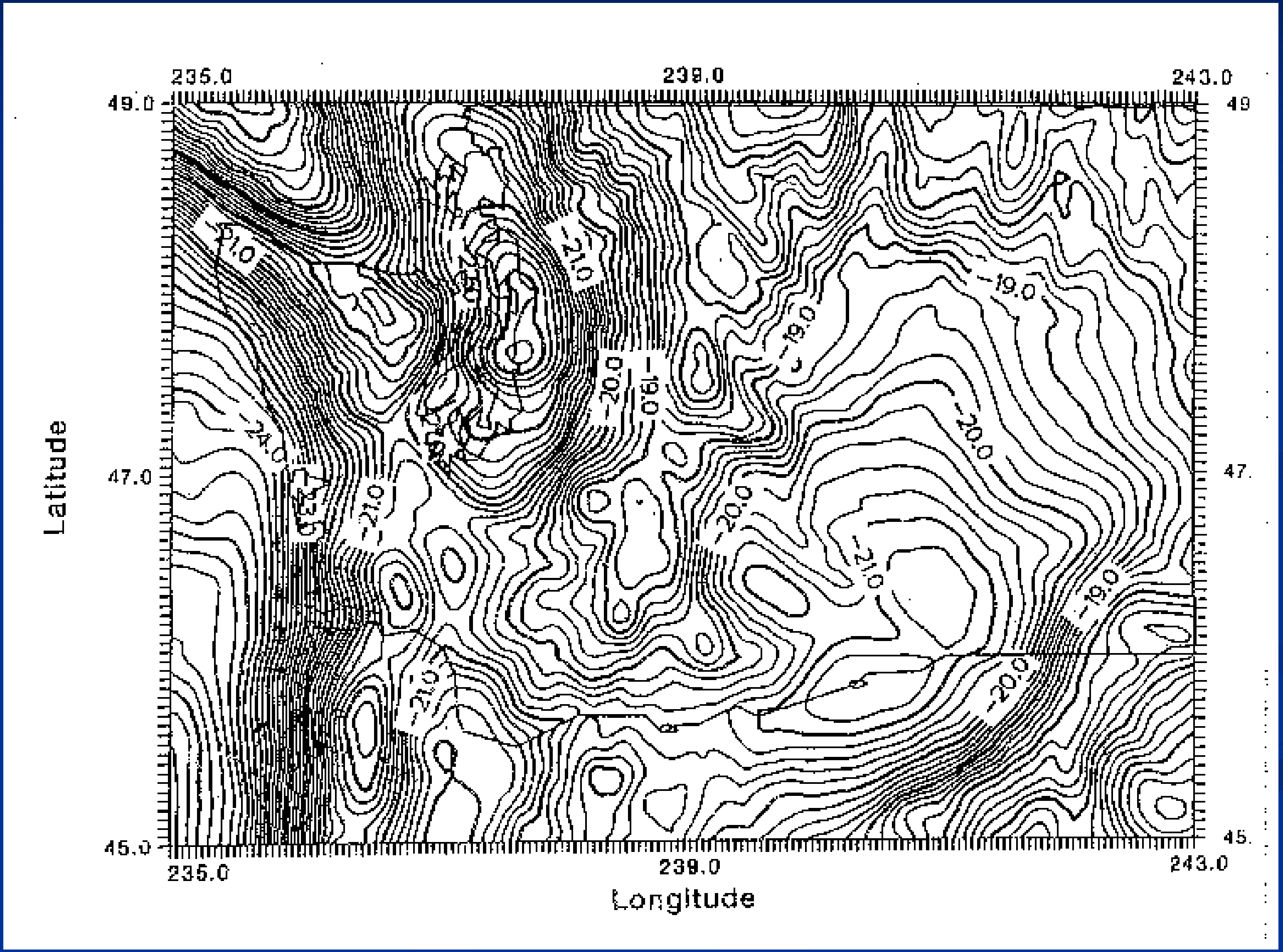
$= 253^{o}\ 26'\ 14.8''$ (Geodetic Azimuth)

$-\ \underline{\ 0\ \ 36\ \ 37.0}$ (Convergence Angle)

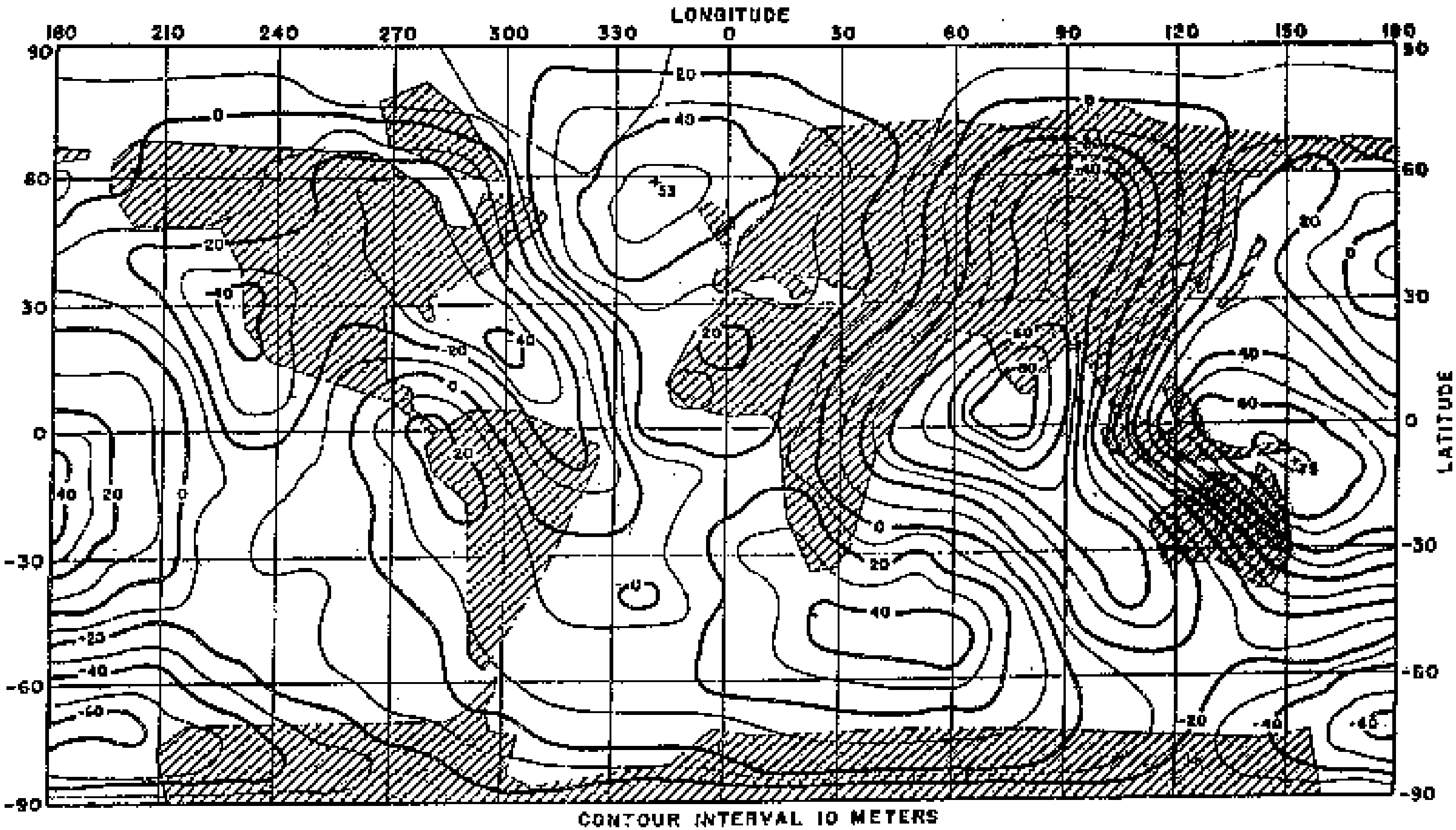
$= 252^{o}\ 49'\ 37.8''$

The convention of the sign of the convergence angle is always from Grid to Geodetic

UNDULATIONS OF THE GEOID



UNDULATIONS OF THE GEOID



Undulations of the geoid

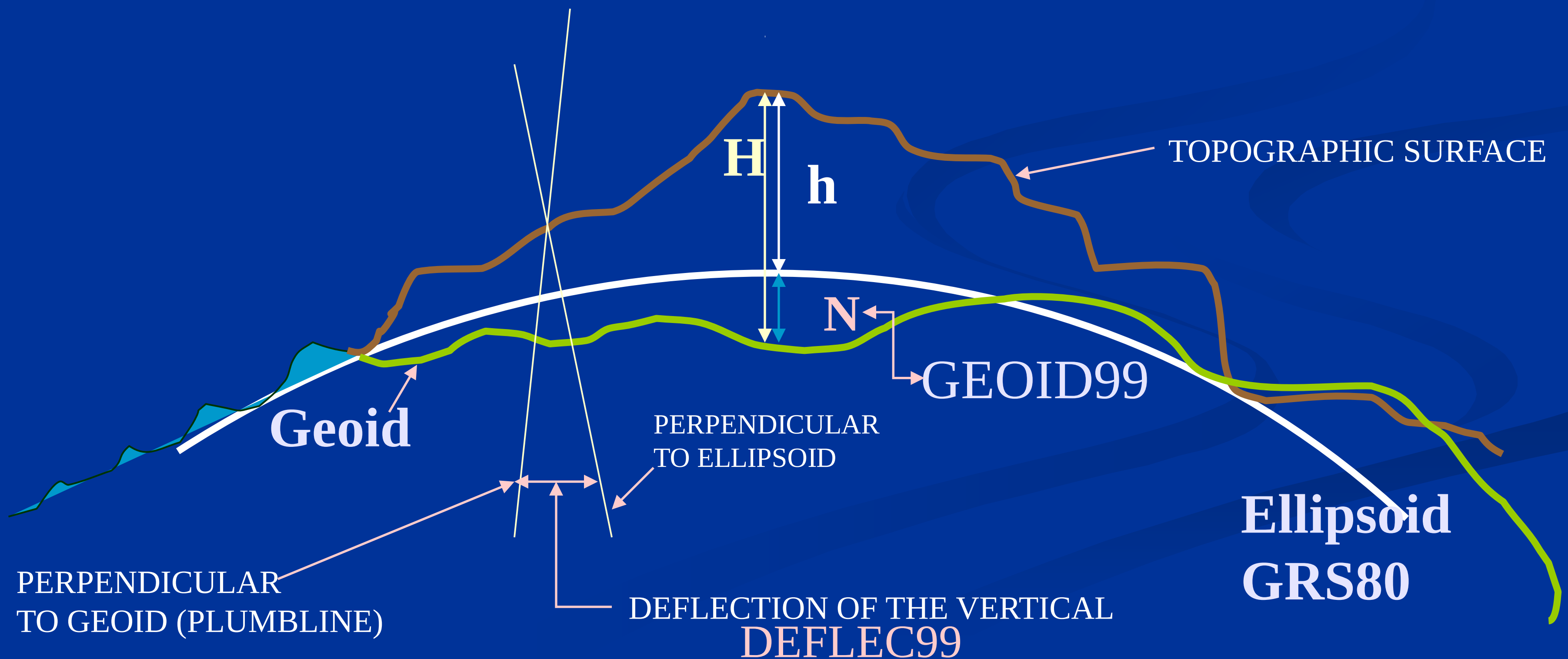
ELLIPSOID - GEOID RELATIONSHIP

H = Orthometric Height (NAVD 88)

h = Ellipsoidal Height (NAD 83)

N = Geoid Height (GEOID 99)

$$H = h - N$$



State Plane Coordinates

BRIEF HISTORY:

-Originally a U.S. English unit grid system

-Developed by land surveyors in the 1930's to simplify surveying computations

cooperative venture between the Coast and Geodetic Survey and the North Carolina state government, and efforts to build a North Carolina spatial coordinate system with ***minimal*** distortion was started. In 1933 this cooperative venture produced the North Carolina Coordinate System. In less that 12 months, the North Carolina system had been copied into all of the remaining states, and the State Plane coordinate system was born.

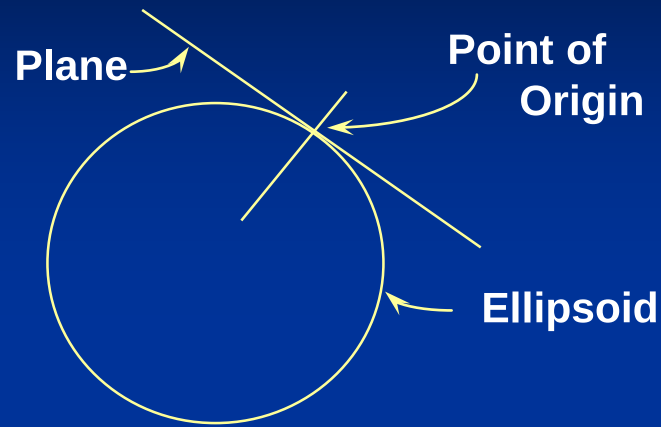
-Used only in the US

STATE PLANE COORDINATE SYSTEMS

Lambert Conformal Conic and Transverse Mercator Projections
International, State and County Boundaries
NAD 27 - Coordinates in U.S. Survey Feet

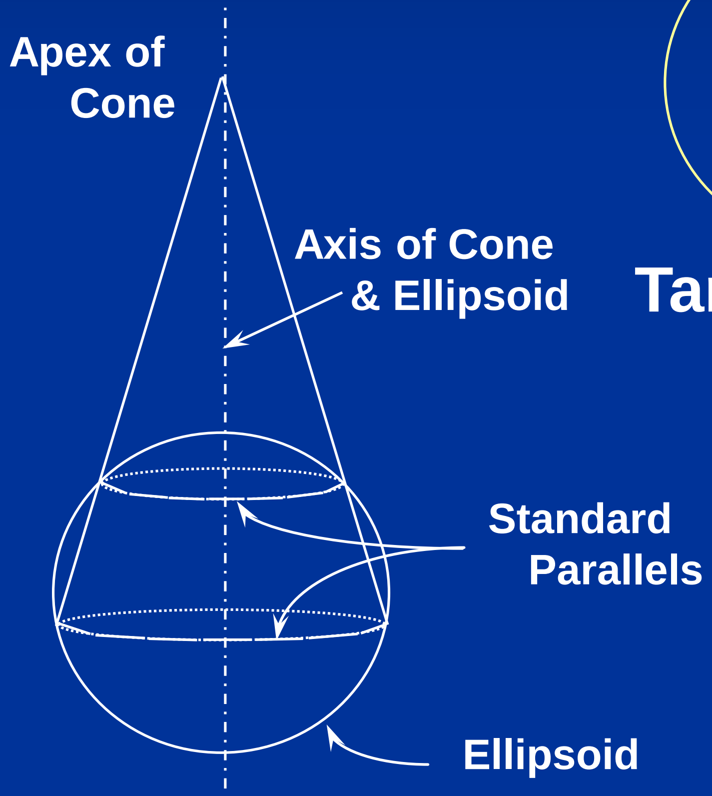
NAD 83 - Coordinates Metric w/State Defined Foot Conversion
1 Meter = 3.280833333 U.S. Survey Feet
1 Meter = 3.280839895 International Feet
NAD 27 to NAD 83 <u>VERY</u> large Positional Shifts

