3.3 North American Datum (NAD) 83

A. Description of NAD83 (Taken from the Caltrans Surveys Manual **4.1-2**)

The sea-level surface of the Earth is called the geoid and is defined as the surface that is perpendicular to the direction of gravity at all points. The geoid is not a mathematically definable geometric shape. It is irregular because the direction of gravity varies from point to point as the result of the irregular distribution of mass within the earth.

Because of its irregular non-mathematical shape, the geoid cannot be used for calculations of the relative horizontal positions of points on the earth's surface. So, a representative geometric surface that approximates the geoid is used to perform positional calculations. The reference surface used for the North American Datum of 1983 (NAD83) is an ellipsoid named the Geodetic Reference System of 1980 (GRS80). GRS80 is a worldwide best-fit model. It meets the needs of worldwide geodetic systems or the Global Positioning System (GPS).

(GRS80 has replaced the Clarke's Spheroid of 1866 which is a best-fitting model for North America, and which was the reference surface for NAD27.)

NAD83 was established by first performing a least squares adjustment of all the observations used to establish the NAD27 network and then redefining the mathematical reference surface from Clarke's Spheroid to the GRS80. NAD83 has geodetic coordinates that measure 70 to 100 m different from those of NAD27. There is no direct mathematical method to accurately transform coordinates from one system to the other. Data conversion programs such as NADCON, developed by NGS (National Geodetic Survey), and CORPSCON, developed by the Army Corps of Engineers, are only approximations that are not accurate enough for boundary or engineering surveys. With a general accuracy of 0.15 m these programs are satisfactory for some map conversions.

The geodetic coordinate system for NAD 83 is based on longitude defined as angular distance East or West of the prime meridian, which runs through the observatory at Greenwich, England, and latitude defined as the angular distance North or South of the Equator.

B. NAD83 Epochs (Taken from the Caltrans Surveys Manual **4.1-3**)

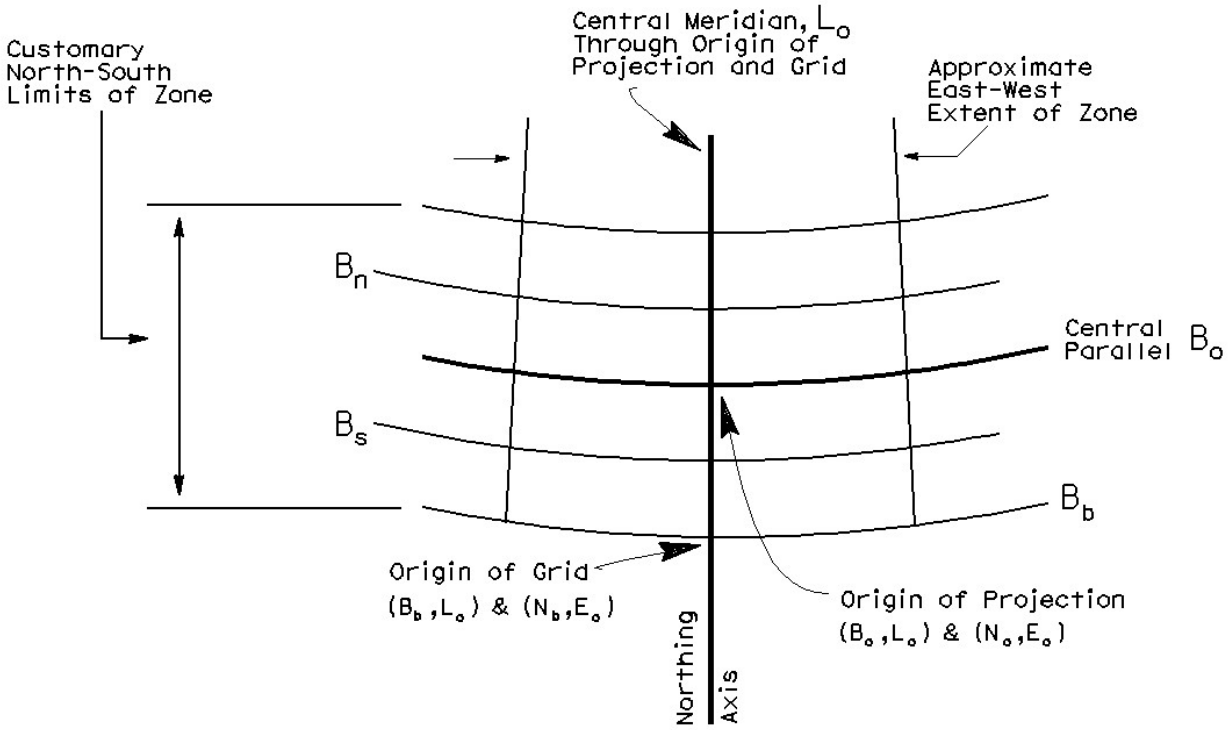
The initial NGS station coordinates based on NAD83 were the result of a simultaneous nationwide adjustment of the original observation that incrementally built up the NAD27 network. The adjustment results were published in 1986. Subsequently, in 1991 the California High Precision Geodetic Network (CA-HPGN) was established using GPS technology. The GPS survey was more precise than the methods used to establish the NAD83 reference system in 1986. Consequently, coordinates for stations determined with reference to the CA-HPGN are more accurate and may differ from those referenced to the original NAD83 positions by as much as 3 feet. To avoid confusion, an epoch (date) must be designated for all NAD83 data.