Types of Plane Systems



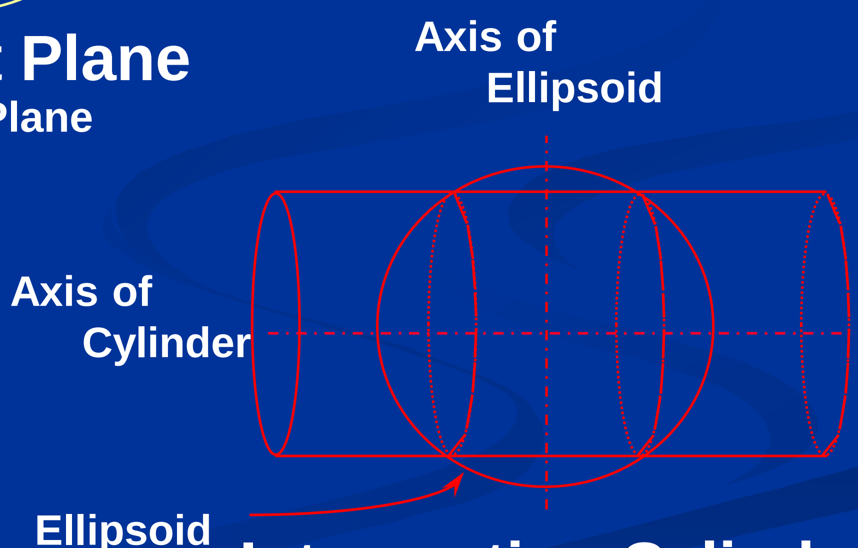
Tangent Plane

Local Plane



Intersecting Cone

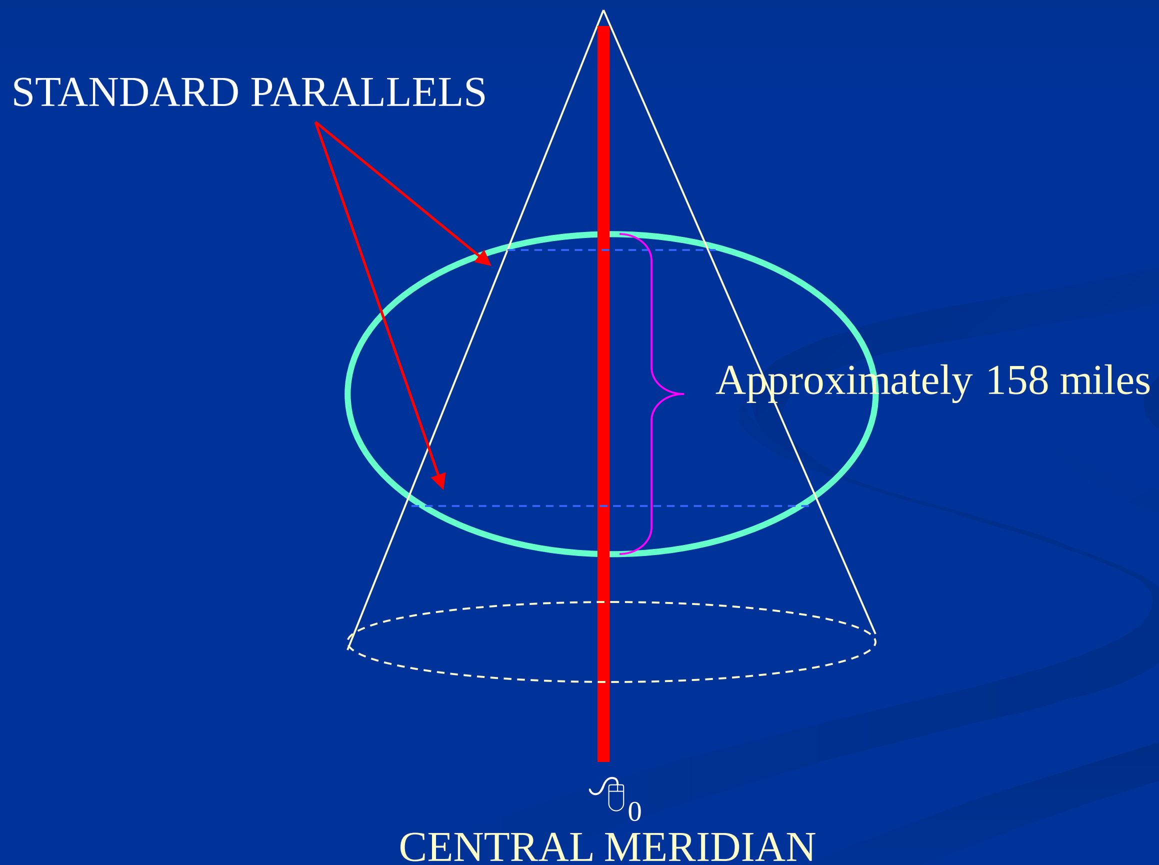
2 Parallel Lambert



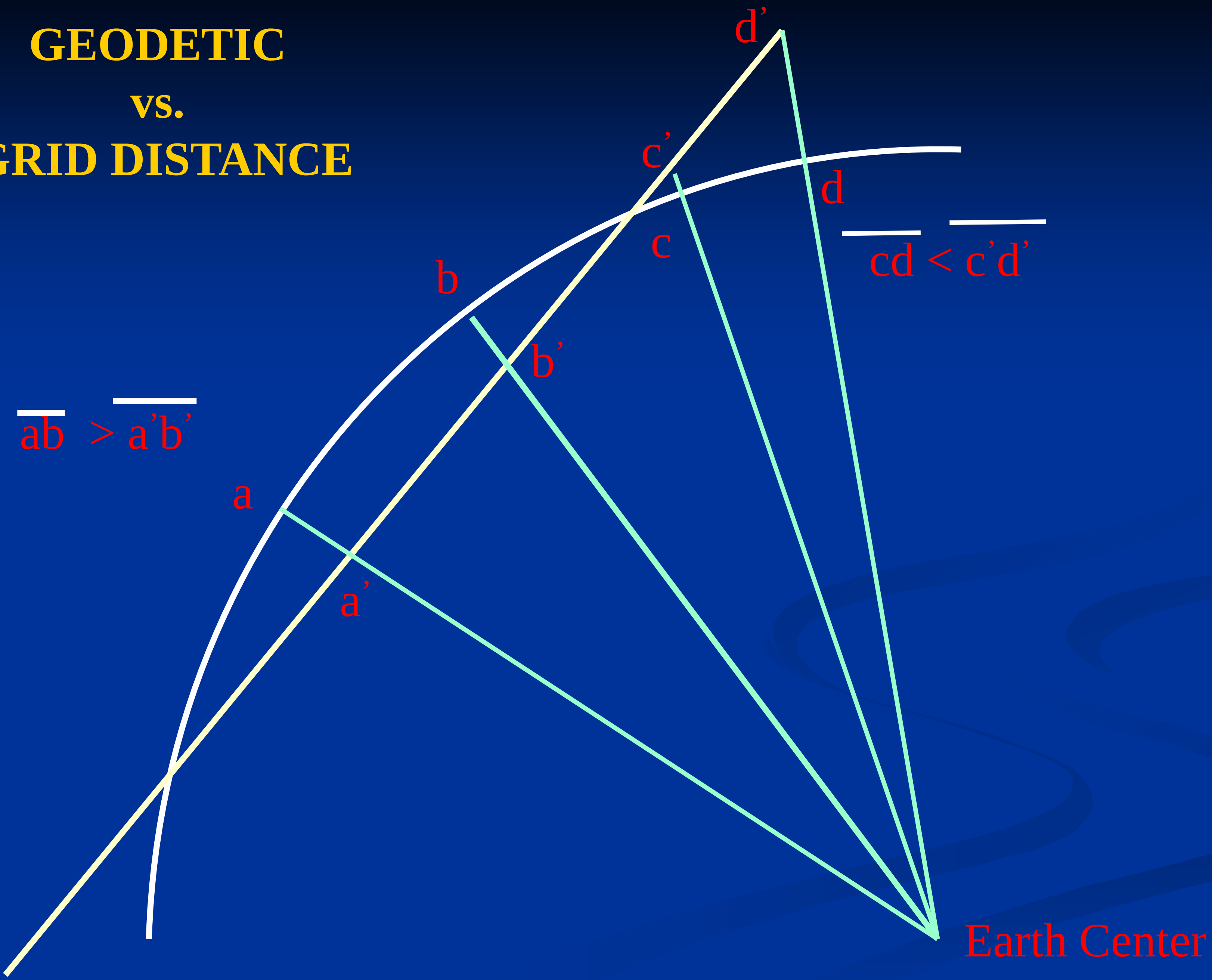
Intersecting Cylinder

Transverse Mercator

LAMBERT CONFROMAL CONIC WITH 2 STANDARD PARALLELS

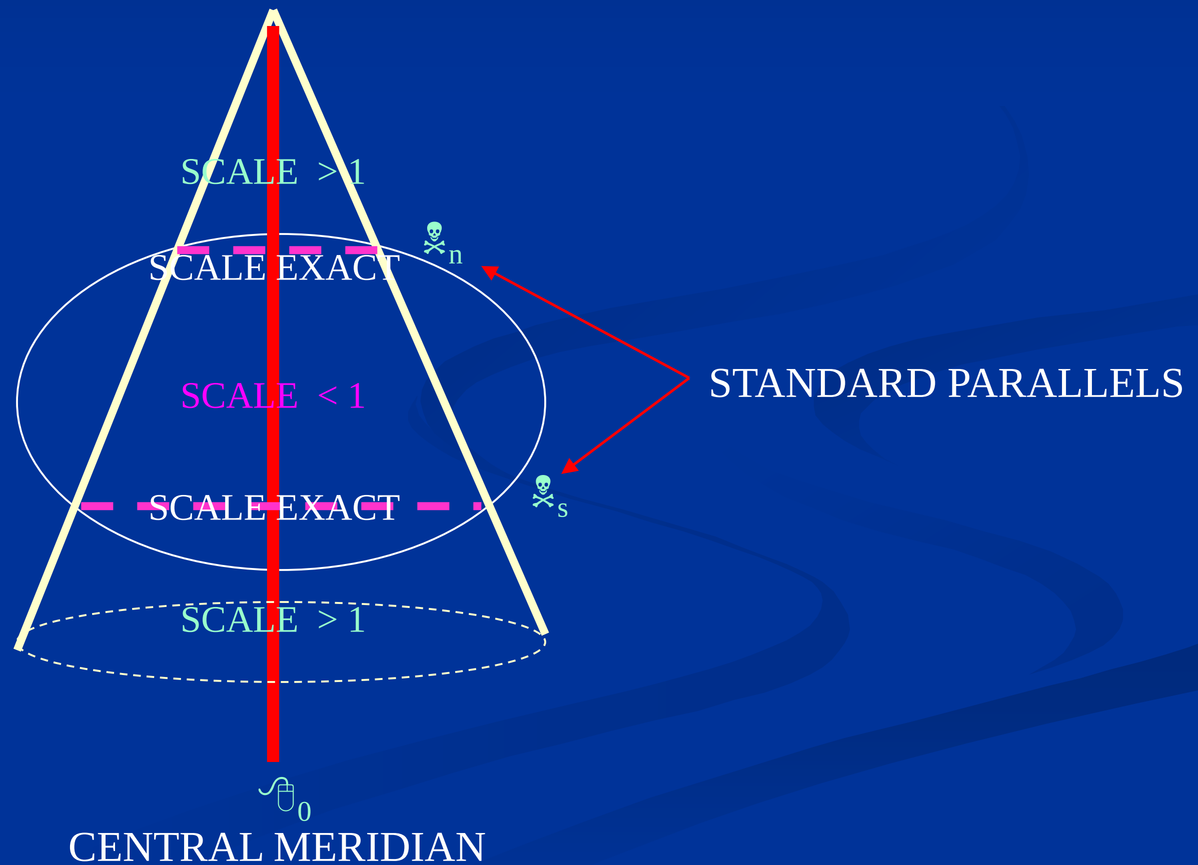


GEODETIC
vs.
GRID DISTANCE



LAMBERT CONFROMAL CONIC WITH 2 STANDARD PARALLELS

Grid Scale Factor



Standard Parallels

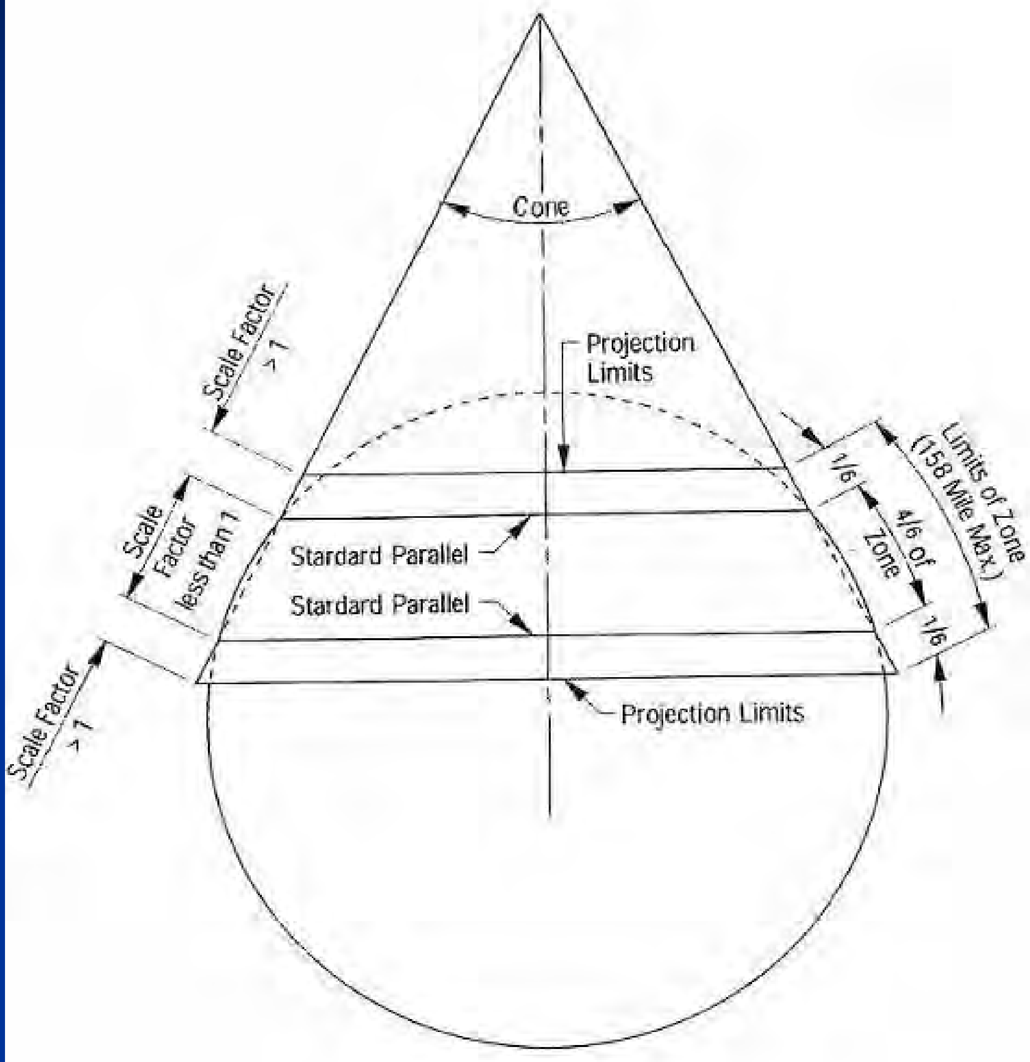
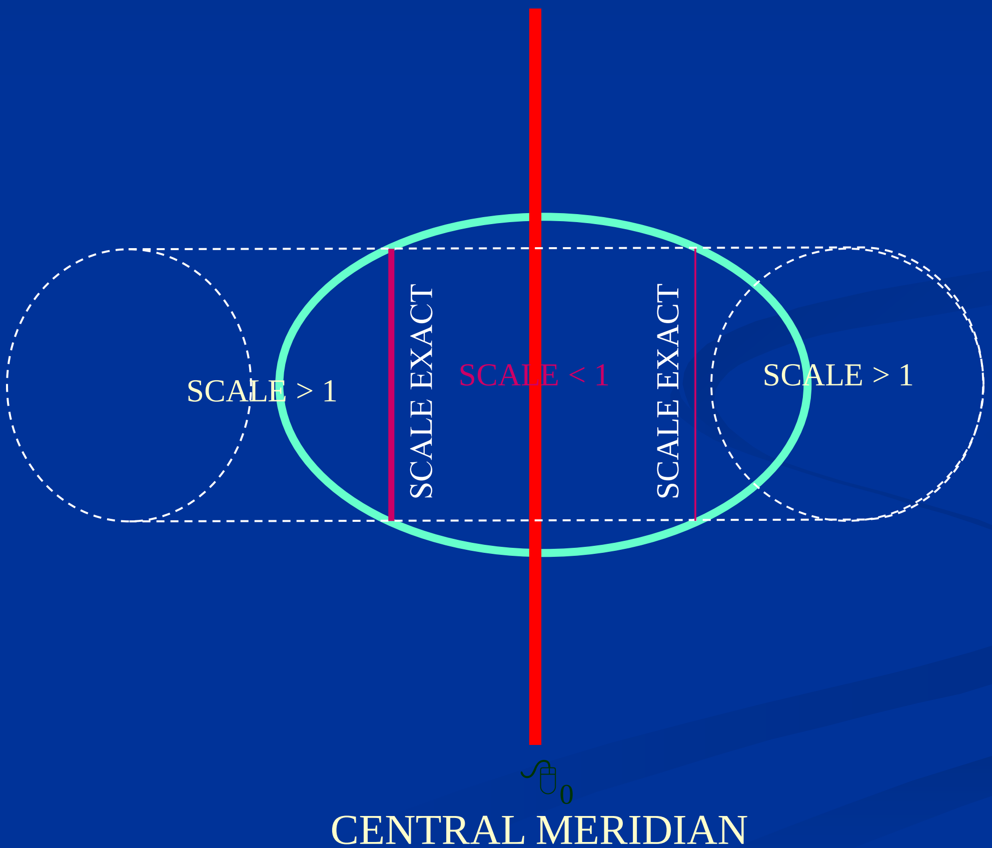
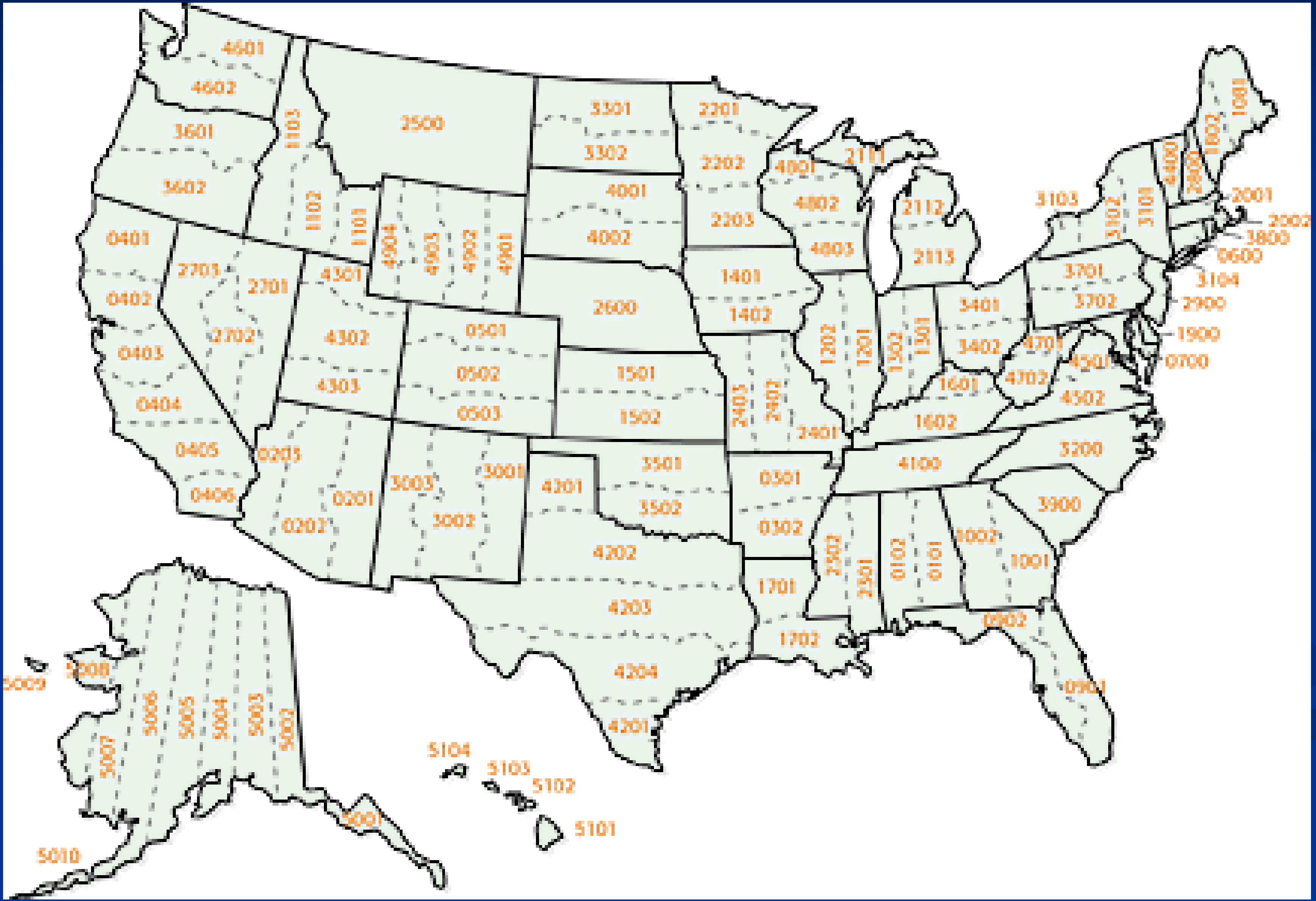


Figure 6-2

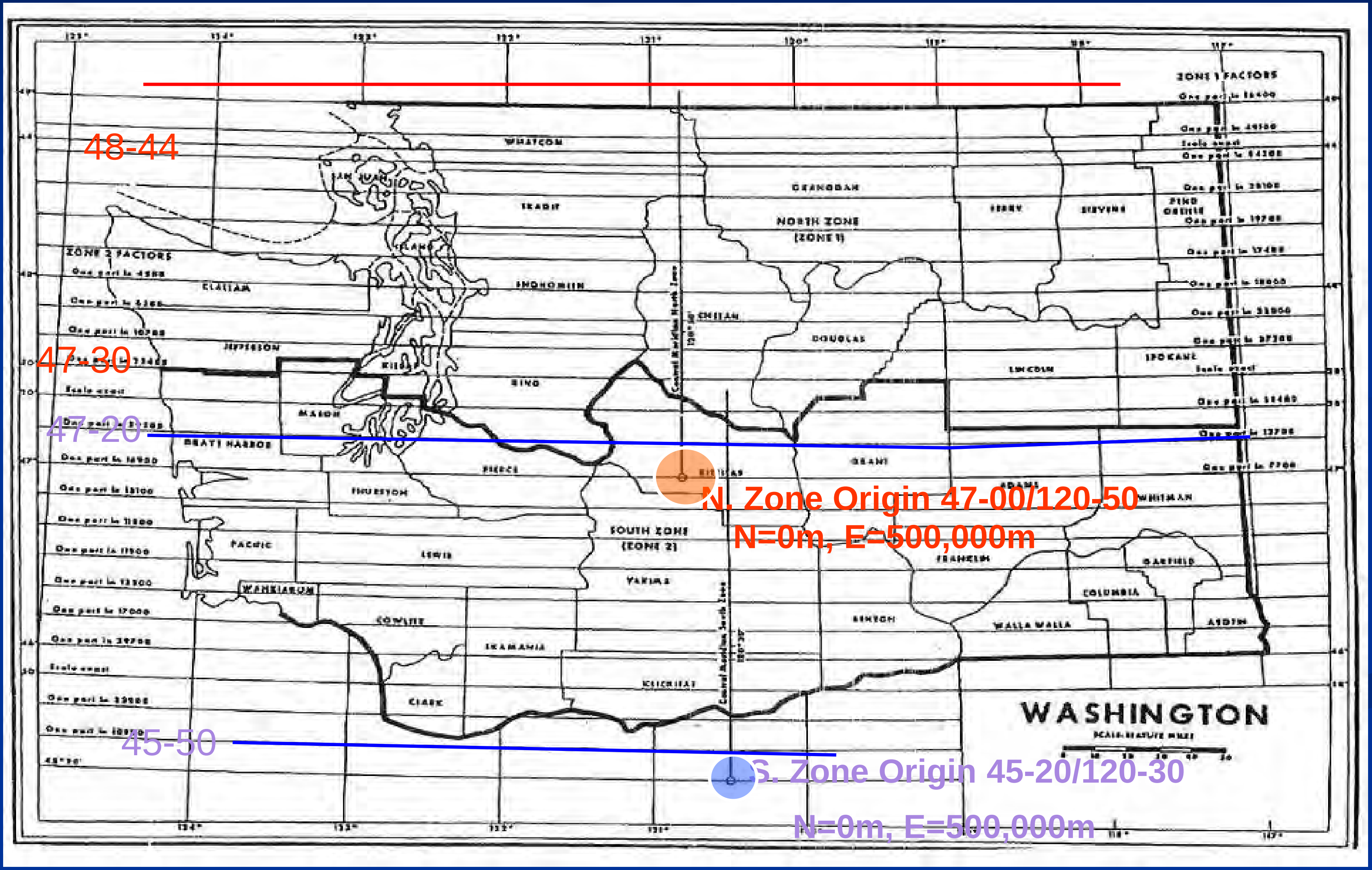
TRANSVERSE MERCATOR



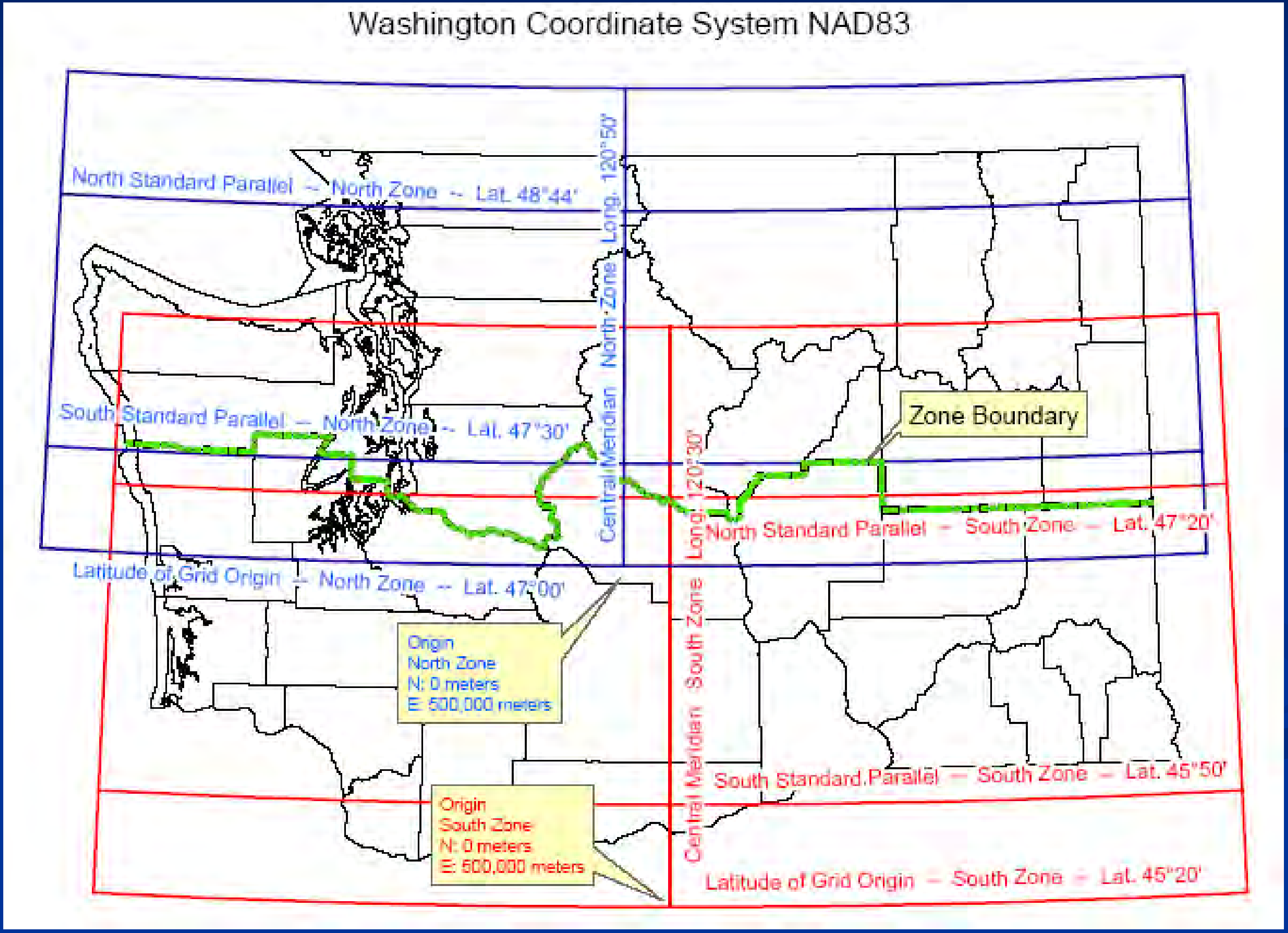
STATE PLANE COORDINATE SYSTEMS



North and South Zones



WASHINGTON ZONES



PARAMETERS OF A LAMBERT PROJECTION

WASHINGTON NORTH ZONE

		NAD 27	NAD 83
1.	PROJECTION	Lambert	Lambert
2.	LATITUDE OF ORIGIN	47° 00'	47° 00'
3.	CENTRAL MERIDIAN	120° 50'	120° 50'
4.	STANDARD PARALLEL 1	47° 30'	47° 30'
5.	STANDARD PARALLEL 2	48° 44'	48° 44'
6.	FALSE EASTING	2,000,000.00 FT.	500,000.000 M.
7.	FALSE NORTHING	0.00 FT.	0.000 M.

WASHINGTON SOUTH ZONE

		NAD 27	NAD 83
1.	PROJECTION	Lambert	Lambert
2.	LATITUDE OF ORIGIN	45° 20'	45° 20'
3.	CENTRAL MERIDIAN	120° 30'	120° 30'
4.	STANDARD PARALLEL 1	45° 50'	45° 50'
5.	STANDARD PARALLEL 2	47° 20'	47° 20'
6.	FALSEEASTING	2,000,000.00 FT.	500,000.000 M.
7.	FALSE NORTHING	0.00 FT.	0.000 M.

	NAD 27	NAD 83
Projection	Lambert conformal	Same
Zones	North and South	Same
Coordinates	Feet	Meters
Azimuth orientation	0° = South	0° = North
Foot (US or Int)	US Survey	US Survey
Mean Radius 'R'	20,906,000 ft	Same
Elevation Factor	To sea level	To ellipsoid

RCW 58.20

- **RCW 58.20.110**
- **Definitions.**
- Unless the context clearly requires otherwise, the definitions in this section apply throughout RCW 58.20.110 through 58.20.220 and 58.20.901:

  (1) "Committee" means the interagency federal geodetic control committee or its successor;

  (2) "GRS 80" means the geodetic reference system of 1980 as adopted in 1979 by the international union of geodesy and geophysics defined on an equipotential ellipsoid;

  (3) "National geodetic survey" means the national ocean service's national geodetic survey of the national oceanic and atmospheric administration, United States department of commerce, or its successor;

  (4) "Washington coordinate system of 1927" means the system of plane coordinates in effect under this chapter until July 1, 1990, which is based on the North American datum of 1927 as determined by the national geodetic survey of the United States department of commerce;

  (5) "Washington coordinate system of 1983" means the system of plane coordinates under this chapter based on the North American datum of 1983 as determined by the national geodetic survey of the United States department of commerce.
- [1989 c 54 § 9.]

RCW 58.20

- **RCW 58.20.120**
- **System designation — Permitted uses.**
- Until July 1, 1990, the Washington coordinate system of 1927, or its successor, the Washington coordinate system of 1983, may be used in Washington for expressing positions or locations of points on the surface of the earth. On and after that date, the Washington coordinate system of 1983 shall be the designated coordinate system in Washington. The Washington coordinate system of 1927 may be used only for purposes of reference after June 30, 1990.

RCW 58.20

- **RCW 58.20.130**
- **Plane coordinates adopted — Zones.**
- The system of plane coordinates which has been established by the national geodetic survey for defining and stating the positions or locations of points on the surface of the earth within the state of Washington is designated as the "Washington coordinate system of 1983."

  For the purposes of this system the state is divided into a "north zone" and a "south zone."

  The area now included in the following counties shall constitute the north zone: Chelan, Clallam, Douglas, Ferry, Island, Jefferson, King, Kitsap, Lincoln, Okanogan, Pend Oreille, San Juan, Skagit, Snohomish, Spokane, Stevens, Whatcom, and that part of Grant lying north of parallel 47° 30' north latitude.

  The area now included in the following counties shall constitute the south zone: Adams, Asotin, Benton, Clark, Columbia, Cowlitz, Franklin, Garfield, that part of Grant lying south of parallel 47° 30' north latitude, Grays Harbor, Kittitas, Klickitat, Lewis, Mason, Pacific, Pierce, Skamania, Thurston, Wahkiakum, Walla Walla, Whitman and Yakima.

RCW 58.20

- **RCW 58.20.150**
- **Designation of coordinates — "N" and "E."**
- "N" and "E" shall be used in labeling coordinates of a point on the earth's surface and in expressing the position or location of such point relative to the origin of the appropriate zone of this system, expressed in meters and decimals of a meter. These coordinates shall be made to depend upon and conform to the coordinates, on the Washington coordinate system of 1983, of the horizontal control stations of the national geodetic survey within the state of Washington, as those coordinates have been determined, accepted, or adjusted by the survey.

RCW 58.20

- **RCW 58.20.160**
- **Tract in both zones — Description.**
- When any tract of land to be defined by a single description extends from one into the other of the coordinate zones under RCW 58.20.130, the positions of all points on its boundaries may be referred to either of the zones, the zone which is used being specifically named in the description.