Much of California is affected by relatively large crustal motions, both secular (constant slip) and episodic (earthquake). Secular crustal motions can exceed 0.15 foot per year, and episodic events are observable with GPS surveys. As of October 1995, portions of the CA-HPGN have been resurveyed because of the Landers, Northridge, Mendocino, and Hector Mine earthquakes. These resurveys will continue to be necessary to maintain the accuracy of the CA-HPGN as the crustal motion constantly works to degrade the network. Each CA-HPGN resurvey is labeled with an epoch and all surveys using CA-HPGN for control must note the applicable epoch. The epoch of the original CA-HPGN survey is 1991.35. This is a dating system which indicates the mean date that the survey was conducted. The numbers to the right of the decimal point are derived from the day of the year. In this case, multiply 0.35 times 365 days to find that the mean date of the original CA-HPGN survey took place on the 128th day of the year, or May 8, 1991.

Sections taken from the Caltrans Surveys Manual may not be complete. Please refer to the 2006 Caltrans Surveys Manual for additional information on horizontal and vertical datums, an epoch and the California Coordinated System.

http://www.dot.ca.gov/hq/row/landsurveys

C. CA Coordinate System (CCS) – NAD 83

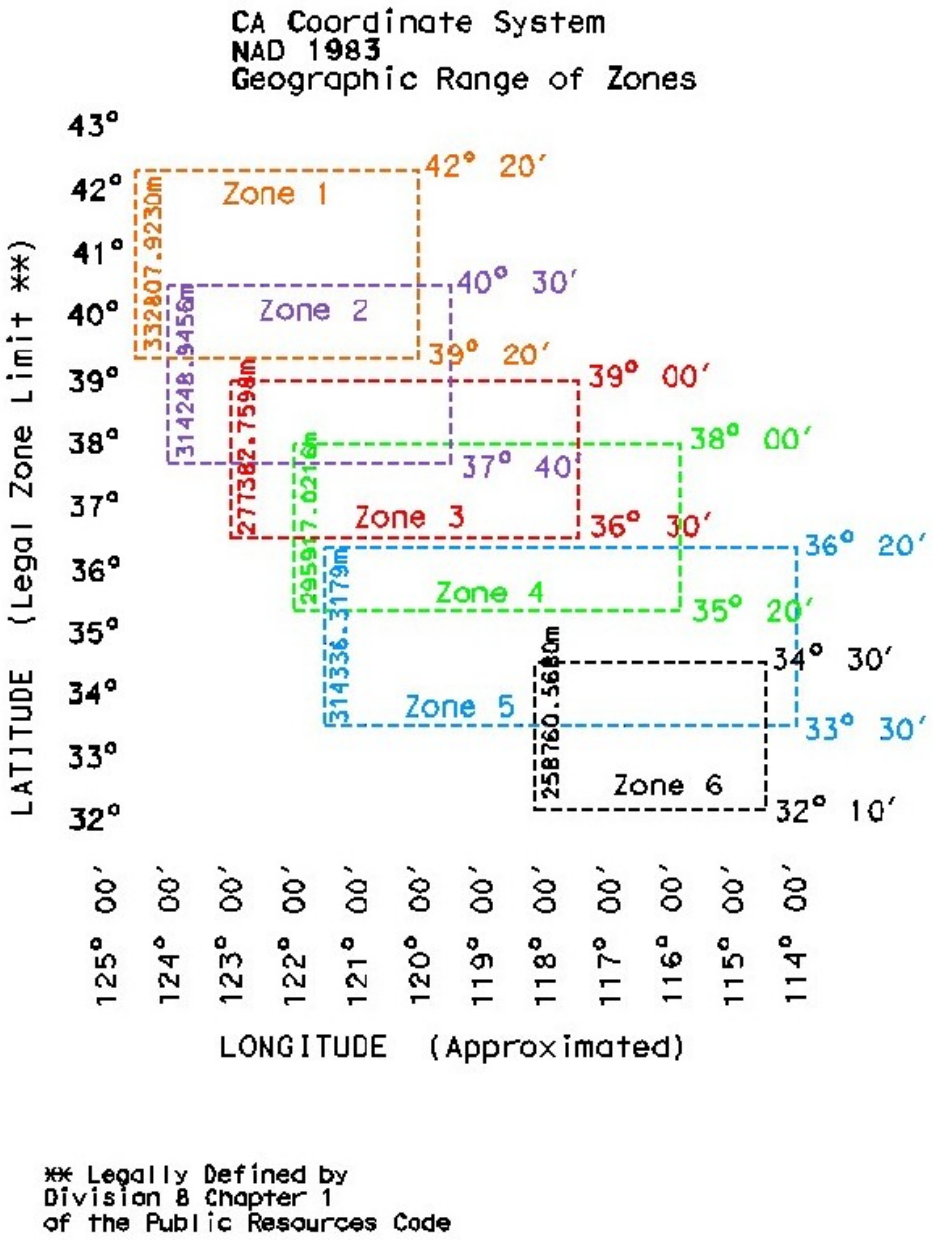


(N_b, E_o) & (B_b, L_o) – Origin of Grid
N_b = 500,000.00 m or **1640416.67 ft** (For all 6 zones)
E_o = 2,000,000.00 m or **6561666.67 ft** (For all 6 zones)