RCW 58.20

- **RCW 58.20.170**
- **Zones — Technical definitions.**
- For purposes of more precisely defining the Washington coordinate system of 1983, the following definition by the national geodetic survey is adopted:

  The Washington coordinate system of 1983, north zone, is a Lambert conformal conic projection of the GRS 80 spheroid, having standard parallels at north latitudes 47° 30' and 48° 44', along which parallels the scale shall be exact. The origin of coordinates is at the intersection of the meridian 120° 50' west of Greenwich and the parallel 47° 00' north latitude. This origin is given the coordinates: E = 500,000 meters and N = 0 meters.

  The Washington coordinate system of 1983, south zone, is a Lambert conformal conic projection of the GRS 80 spheroid, having standard parallels at north latitudes 45° 50' and 47° 20', along which parallels the scale shall be exact. The origin of coordinates is at the intersection of the meridian 120° 30' west of Greenwich and the parallel 45° 20' north latitude. This origin is given the coordinates: E = 500,000 meters and N = 0 meters.

RCW 58.20

- **RCW 58.20.180**
- **Recording coordinates — Control stations.**
- Coordinates based on the Washington coordinate system of 1983, purporting to define the position of a point on a land boundary, may be presented to be recorded in any public land records or deed records if the survey method used for the determination of these coordinates is established in conformity with standards and specifications prescribed by the interagency federal geodetic control committee, or its successor. These surveys shall be connected to monumented control stations that are adjusted to and published in the national network of geodetic control by the national geodetic survey and such connected horizontal control stations shall be described in the land or deed record. Standards and specifications of the committee in force on the date of the survey shall apply. In all instances where reference has been made to such coordinates in land surveys or deeds, the scale and sea level factors shall be stated for the survey lines used in computing ground distances and areas.

RCW 58.20

- The position of the Washington coordinate system of 1983 shall be marked on the ground by horizontal geodetic control stations which have been established in conformity with the survey standards adopted by the committee and whose geodetic positions have been rigorously adjusted on the North American datum of 1983, and whose coordinates have been computed and published on the system defined in RCW 58.20.110 through 58.20.220 and 58.20.901. Any such control station may be used to establish a survey connection with the Washington coordinate system of 1983.

- **RCW 58.20.190**
- **Conversion of coordinates — Metric.**
- Any conversion of coordinates between the meter and the United States survey foot shall be based upon the length of the meter being equal to exactly 39.37 inches.

RCW 58.20

- **RCW 58.20.200**
- **Term — Limited use.**
- The use of the term "Washington coordinate system of 1983" on any map, report of survey, or other document, shall be limited to coordinates based on the Washington coordinate system of 1983 as defined in this chapter.
- **RCW 58.20.210**
- **United States survey prevails — Conflict.**
- Whenever coordinates based on the Washington coordinate system of 1983 are used to describe any tract of land which in the same document is also described by reference to any subdivision, line or corner of the United States public land surveys, the description by coordinates shall be construed as supplemental to the basic description of such subdivision, line, or corner contained in the official plats and field notes filed of record, and in the event of any conflict the description by reference to the subdivision, line, or corner of the United States public land surveys shall prevail over the description by coordinates.

RCW 58.20

- RCW 58.20.220
- **Real estate transactions — Exemption.**
- Nothing contained in this chapter shall require any purchaser or mortgagee to rely on a description, any part of which depends exclusively upon the Washington coordinate system of 1927 or 1983.
- **RCW 58.20.901**
- **Severability — 1989 c 54.**
- If any provision of this act or its application to any person or circumstance is held invalid, the remainder of the act or the application of the provision to other persons or circumstances is not affected.
- **58.09.070**
  Coordinates — Map showing control scheme required.
- When coordinates in the Washington coordinate system are shown for points on a record of survey map, the map may not be recorded unless it also shows, or is accompanied by a map showing, the control scheme through which the coordinates were determined from points of known coordinates.

WAC 332-130-090

- **WAC 332-130-060**
- Washington State Register filings since 2003**Local geodetic control survey standards.**
- The following standards shall apply to local geodetic control surveys:

  The datum for the horizontal control network in Washington shall be NAD83 as officially adjusted and published by the National Geodetic Survey of the United States Department of Commerce or as established in accordance with chapter 58.20 RCW. The datum tag and coordinate epoch date (if pertinent) shall be reported on all documents prepared, which show local geodetic control; e.g., NAD83 (1991), NAD83 (CORS) (2002.00), NAD83 (NSRS) (2005.50) and other future [standards].

SURVEY RECORDING ACT 1973
RCW 58.09.070

- **58.09.070**
  Coordinates — Map showing control scheme required.
- When coordinates in the Washington coordinate system are shown for points on a record of survey map, the map may not be recorded unless it also shows, or is accompanied by a map showing, the control scheme through which the coordinates were determined from points of known coordinates.
- [1973 c 50 § 7.]

WAC 332-130-090

- **WAC 332-130-090**
- No Washington State Register filings since 2003**Field traverse standards for land boundary surveys.**
- The following standards shall apply to field traverses used in land boundary surveys. Such standards should be considered minimum standards only. Higher levels of precision are expected to be utilized in areas with higher property values or in other situations necessitating higher accuracy.

  (1) Linear closures after azimuth adjustment.

  (a) City - central and local business and industrial

  areas 1:10,000

  (b) City - residential and subdivision lots 1:5,000

  (c) Section subdivision, new subdivision boundaries for residential lots and interior monument control 1:5,000

  (d) Suburban - residential and subdivision lots 1:5,000

  (e) Rural - forest land and cultivated areas 1:5,000

  (f) Lambert grid traverses 1:10,000

  (2) Angular closure.

  (a) Where 1:10,000 minimum linear closure is required, the maximum angular error in seconds shall be determined by the formula of $10 \sqrt{n}$, where "n" equals the number of angles in the closed traverse.

  (b) Where 1:5,000 minimum linear closure is required, the maximum angular error in seconds shall be determined by the formula of $30 \sqrt{n}$ where "n" equals the number of angles in the closed traverse.

SYMBOLS USED IN TEXT

SYMBOLS USED IN TEXT

ϕ = PHI = LATITUDE

λ = LAMBDA = LONGITUDE

α = ALPHA = AZIMUTH OF LINE, USUALLY REFERRING TO GEODETIC VALUES. GRID OR PLANE AZIMUTHS ARE USUALLY DENOTED AS α' OCCASIONALLY USED TO INDICATE AN ANGLE.

Δ = DELTA = DIFFERENCE

$\Delta\phi$ = DELTA PHI = DIFFERENCE IN LATITUDE

$\Delta\lambda$ = DELTA LAMBDA = DIFFERENCE IN LONGITUDE

$\Delta\alpha$ = DELTA ALPHA = DIFFERENCE IN AZIMUTH

ρ = RHO = RADIUS OF CURVATURE OF THE REFERENCE SPHEROID. THE ONLY USE MADE OF THIS QUANTITY IN THIS PAPER IS IN THE REDUCTION OF HORIZONTAL DISTANCES TO ELLIPSOID VALUES. FOR THIS PURPOSE, A MEAN VALUE EQUAL TO 20,906,000 FT. AND DESIGNATED AS "R" HAS BEEN UTILIZED. THIS "R" VALUE SHOULD NOT BE CONFUSED WITH THE "R" OR "R " QUANTITIES USED IN THE COMPUTATIONS INVOLVING THE CONVERSION OF GEOGRAPHIC POSITIONS TO LAMBERT PLANE COORDINATES AND THE INVERSE OF THE PROBLEMS.

h = ELEVATION AND ON RARE OCCASIONS MAY INDICATE A DIFFERENCE IN ELEVATION.

l = SLOPE OR INCLINED DISTANCE

D = HORIZONTAL DISTANCE

S = GEODETIC DISTANCE = DISTANCE AT THE ELLIPSOID SURFACE.

S_g = GRID DISTANCE = GEODETIC DISTANCE MULTIPLIED BY SCALE (GRID) FACTOR.

CM = CENTRAL MERIDIAN = THE MERIDIAN (LONGITUDE) OR AXIS USUALLY SITUATED NEAR THE CENTER OF A PLANE COORDINATE ZONE WHICH SEPARATES THE POSITIVE AND NEGATIVE X' VALUES (SEE DEFINITION OF X').

X' = THE DISTANCE (IN METERS FOR THE STATE GRID SYSTEMS) EAST AND WEST OF THE CENTRAL MERIDIAN. EAST OF THE CENTRAL MERIDIAN THE VALUES ARE POSITIVE, WEST OF THIS MERIDIAN THEY ARE NEGATIVE. THESE QUANTITIES CAN BE DESCRIBED IN PLANE SURVEYING TERMINOLOGY AS THE DEPARTURES MEASURED FROM THE Y AXIS.

SYMBOLS USED IN TEXT

E = THE PLANE COORDINATE VALUES WHICH ARE PERPENDICULAR TO THE N AXIS. THESE VALUES USUALLY CONSIST OF A CONSTANT $C \pm X$. THE CONSTANT "C" IS GENERALLY OF SUFFICIENT SIZE TO ASSURE THAT THE X QUANTITIES WILL BE POSITIVE.

γ = GAMMA = THE MAPPING ANGLE IN THE LAMBERT PROJECTION USUALLY REFERRED TO AS THE "GAMMA" ANGLE. THIS ANGLE IS APPLIED TO GEODETIC AZIMUTHS TO OBTAIN PLANE (GRID) AZIMUTHS AND VICE VERSA.

NOTE: ALTHOUGH THESE REDUCTIONS ARE NOT EXACT, THE ERROR IN NEGLECTING ANOTHER CORRECTION WHICH IS KNOWN AS THE "SECOND TERM" (T-t CORRECTION) IS QUITE SMALL FOR THE STATE SYSTEMS AND CAN BE IGNORED EXCEPT FOR THOSE OCCASIONS WHERE THE MOST PRECISE COMPUTATIONS ARE DESIRED.

N = THE PLANE COORDINATE VALUES (GIVEN IN METERS FOR THE STATE GRID SYSTEMS) WHICH CORRESPOND TO THE DISTANCES NORTH OF THE ORIGIN TO THEIR INTERSECTION WITH THE E COORDINATES OF THE POINTS. THESE QUANTITIES CAN BE DESCRIBED IN PLANE SURVEYING TERMINOLOGY AS THE LATITUDES MEASURED FROM THE ORIGIN.

R = IN THE STATE LAMBERT GRID SYSTEMS, THE DISTANCES IN METERS FROM THE VERTEX OF THE CONE TO THE LATITUDES OF THE POINTS.

R_b = IN THE STATE LAMBERT GRID SYSTEMS, THE DISTANCE IN METERS FROM THE VERTEX OF THE CONE TO THE ORIGIN.

ℓ = A CONSTANT DETERMINED FOR EACH ZONE OR BAND OF A LAMBERT PROJECTION AND IS EQUAL TO THE SINE OF ϕ_0 WHICH IS THE LATITUDE ABOUT MIDWAY BETWEEN THE STANDARD PARALLELS. ℓ MULTIPLIED BY THE DIFFERENCE IN SECONDS BETWEEN THE LONGITUDE OF A POINT AND THE CENTRAL MERIDIAN EQUALS γ (GAMMA) ANGLE IN SECONDS FOR THE POINT.

DEFINITIONS

DEFINITIONS OF GEODETIC AND OTHER TERMS

ASTRONOMIC AZIMUTH

At the point of observation, the angle measured from the vertical plane through the celestial pole to the vertical plane through the observed object. Astronomic azimuth is the azimuth which results directly from observations on a celestial body, and is usually reckoned from south = 0 degrees. It is affected by the local deflection of the vertical (station error) which, in the US, produces differences between astronomic and geodetic azimuths of as much as 20" in the mountain regions of the west.

CARTESIAN COORDINATES

For this discussion, not to be confused with state plane coordinates. The X, Y, Z values expressed on the NGS data sheets beginning at the earth's center of mass and reckoned from the mean value of the earth's axis of rotation, more technically referred to as geocentric coordinates. The Z value is the vertical position on the ellipsoid from the earth's center of mass.

DATUM

A datum is a reference system from which survey measurements are made and are expressed in quantities or set of quantities that serve as a reference or basis for calculation of other quantities. The values or coordinates expressed originate from a specified point of origin. The datum may be a local system, a statewide system, a system that represents North America only or could be a worldwide system.

ELLIPSOID

A mathematical model of a surface generated by rotation of an ellipse about one of its axes and is defined by a semi-major axis and a semi-minor axis. The ellipsoid of the earth is the ellipsoid which most closely approximates the geoid.

EQUIPOTENTIAL SURFACE

A surface with the same potential, usually of gravity or of gravitation, at every point. An equipotential surface is also referred to as a level surface.

GEODETIC AZIMUTH

The angle measured on the horizon between the meridian and the plane of the vertical circle through a celestial body corrected by the laplace correction.

GEODETIC COORDINATES

A set of coordinates designating the location of a point with respect to the reference ellipsoid and with respect to the planes of the geodetic Equator and a selected geodetic meridian. The coordinate system consists of an ellipsoid, the equatorial plane of the ellipsoid, and a meridional plane through the polar axis and is expressed in Latitude and Longitude.

GEOID

The equipotential surface of the earth's gravity field which best fits, in the least squares sense, mean sea level.

GEOID HEIGHT

The value indicating the separation between the geoid (sea level) and the ellipsoid. In the conterminous US the ellipsoid is above the geoid. The ellipsoidal height (h) = height above sea level (H) + geoid height (N).

DEFINITIONS

GRID AZIMUTH

The angle in the plane of projection between a straight line and the central meridian of a plane-rectangular coordinate system.

LAPLACE AZIMUTH OR CORRECTION

The Laplace azimuth is a geodetic azimuth derived from an astronomic azimuth by means of the Laplace equation. The Laplace condition arises from the fact that a deflection of the vertical in the plane of the prime vertical will give a difference between astronomic and geodetic longitude and between astronomic and geodetic azimuth.

MAPPING ANGLE OR CONVERGENCE ANGLE

The angular difference between grid north and geodetic north, which includes the correction for the "second term" or arc-to-chord correction. The symbol 'Y' is gamma.

MAP PROJECTIONS

A system of lines on a plane representing a corresponding system of imaginary lines on an adopted terrestrial or celestial datum surface. The Lambert conformal conic projection is one of many such projections.

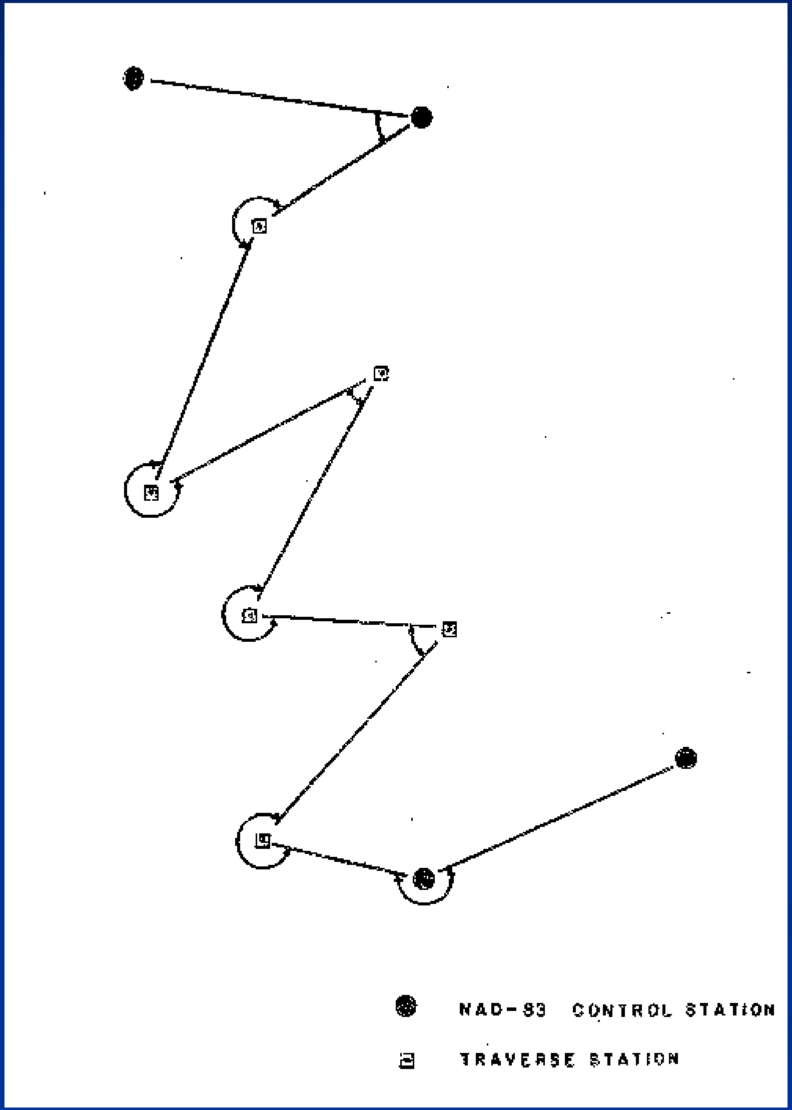
PLANE COORDINATES

A cartesian coordinate system in the plane, with the axes intersecting at right angles. In the Washington Coordinate System the values are identified as "N" for the latitudinal (north-south) position and "E" as the longitudinal (east-west) position.

TRANSFORMATION

The process of projecting a datum or points on it, from its plane onto another plane by translation, rotation, and/or scale change.

TRAVERSING

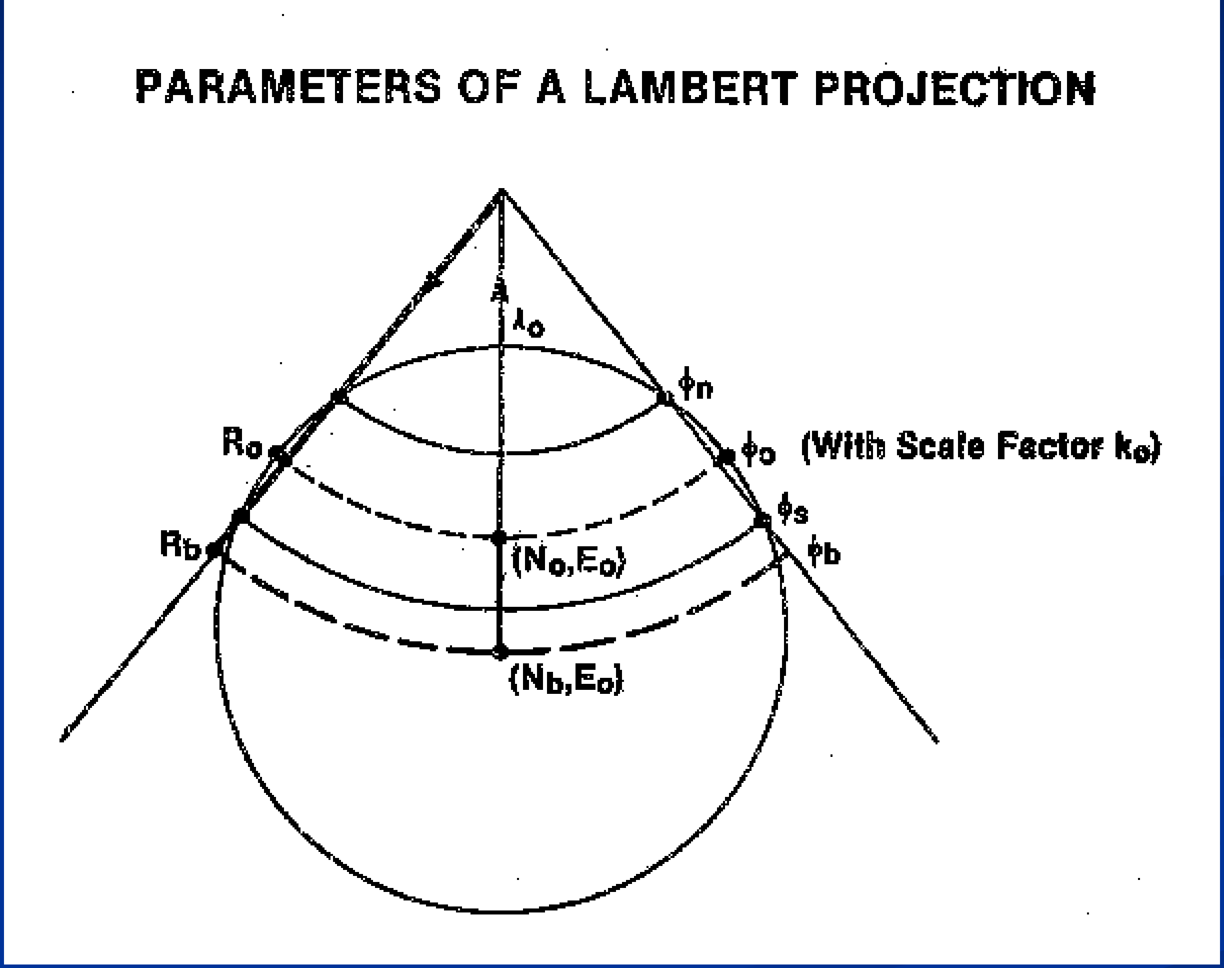


TRAVERSING

STEPS TO CALCULATE TRAVERSE ON WASHINGTON COORDINATE SYSTEM

1. Obtain starting NGS or other acceptable control point with NAD 83 coordinates.
2. Find acceptable NGS backsight control point with NAD 83 coordinates.
3. Calculate inverse directly from published coordinates to derive starting azimuth.
4. Obtain closing NGS or other acceptable control point with NAD 83 coordinates.
5. Find acceptable NGS foresight control point with NAD 83 coordinates.
6. Calculate inverse directly from published coordinates to derive closing azimuth.
7. Determine the appropriate scale (latitude) factor for the project or for each traverse line, depending on the size of the project and accuracy required.
8. Determine the appropriate elevation factor for the project or for each traverse line, depending on the topography of the project and accuracy required.
9. Combine the scale and elevation factors for a project combined factor or compute a factor for each line, depending on the size of the project and accuracy required.
10. Reduce the horizontal distances to grid by multiplying by the combined project factor or the factor for each line.
11. If the project is small and the traverse lines are shorter than 5 miles long, skip to step 15.
12. Use preliminary azimuths derived from mean field angles and using grid distances compute approximate state plane coordinates.
13. Compute the second term, t-T corrections, using the approximate coordinates for each point.
14. Apply t-T corrections to the measured angles to obtain grid angles.
15. Determine the angular closure and adjust the angles.
16. Determine the closing error and adjust the traverse.
17. The computed inverses between the adjusted final coordinates will be the adjusted grid azimuths and distances.
18. To obtain the ground distances, divide the adjusted grid distances by the combined project grid factor or the combined factor for each line.

PARAMETERS OF A LAMBERT PROJECTION



PARAMETERS OF A LAMBERT PROJECTION

WA N WASHINGTON NORTH — ZONE # 4601

Defining Constants

Bs	=	47:30
Bn	=	48:44
Bb	=	47:00
Lo	=	120:50
Nb	=	0.0000
Eo	=	500000.0000

Computed Constants

Bo	=	48.1179151437
SinBo	=	0.744520326553
Rb	=	6053778.6038
Ro	=	5729486.2170
No	=	124392.3869
K	=	11670409.5559
ko	=	0.999942253481
Mo	=	6370499.7054
ro	=	6380060.

Coefficients for GP to PC

L(1)	=	111186.1944
L(2)	=	9.72145
L(3)	=	5.61785
L(4)	=	0.027630

Coefficients for PC to GP

G(1)	=	8.993922319E-06
G(2)	=	-7.07270E-15
G(3)	=	-3.67384E-20
G(4)	=	-1.4705E-27

Coefficients for Grid Scale Factor

F(1)	=	0.999942253481
F(2)	=	1.22844E-14
F(3)	=	7.08E-22

WA S WASHINGTON SOUTH — ZONE # 4602

Defining Constants

Bs	=	45:50
Bn	=	47:20
Bb	=	45:20
Lo	=	120:30
Nb	=	0.0000
Eo	=	500000.0000

Computed Constants

Bo	=	46.5850847865
SinBo	=	0.726395784020
Rb	=	6183952.2755
Ro	=	6044820.3637
No	=	139131.9123
K	=	11760132.9643
ko	=	0.999914597646
Mo	=	6368612.1773
ro	=	6378741.

Coefficients for GP to PC

L(1)	=	111153.2505
L(2)	=	9.75921
L(3)	=	5.62365
L(4)	=	0.026539

Coefficients for PC to GP

G(1)	=	8.996587926E-06
G(2)	=	-7.10693E-15
G(3)	=	-3.68032E-20
G(4)	=	-1.3823E-27

Coefficients for Grid Scale Factor

F(1)	=	0.999914597646
F(2)	=	1.22897E-14
F(3)	=	6.73E-22

PARAMETERS OF A LAMBERT PROJECTION

Constants For The Lambert Projection By The Polynomial Coefficient Method

Constants		Description
Bs	=	Southern standard parallel
Bn	=	Northern standard parallel
Bb	=	Latitude of grid origin
Lo	=	Longitude of the true and grid origin, the "central meridian"
Nb	=	Northing value at grid orgin "Bb"
Eo	=	Easting value at the origin "Lo"
Bo	=	Latitude of the true projection origin, the "central parallel"
SinBo	=	Sine of Bo
Rb	=	Mapping radius at Bb
Ro	=	Mapping radius at Bo
K	=	Mapping radius at the equator
No	=	Northing value at the true projection origin "Bo"
ko	=	Central parallel grid scale factor
Mo	=	Scaled radius of curvature in the meridian at "Bo"
ro	=	Geometric mean radius of curvature at Bo scaled to the grid

Bs, Bn, Bb, and Lo in degrees: minutes
Bo in decimal degrees
Linear units in meters

PROJECTION TABLES

Lambert conformal conic projection with two standard parallels
Plane coordinate projection tables

DATUM: NAD 83
The projection is WASHINGTON NORTH

Ellipsoidal constants

$a = 6378137$ m
$f = 1/298.25722210$

Defining constants

$\phi_b =$ 47 0 (latitude of grid origin)
$\lambda_{CM} =$ 120 50 (longitude of origin and Central Meridian, CM)
$\phi_s =$ 47 30 (southern standard parallel)
$\phi_n =$ 48 44 (northern standard parallel)
$E_o =$ 500000.0000 m (easting coordinate of origin)
$N_b =$ 0.0000 m (northing coordinate of origin)

Derived constants

$\ell = 0.744520326553 = \sin(\phi_o)$
$K =$ 11670409.5559 m (mapping radius at the equator)
$R_b =$ 5853778.6038 m (mapping radius at grid origin)

Lambert coordinates (N,E) from geodetic positions (ϕ,λ)

$\gamma = (\lambda_{CM} - \lambda)\sin(\phi_o)$ (γ is the meridional convergence)
$E = R\sin(\gamma) + E_o$ (R from table)
$N = R_b - R\cos(\gamma) + N_b$

Station	Latitude Longitude	R γ	$\sin(\gamma)$ $\cos(\gamma)$	E N
sample 1	48 7 0.00000 121 20 0.00000	5729625.030 m -0 22 20.13659	-0.0064971198 0.9999788935	462773.940 m 124274.506 m

Geodetic positions from Lambert coordinates

$\tan(\gamma) = (E - E_o)/((R_b - (N - N_b))$
$R = (R_b - (N - N_b))/\cos(\gamma)$
$\lambda = \lambda_{CM} - \gamma/\ell$
ϕ from table using R

Station	E N	$E - E_o$ $R_b - (N - N_b)$	R γ	Latitude Longitude
sample 2	540000.000 m 130000.000 m	40000.000 m 5723778.604 m	5723916.3699 m 0 24 1.43555	48 10 4.7701 120 17 43.9406

WARNING: Use sufficient significant digits for trig.functions

PROJECTION TABLES

Lambert conformal conic projection with two standard parallels
Plane coordinate projection tables

DATUM: NAD 83
The projection is WASHINGTON SOUTH

Ellipsoidal constants

$a = 6378137$ m
$f = 1/298.25722210$

Defining constants

$\phi_b = 45°20'$ (latitude of grid origin)
$\lambda_{CM} = 120\ 30$ (longitude of origin and Central Meridian, CM)
$\phi_s = 45\ 50$ (southern standard parallel)
$\phi_n = 47\ 20$ (northern standard parallel)
$E_o = 500000.0000$ m (easting coordinate of origin)
$N_b = 0.0000$ m (northing coordinate of origin)

Derived constants

$\ell = 0.726395784020 = \sin(\phi_o)$
$K = 11760132.9643$ m (mapping radius at the equator)
$R_b = 6183952.2755$ m (mapping radius at grid origin)

Lambert coordinates (N,E) from geodetic positions (ϕ,λ)

$\gamma = (\lambda_{CM} - \lambda)\sin(\phi_o)$ (γ is the meridional convergence)
$E = R\sin(\gamma) + E_o$ (R from table)
$N = R_b - R\cos(\gamma) + N_b$

Station	Latitude Longitude	R γ	$\sin(\gamma)$ $\cos(\gamma)$	E N
sample 1	46 35 0.00000 121 0 0.00000	6045015.043 m -0 21 47.51241	-0.0063389566 0.9999799086	461680.912 m 139058.685 m

Geodetic positions from Lambert coordinates

$\tan(\gamma) = (E - E_o)/(R_b - (N - N_b))$
$R = (R_b - (N - N_b))/\cos(\gamma)$
$\lambda = \lambda_{CM} - \gamma/\ell$
ϕ from table using R

Station	E N	$E - E_o$ $R_b - (N - N_b)$	R γ	Latitude Longitude
sample 2	540000.000 m 140000.000 m	40000.000 m 6043952.275 m	6044084.6377 m 0 22 45.07891	46 35 30.1337 119 58 40.7506

WARNING: Use sufficient significant digits for trig.functions

WHAT YOU NEED TO USE THE STATE PLANE COORDINATE SYSTEMS

- N & E STATE PLANE COORDINATES FOR CONTROL POINTS

AZIMUTHS

- Conversion from Astronomic to Geodetic
- Conversion from Geodetic to Grid (Mapping Angle)

DISTANCES

- Reduction from Horizontal to Ellipsoidal
  "Sea-Level Reduction Factor"
- Correction for Grid Scale Factor
- Combined Factor

SYMBOLS USED IN TEXT

SYMBOLS USED IN TEXT

ϕ = PHI = LATITUDE

λ = LAMBDA = LONGITUDE

α = ALPHA = AZIMUTH OF LINE, USUALLY REFERRING TO GEODETIC VALUES. GRID OR PLANE AZIMUTHS ARE USUALLY DENOTED AS α_2. OCCASIONALLY USED TO INDICATE AN ANGLE.

Δ = DELTA = DIFFERENCE

$\Delta\phi$ = DELTA PHI = DIFFERENCE IN LATITUDE

$\Delta\lambda$ = DELTA LAMBDA = DIFFERENCE IN LONGITUDE

$\Delta\alpha$ = DELTA ALPHA = DIFFERENCE IN AZIMUTH

ρ = RHO = RADIUS OF CURVATURE OF THE REFERENCE SPHEROID. THE ONLY USE MADE OF THIS QUANTITY IN THIS PAPER IS IN THE REDUCTION OF HORIZONTAL DISTANCES TO ELLIPSOID VALUES. FOR THIS PURPOSE, A MEAN VALUE EQUAL TO 20,906,000 FT. AND DESIGNATED AS "R" HAS BEEN UTILIZED. THIS "R" VALUE SHOULD NOT BE CONFUSED WITH THE "R" OR "R " QUANTITIES USED IN THE COMPUTATIONS INVOLVING THE CONVERSION OF GEOGRAPHIC POSITIONS TO LAMBERT PLANE COORDINATES AND THE INVERSE OF THE PROBLEMS.

h = ELEVATION AND ON RARE OCCASIONS MAY INDICATE A DIFFERENCE IN ELEVATION.

L = SLOPE OR INCLINED DISTANCE

D = HORIZONTAL DISTANCE

S = GEODETIC DISTANCE = DISTANCE AT THE ELLIPSOID SURFACE.

S_g = GRID DISTANCE = GEODETIC DISTANCE MULTIPLIED BY SCALE (GRID) FACTOR.

CM = CENTRAL MERIDIAN = THE MERIDIAN (LONGITUDE) OR AXIS USUALLY SITUATED NEAR THE CENTER OF A PLANE COORDINATE ZONE WHICH SEPARATES THE POSITIVE AND NEGATIVE X' VALUES (SEE DEFINITION OF X').

X' = THE DISTANCE (IN METERS FOR THE STATE GRID SYSTEMS) EAST AND WEST OF THE CENTRAL MERIDIAN. EAST OF THE CENTRAL MERIDIAN THE VALUES ARE POSITIVE, WEST OF THIS MERIDIAN THEY ARE NEGATIVE. THESE QUANTITIES CAN BE DESCRIBED IN PLANE SURVEYING TERMINOLOGY AS THE DEPARTURES MEASURED FROM THE Y AXIS.

SYMBOLS USED IN TEXT

E = THE PLANE COORDINATE VALUES WHICH ARE PERPENDICULAR TO THE N AXIS. THESE VALUES USUALLY CONSIST OF A CONSTANT $C \pm X$. THE CONSTANT "C" IS GENERALLY OF SUFFICIENT SIZE TO ASSURE THAT THE X QUANTITIES WILL BE POSITIVE.

γ = GAMMA = THE MAPPING ANGLE IN THE LAMBERT PROJECTION USUALLY REFERRED TO AS THE "GAMMA" ANGLE. THIS ANGLE IS APPLIED TO GEODETIC AZIMUTHS TO OBTAIN PLANE (GRID) AZIMUTHS AND VICE VERSA.

<u>NOTE</u>: ALTHOUGH THESE REDUCTIONS ARE NOT EXACT, THE ERROR IN NEGLECTING ANOTHER CORRECTION WHICH IS KNOWN AS THE "SECOND TERM" (T-t CORRECTION) IS QUITE SMALL FOR THE STATE SYSTEMS AND CAN BE IGNORED EXCEPT FOR THOSE OCCASIONS WHERE THE MOST PRECISE COMPUTATIONS ARE DESIRED.

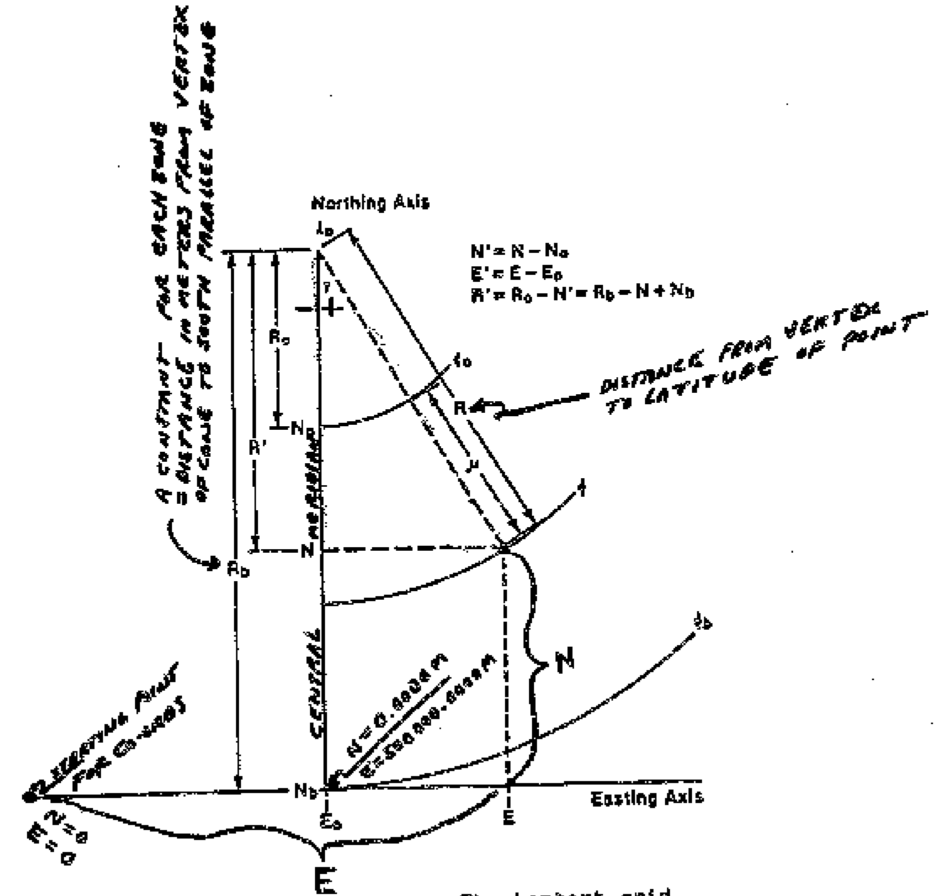
N = THE PLANE COORDINATE VALUES (GIVEN IN METERS FOR THE STATE GRID SYSTEMS) WHICH CORRESPOND TO THE DISTANCES NORTH OF THE ORIGIN TO THEIR INTERSECTION WITH THE E COORDINATES OF THE POINTS. THESE QUANTITIES CAN BE DESCRIBED IN PLANE SURVEYING TERMINOLOGY AS THE LATITUDES MEASURED FROM THE ORIGIN.

R = IN THE STATE LAMBERT GRID SYSTEMS, THE DISTANCES IN METERS FROM THE VERTEX OF THE CONE TO THE LATITUDES OF THE POINTS.

R_b = IN THE STATE LAMBERT GRID SYSTEMS, THE DISTANCE IN METERS FROM THE VERTEX OF THE CONE TO THE ORIGIN.

ℓ = A CONSTANT DETERMINED FOR EACH ZONE OR BAND OF A LAMBERT PROJECTION AND IS EQUAL TO THE SINE OF ϕ_o WHICH IS THE LATITUDE ABOUT MIDWAY BETWEEN THE STANDARD PARALLELS. ℓ MULTIPLIED BY THE DIFFERENCE IN SECONDS BETWEEN THE LONGITUDE OF A POINT AND THE CENTRAL MERIDIAN EQUALS γ (GAMMA) ANGLE IN SECONDS FOR THE POINT.

SOLUTION EQUATIONS



The Lambert grid.

$$\gamma = \ell\,(\Delta\lambda)''$$

$\Delta\lambda$ = CENTRAL MERIDIAN − LONG OF STATION

$$R = (R_b - N)/\cos\gamma$$

SOLUTIONS

STEPS TO CONVERT

GEODETIC POSITIONS TO LAMBERT COORDINATES

WARNING: Use sufficient significant digits for trig.functions

STEP 1 COMPUTE R VALUE FOR LATITUDE OF POINT

GIVEN : 48-07-00.00000 LATITUDE OF POINT

PAGE 4-17 3

Lambert conformal conic projection tables
WASHINGTON NORTH

Lat		R (meters)	tab diff.	k
48	5	5733331.225	30.88492	0.99994244
48	6	5731478.131	30.88500	0.99994230
48	7	5729625.030	30.88509	0.99994225
48	8	5727771.925	30.88519	0.99994229
48	9	5725918.814	30.88528	0.99994241

= 5729625.030

STEP 2 COMPUTE γ VALUE FOR LONGITUDE OF POINT

$\gamma = (\lambda_{CM} - \lambda)\sin(\phi_o)$ (γ is the meridional convergence)

GIVEN : 121-20-00.00000 = (λ) LONGITUDE OF POINT

λ_{CM} = 120 50 (longitude of origin and Central Meridian, CM)

ℓ = 0.744520326553 = $\sin(\phi_o)$ THIS IS A CONSTANT

$$\gamma = (\underbrace{120\text{-}50\text{-}00}_{\lambda_{CM}} - \underbrace{121\text{-}20\text{-}00.00000}_{\lambda})\ \underbrace{0.744520326553}_{\sin(\phi_o)}$$

$$= (-0\text{-}30\text{-}00)\ 0.744520326553$$

-0.50

$$= -0\text{-}22\text{-}20.13659$$

SOLUTIONS

STEP 3 COMPUTE EASTING OF POINT

$$E = R\sin(\gamma) + E_o \qquad \left\{ \begin{array}{l} E_o = 500000.0000\ \text{m} \\ \text{(easting coordinate of origin)} \end{array} \right.$$

$$E = \overset{R}{5729625.030} \times \sin \overset{\gamma}{-0\text{-}22\text{-}20.13659} + \overset{E_o}{500000.0000}\ \text{m}$$

$$= 5729625.030 \times -0.006477120 + 500000.0000\ \text{m}$$

$$= -37226.06036 + 500000.0000\ \text{m}$$

$$= 462{,}773.940\ \text{m}$$

STEP 4 COMPUTE NORTHING OF POINT

$$N = R_b - R\cos(\gamma) + N_b$$

R_b = 5853778.6038 m (mapping radius at grid origin)

N_b = 0.0000 m (northing coordinate of origin)

$$N = \overset{R_b}{5853778.6038\ \text{m}} - \overset{R}{5729625.030} \times \cos \overset{\gamma}{-0\text{-}22\text{-}20.13659} + \overset{N_b}{0.0000\ \text{m}}$$

$$= 5853778.6038\ \text{m} - 5729625.030 \times 0.999978894 + 0.0000\ \text{m}$$

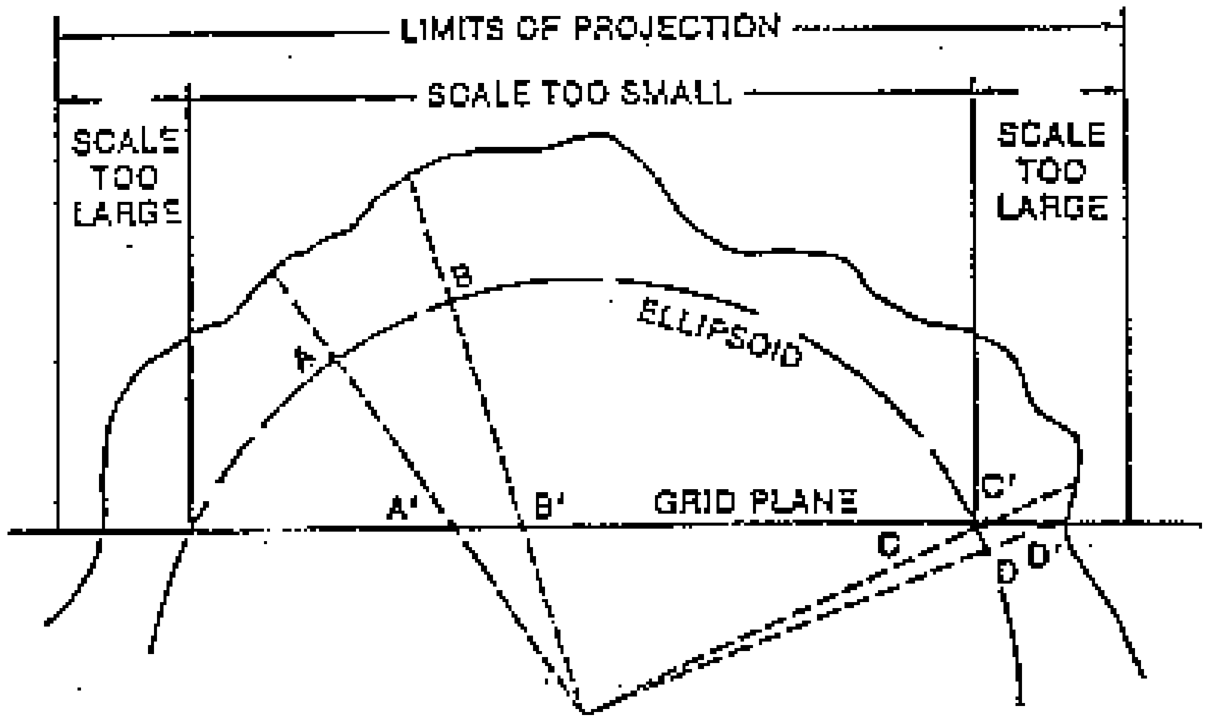
$$= 5853778.6038\ \text{m} - 5729504.098 + 0.0000\ \text{m}$$

$$= 5853778.6038\ \text{m} - 5729504.098$$

$$= 124274.506\ \text{m}$$

Station	Latitude Longitude	R γ	sin(γ) cos(γ)	E N
sample 1	48 7 0.00000 121 20 0.00000	5729625.030 m -0 22 20.13659	-0.0064971198 0.9999788935	462773.940 m 124274.506 m

SCALE FACTORS



Grid Distance A' to B' is Smaller Than Geodetic Distance A to B

Grid Distance C' to D' is Larger Than Geodetic Distance C to D

Figure 4.2.--Geodetic vs. grid distances.

REDUCTION TO GRID

(Geodetic Distance) x k (Grid Scale Factor)

SCALE FACTORS

The scale factor for the State of Washington south zone at 47° 15' 06.14

.99998235

47° 15' $K =$ 0.99998200

47° 16' $K =$ 0.99998543

0.00000343

$$\frac{0.00000343}{60''} = 0.000000006$$

0.0000000006 × 06.14'' = 0.0000000035

0.99998200

0.00000035

0.99998235 = K for 47-15-06.14

SCALE FACTORS

TRAVERSE COMPUTATION SHEET

JOB & PROJECT:

COMPUTED BY L. SIGNANI | DATE

CHECKED BY | DATE

SURVEY OF | BY | DATE

FIELD BOOK FILE NO. | MAP FILE NO.

Grid Coords

STATION	DEFLECTION ANGLE	AZIMUTH (OR BEARING)	DISTANCE	COSINE	SINE	N.	S.	E.	W.	CO-ORDINATES
A-17										[illegible]
6 MILES NORTH		NORTH	31680.00			31680.00				[illegible]
12 MILES NORTH		✓	31680.00			31680.00				[illegible]

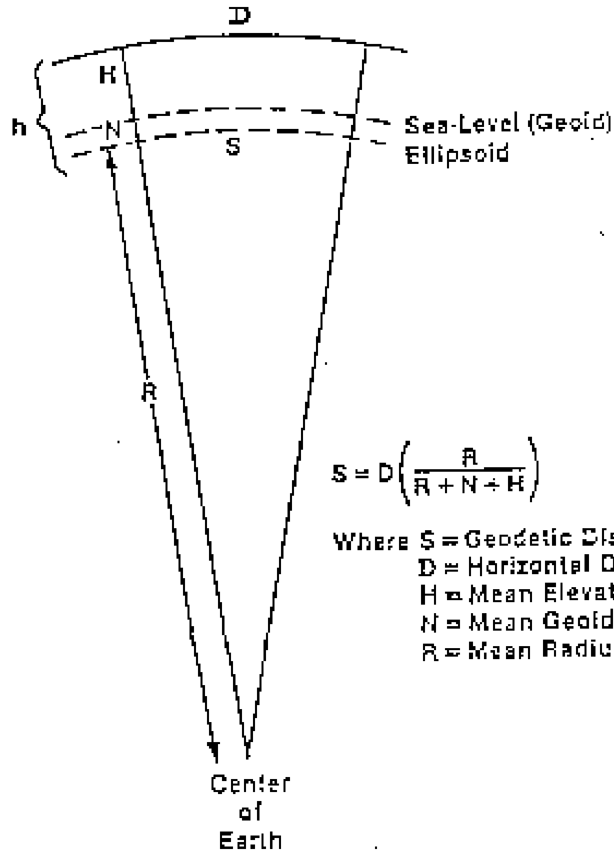
A-17	586947.67500 N	46 56 30.96315 N
	2116321.24300 E	120 02 03.54579 W
Convergence	00 20 17.76929	
Scale Factor	0.999933979	
6 MILES NORTH	618627.67500 N	47 01 43.66785 N
	2116321.24300 E	120 02 00.84587 W
Convergence	00 20 19.73050	
Scale Factor	0.999944576	
12 MILES NORTH	650307.67500 N	47 06 56.36403 N
	2116321.24300 E	120 01 58.13723 W
Convergence	00 20 21.69804	
Scale Factor	0.999957482	

Scale factor is a function of latitude and can be obtained from the appropriate projection table. Depending on accuracy requirements and the extent of the project area in a north-south direction, the average latitude as obtained from a quad sheet is sufficient. When working on the 83 system in Washington, a very conservative rule of thumb is use an average latitude for a township. For "real picky" surveys a weighted average of scale factor for each line can be used. But there are usually more important things to worry about - optical plummets, ppm correction, baseline calibration, etc.

NPS FORM 177 (Previous) MAR 1959

SHEET NO ____

ELEVATION FACTORS



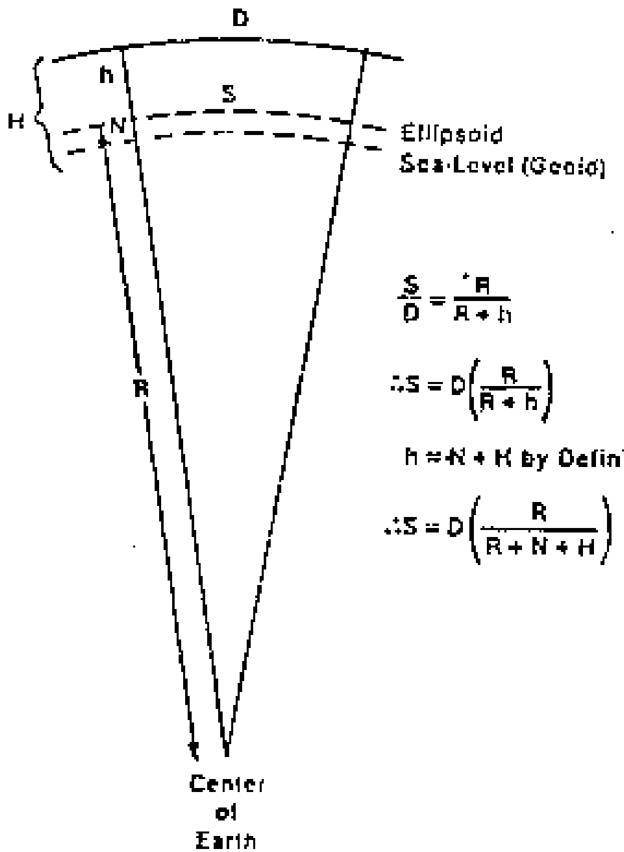
$$S = D\left(\frac{R}{R+N+H}\right)$$

Where S = Geodetic Distance
D = Horizontal Distance
H = Mean Elevation
N = Mean Geoid Height
R = Mean Radius of Earth

REDUCTION TO THE ELLIPSOID

ALASKA

ELEVATION FACTORS



$$\frac{S}{D} = \frac{R}{R+h}$$

$$\therefore S = D\left(\frac{R}{R+h}\right)$$

$h = N + H$ by Definition

$$\therefore S = D\left(\frac{R}{R+N+H}\right)$$

REDUCTION TO THE ELLIPSOID

LOWER STATES

GEOID MODELS

U.S. NATIONAL MODEL -- GEOID99

(http://www.ngs.noaa.gov/cgi-bin/GEOID_STUFF/geoid99_prompt1.prl)

CANADIAN NATIONAL MODEL -- CGG2000

http://www.geod.nrcan.gc.ca/products/html-public/GSDinfo/English/factsheets/gpsht_fact.html

GLOBAL MODEL -- EGM 96

(http://www.nima.mil/GandG/wgs-84/egm96.html)

GEOID03

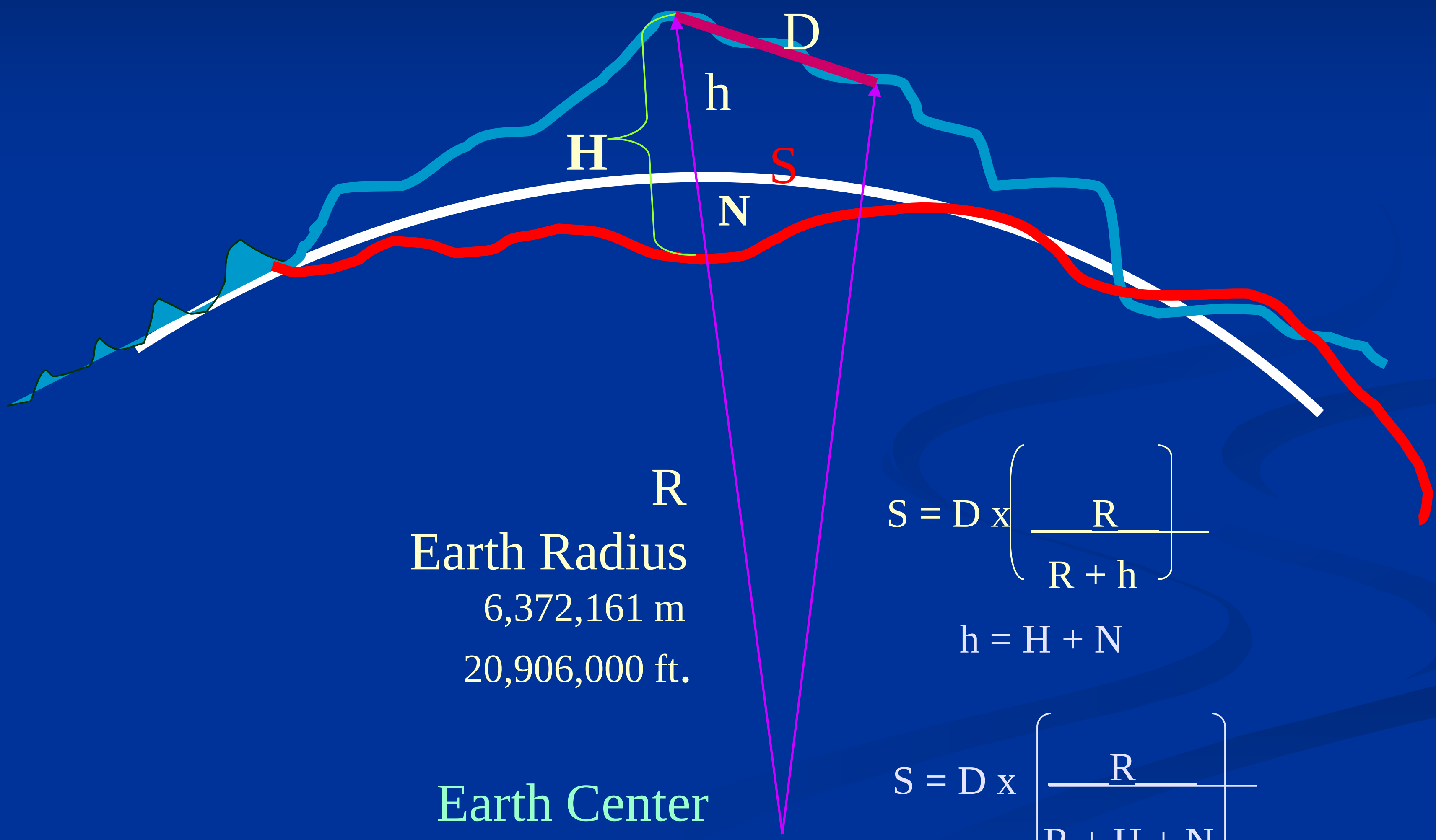
USGG2003 and GEOID03

USGG = U.S. Gravimetric Geoid
GEOID03 = U.S. Hybrid Geoid

In excess of 11,000 GPS on BMs
(A, B, and 1st- Order GPS on 1st, 2nd and 3rd – Order NAVD 88 BMs)

Possibly overall misfit will be about 2.9 cm.

REDUCTION TO THE ELLIPSOID



$$S = D \times \left(\frac{R}{R + h} \right)$$

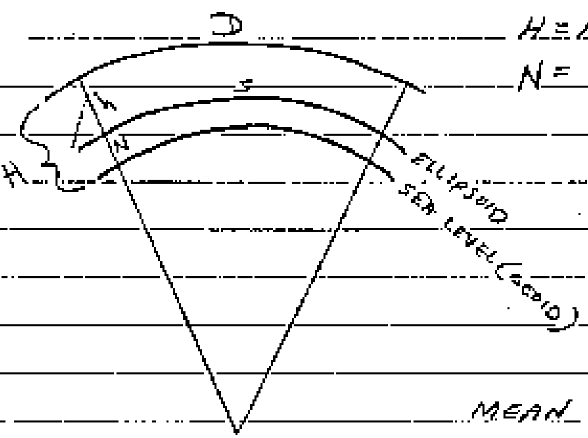
$$h = H + N$$

$$S = D \times \left(\frac{R}{R + H + N} \right)$$

ELEVATION FACTORS

The Elevation factor for a mean elevation of 1941.8 ft. and a Mean Geoid Height of -19.65m is

0.99991023



H = Mean elevation of traverse pt

N = " Geoid Height

MEAN H = 1941.8 ft.

MEAN N = -19.65 m = 64.5 ft

Elevation factor = (20,906,000) / (20,906,000 + H + N)

= (20,906,000) / (20,907,877) = 0.99991023

ELEVATION FACTORS

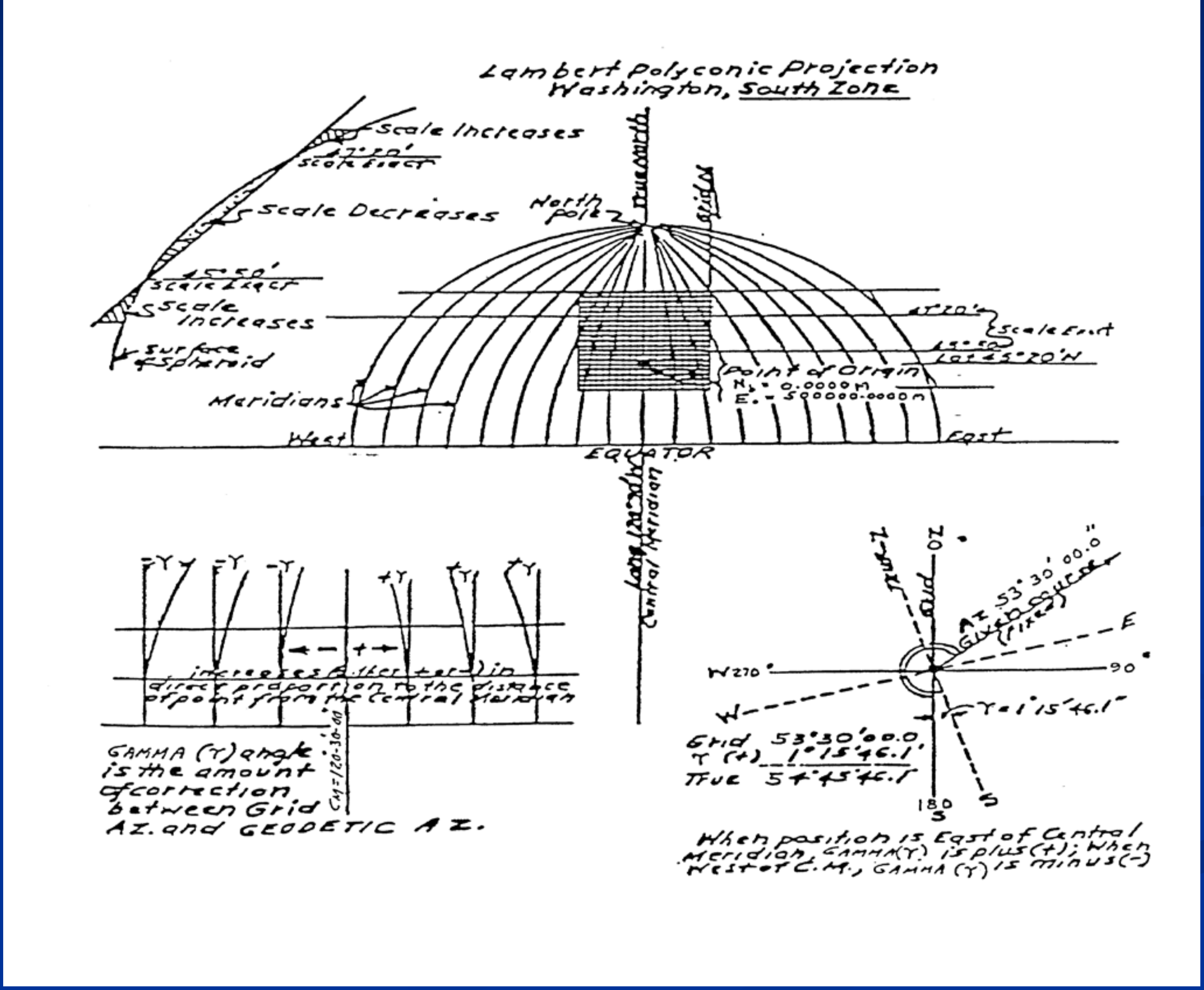
ELEVATION FEET	FACTOR	ELEVATION FEET	FACTOR
	1.0000000	4500	.9997848
500	.9999761	5000	.9997609
1000	.9999522	5500	.9997370
1500	.9999283	6000	.9997131
2000	.9999043	6500	.9996892
2500	.9998804	7000	.9996653
3000	.9998565	7500	.9996414
3500	.9998326	8000	.9996175
4000	.9998087		

NOTE: Where difference in elevation does not exceed 500' along any traverse, mean traverse elevation can be used and one factor may be interpolated for entire traverse. When violent difference in elevation occurs, individual factors must be interpolated.

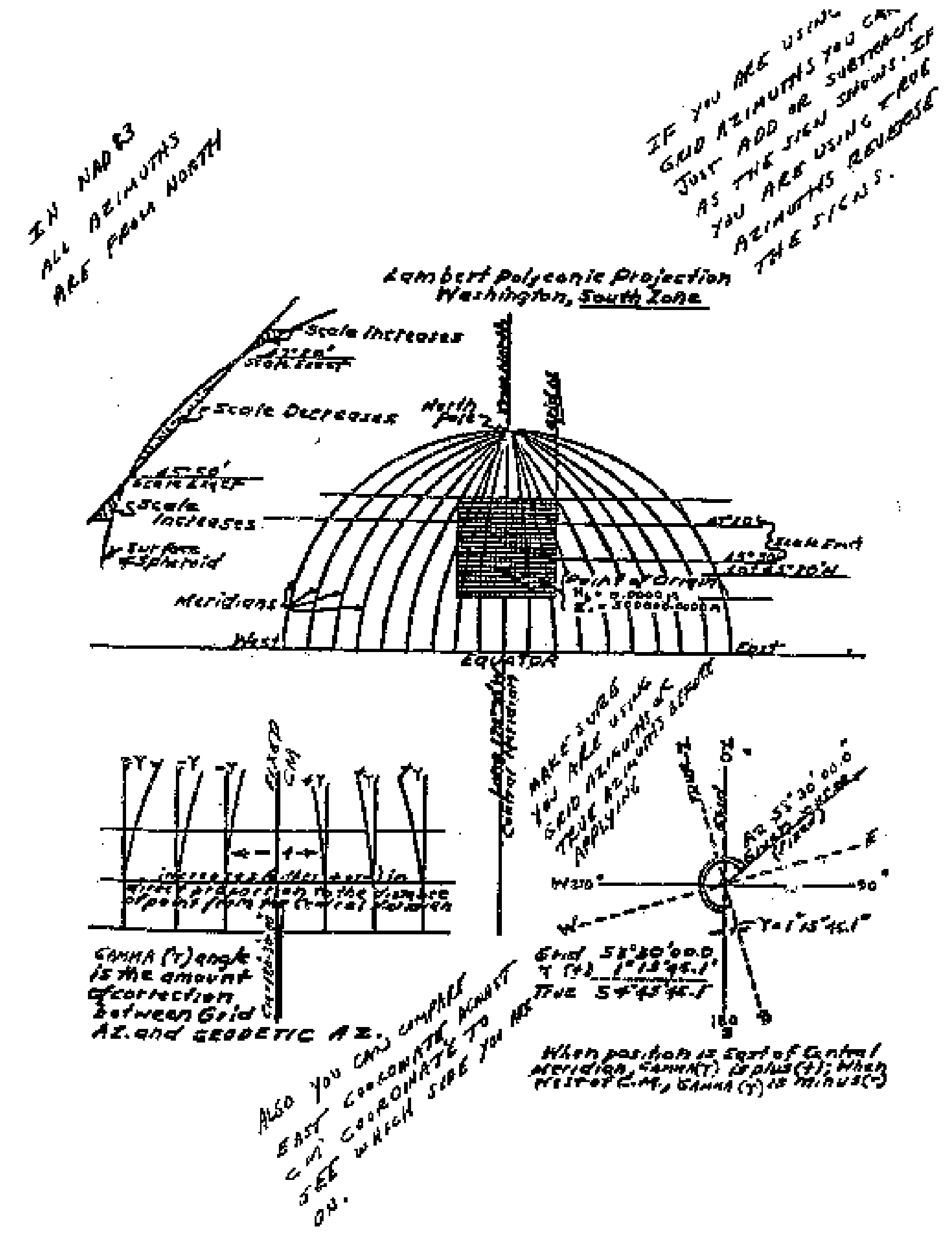
COMBINED FACTOR

CF = Ellipsoidal Reduction Factor x Grid Scale Factor (k)

CONVERGENCE

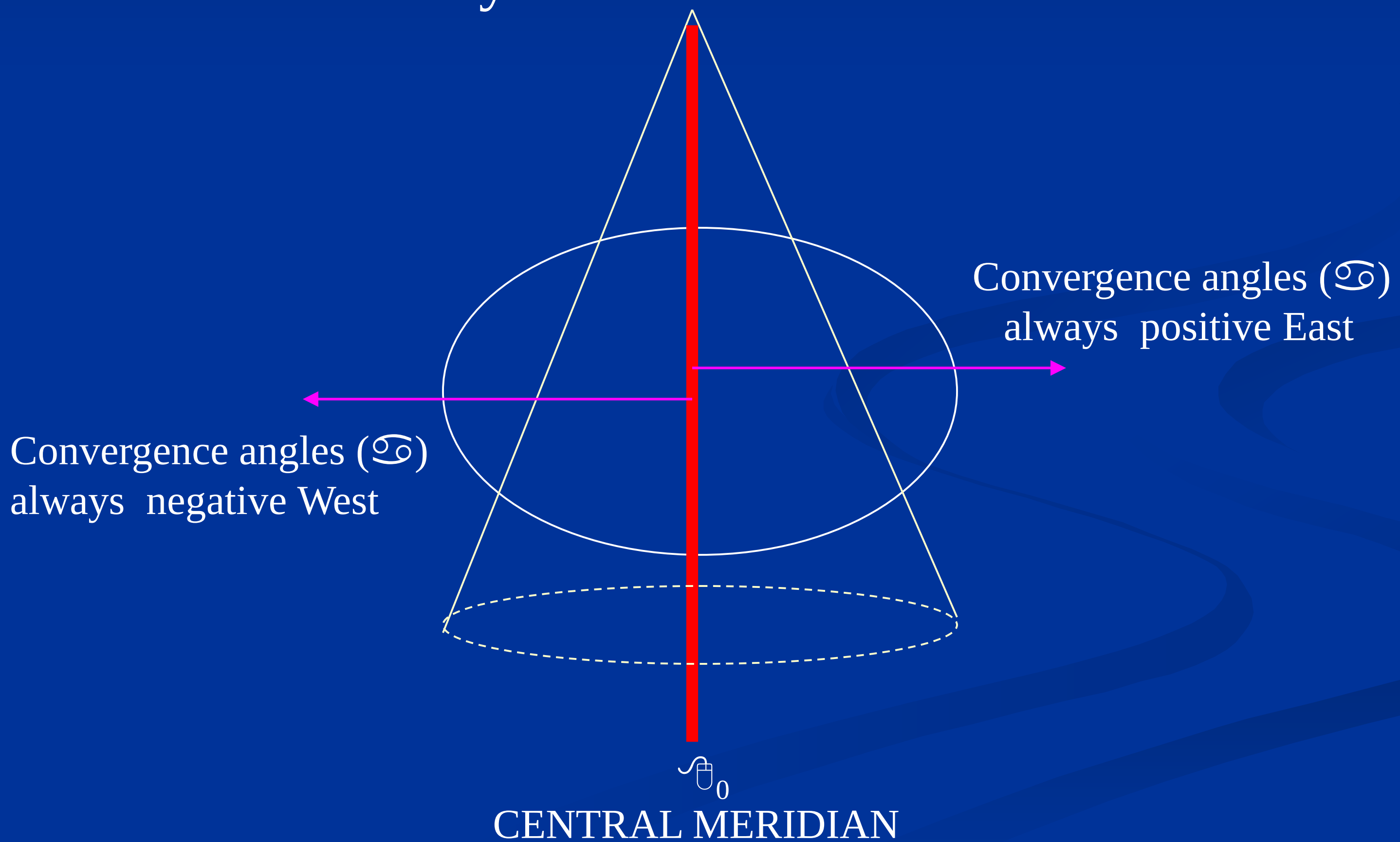


CONVERGENCE



LAMBERT CONFROMAL CONIC WITH 2 STANDARD PARALLELS

The Convention of the Sign of the Convergence Angle is Always From Grid To Geodetic



GROUND LEVEL COORDINATES

"I WANT STATE PLANE COORDINATES RAISED TO GROUND LEVEL"

GROUND LEVEL COORDINATES ARE NOT STATE PLANE COORDINATES!!!!!

PROJECT COORDINATES

PROJECT LENGTHS FROM STATE COORDINATES

Engineering projects require the field location of construction lines and survey points. Since most large projects will be established with reference to control points on the state coordinate system, the construction plans and drawings will contain state coordinates and grid lines. If the state coordinates of two ends of a construction line are used to inverse the line, the grid length and grid bearing or azimuth will result. The proper length to be laid off, however, is the actual ground length. The difference between the grid length and the ground length can be taken into account by one of two methods. The first method, which is quite practical, is to ignore the difference. This method assumes that the errors in layout measurements are larger than the errors introduced by neglecting the difference between the grid and the ground distance. For example, in an area whose elevation is 2500 ft, the sea-level reduction factor is 0.9998804. Suppose the grid scale factor is 0.9999000 or one part in 10,000. The combination factor is then 0.9997804. This means that the difference between the ground length and the grid length is only 0.02 ft/100 ft or 0.22 ft/1000 ft. This small discrepancy, amounting to about one part in 5000, could be ignored on most construction projects. In high country the sea-level reduction factor becomes significant, particularly if the project lies in an area of the state projection where the grid scale factor is less than unity.

The second method is to compute the combination sea-level grid factor, and then to *divide* all grid distances indicated on, or derived from, the plans in order to obtain the correct ground or project lengths. In order to accomplish this without misunderstanding between the surveyor, engineer, and contractor, a note should accompany each construction drawing giving explicit instructions to the user. The note could possibly read, "All distances shown on this set of plans (this drawing) or derived from plane coordinates shown on the plans (drawing) are grid distances on the—Coordinate System, Zone—. To obtain ground distances for laying out construction lines, divide grid distances by 0.9998940."

PROJECT COORDINATES

PROJECT DATUM COORDINATES

THE NAD 83 PLANE COORDINATE DATA ISSUED BY THE NATIONAL GEODETIC SURVEY IS AT THE ELLIPSOID REFERENCE. TO PROPERLY USE THIS DATA, GROUND DISTANCES SHOULD BE CORRECTED BY A SCALE FACTOR AND REDUCED TO THE ELLIPSOID. THIS COMPUTATION IS USUALLY MADE USING A COMBINED FACTOR. IT HAS BEEN SHOWN THAT TO OBTAIN ADJUSTED GROUND LEVEL DISTANCES THE ADJUSTED GRID DISTANCES ARE DIVIDED BY THE COMBINED FACTOR. TO OBTAIN GROUND LEVEL OR PROJECT DATUM COORDINATES, ALL THAT NEEDS TO BE DONE IS TO DIVIDE THE ELLIPSOID COORDINATES BY THE COMBINED FACTOR. THE DISTANCES COMPUTED FROM THESE COORDINATES WILL BE AT GROUND LEVEL.

THERE IS ANOTHER APPROACH THAT MAY BE TAKEN WHEN PROJECT DATUM COORDINATES ARE DESIRED. FIRST, THE PLANE COORDINATES FOR THE FIXED CONTROL POINTS ARE DIVIDED BY THE COMBINED FACTOR, WHICH REPRESENTS THE MEAN ELEVATION AND THE MEAN SCALE FACTOR FOR THE AREA TO PLACE THE FIXED CONTROL AT GROUND LEVEL. HORIZONTAL GROUND LEVEL DISTANCES ARE USED IN THE COMPUTATIONS WITH PROJECT DATUM COORDINATES THE END RESULT.

EXTREME CAUTION MUST BE EXERCISED WHEN SHOWING PROJECT DATUM COORDINATES ON A PLAT OR DOCUMENT. IN ADDITION TO A CLEAR EXPLANATION OF THE COORDINATES, THE COMBINED FACTOR SHOULD BE SHOWN, AND THE COORDINATES SHOULD BE CHANGED BY ADDING OR SUBTRACTING CONSTANTS OF SUFFICIENT SIZE SO THAT THEY WOULD NEVER BE TAKEN AS STATE PLANE COORDINATES.

PROJECT COORDINATES

PROJECT DATUM COORDINATES

(1) DETERMINE COMBINED ELLIPSOID AND SCALE FACTOR FOR PROJECT AREA.

(2) DIVIDE COORDINATES FOR CONTROL POINTS BY COMBINED FACTOR OR MULTIPLY BY 1/CF.

(3) USE HORIZONTAL GROUND LEVEL DISTANCES.

(4) BALANCE TRAVERSE - RESULTS ARE GROUND LEVEL COORDINATES. DISTANCES COMPUTED FROM THESE COORDINATES ARE ADJUSTED GROUND LEVEL VALUES.

(5) IN ORDER THAT THE GROUND LEVEL COORDINATES WILL NOT BE MISTAKEN AS SPCS VALUES, DO THE FOLLOWING:

(a). MAKE COORDINATES UNIQUE BY DROPPING SOME FIGURES ON LEFT OR ADD LARGE CONSTANTS.

(b). DOCUMENT ALL COMPUTATIONS, PLATS, MAPS, ETC., WITH PERTINENT DETAILS INCLUDING COMBINED FACTOR USED. NOTE MEAN LATITUDE AND MEAN ELEVATION OF PROJECT IN DOCUMENTATION.

Ground Level Coordinates

Project Datum coordinates are based on state plane, but…..

Are NOT state plane coordinates!!!!

GROUND LEVEL COORDINATES

TRUNCATE COORDINATE VALUES

SUCH AS:

N = 13,750,260.07 ft becomes 50,260.07

E = 2,099,440.89 ft becomes 99,440.89

AND

DOCUMENT DOCUMENT DOCUMENT !!

LEGAL DESCRIPTIONS

BASIS OF BEARINGS FOR THIS SURVEY IS N02°00'54"E BETWEEN THE CASED MONUMENTS AT THE SOUTHEAST CORNER AND THE EAST QUARTER CORNER OF SECTION 28, TOWNSHIP 31 NORTH, RANGE 5 EAST, WILLAMETTE MERIDIAN, ORIENTED ON THE WASHINGTON COORDINATE SYSTEM NAD 83 (1991), NORTH ZONE.

SECTION SUBDIVISION INFORMATION SHOWN HEREON WAS ESTABLISHED BY GPS, AND IS SCALED TO GROUND DISTANCES WITH A GRID SCALE FACTOR OF 0.9999423 AND AN ELEVATION FACTOR OF 0.9999970 BEING APPLIED, FOR A COMBINED FACTOR OF 0.9999393, YIELDING HORIZONTAL GROUND DISTANCES FOR THE SECTION SUBDIVISION AND THROUGHOUT THIS MAP.

FIELD MEASUREMENTS FOR THIS MAP PERFORMED WITH TRIMBLE 4000SSE GPS, WILD 1610 AND SOKKIA SET 2 TOTAL STATIONS, AND MEET OR EXCEED A LINEAR CLOSURE OF 1:15,000 AND THE LEAST SQUARES ADJUSTMENTS YIELDS A RELATIVE ACCURACY NO GREATER THAN 0.08 FEET AT A 95% CONFIDENCE LEVEL, RELATIVE TO THE CONTROLLING MONUMENTS (SNOHOMISH COUNTY GPS CONTROL POINTS #516 AND #438).

ALL PRIMARY MEASUREMENT EQUIPMENT UTILIZED HAS BEEN COMPARED AND ADJUSTED TO A NATIONAL GEODETIC SURVEY CALIBRATED BASELINE, WITHIN THE LAST YEAR.

THIS SURVEY UTILIZED CHICAGO TITLE REPORT NOS. 363284 & 363066.

LEGAL DESCRIPTIONS

SAMPLE

LEGAL DESCRIPTION USING WASHINGTON COORDINATES

That portion of the southwest one-quarter of the northwest one-quarter of Section 16, Township 12 North, Range 19 East, Willamette Meridian, situate in county of Yakima, State of Washington, described as follows:

> Commencing at the northwest corner of said Section 16, having grid coordinates of N 438 136.45 and E 1650719.03, South Zone, Washington Coordinate System NAD 83/91; thence South 0°21'01" West, a grid distance of 1,388.13 feet along the West line of said Section 16; thence South 89°38'59" East, a grid distance of 173.54 feet to the True Point of Beginning having grid coordinates of N 436747.29 and E 1650884.07; thence North 79°55'36" East, a grid distance of 149.97 feet; thence South 10°04'24" East, a grid distance of 149.97 feet; thence South 79°55'36" West, a grid distance of 149.97 feet; thence North 10°04'24" West, a grid distance of 149.97 feet to the True Point of Beginning.

All bearings and distances shown are on the Washington Coordinate System NAD 83/91, South Zone and the combined grid factor is 0.9998306

NOTE: TO OBTAIN THE AREA AT THE MEAN ELEVATION OF THE PROPERTY, DIVIDE THE GRID AREA BY THE COMBINED FACTOR SQUARED.

METER TO FEET CONVERSIONS

SAMPLE CONVERSIONS OF PLANE COORDINATE VALUES FROM METRIC TO ENGLISH UNITS

EXAMPLE 1: Convert NAD 83 State Plane Coordinate Value in Meters to Value

Expressed in U.S. Survey Feet (1200/3937 meter)

(1 meter = 39.37 inches exactly = 3937/1200 feet)

Northing (meters) x (3937/1200) U.S. Survey Feet/meter = Northing (U.S Survey Feet)

98,923.927 m x (3937/1200) U.S. Survey Feet/meter = 324,552.917 U.S. Survey Feet

Easting (meters) x (3937/1200) U.S. Survey Feet/meter = Easting (U.S. Survey Feet)

602,242.230 m x (3937/1200) U.S. Survey Feet/meter = 1,975,856.383 U.S. Survey Feet

EXAMPLE 2: Convert NAD 83 State Plane Coordinate Value in Meters to Value

Expressed in International Feet (381/1250 meter)

(1 inch = 2.54 centimeters exactly)

1 foot = (12 in/ft x 2.54 cm/in) x (1 m/100 cm) = 0.3048 m = 381/1250 m

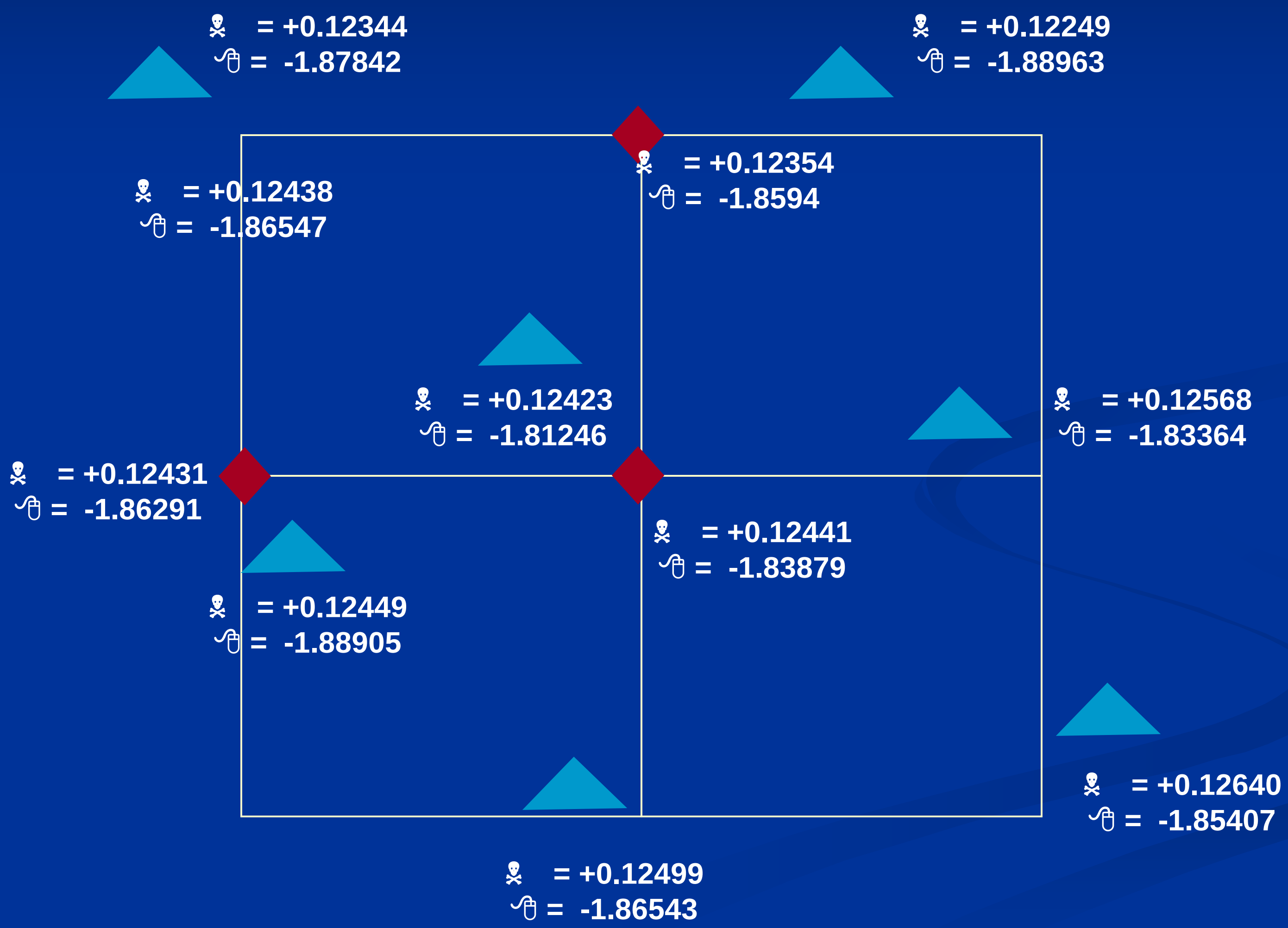
Northing (meters) x (1250/381) International Feet/meter = Northing (International Feet)

98,923.927 m x (1250/381) International Feet/meter = 324,553.566 International Feet

Easting (meters) x (1250/381) International Feet/meter = Easting (International Feet)

602,242.230 m x (1250/381) International Feet/meter = 1,975,860.335 International Feet

NADCON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🖱 = -1.86543

CORPSCON

- http://crunch.tec.army.mil/software/corpscon/corpscon.html#download