(N_o, E_o) & (B_o, L_o) – Origin of Projection
N_o – North coordinate of Projection Origin – (A tabled constant)
Each zone has a different value.

- N_o – Zone 1 = 2187504.09 ft
- N_o – Zone 2 = 2156844.53 ft
- N_o – Zone 3 = 2095943.33 ft
- N_o – Zone 4 = 2110955.38 ft
- N_o – Zone 5 = 2095707.85 ft
- N_o – Zone 6 = 2065126.16 ft

B_o – Central Parallel
L_o – Central Meridian through origin of projection and grid
B_b – Standard Parallel that defines south limit of zone
B_n – Standard Parallel that lies north of the projection's Central Parallel
B_s – Standard Parallel that lies south of the projection's Central Parallel



The Central Meridian is the line of longitude at the center of a projection. By defining the Central Meridian, the cone becomes oriented with respect to the ellipsoid.

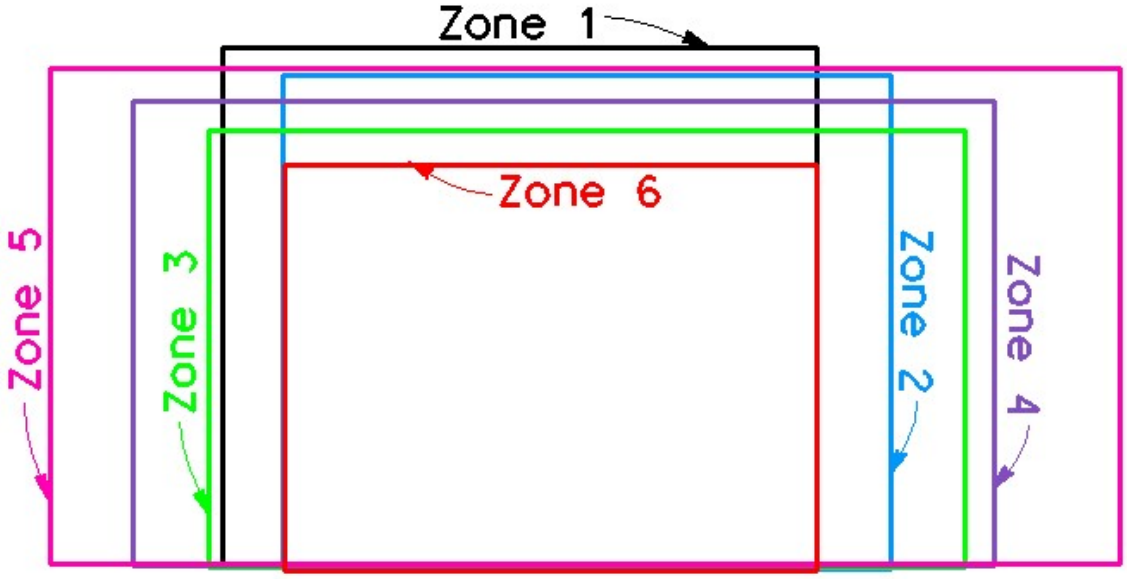
- The central meridian for Zone 1 is 122° 00’
- The central meridian for Zone 2 is 122° 00’
- The central meridian for Zone 3 is 120° 30’
- The central meridian for Zone 4 is 119° 00’
- The central meridian for Zone 5 is 118° 00’
- The central meridian for Zone 6 is 116° 15’

D. Summary

It is very important for users to remember that each “CA Coordinate System - NAD 83” zone, of which there are 6, is a separate Lambert projection. Please refer to the Caltrans – Surveys Manual – Section 4.3-2 for a thorough explanation of CCS83. http://www.dot.ca.gov/hq/row/landsurveys

Now, knowing some basic projection information concerning the calculation of CCS NAD 83 coordinates, one should understand the following:

- Each zone is a unique coordinate system.
- Since the Grid Origin (N_b, E_o) for each zone has the same coordinate values, each zone consists of coordinates in the same numerical range.
- If we convert the geodetic limits of each zone to CCS NAD 83 coordinates, the zones would appear to lie on top of one another due to their coordinates (as shown below).



- Each CCS – NAD 83 coordinate needs to include at minimum its Zone, Epoch and scale factor.
- A project that extends from one zone into another zone should use CCS83 coordinates based upon only one zone. CCS83 coordinates for one zone can be converted to coordinates of a second zone by first converting the CCS83 coordinates (Northing and Easting) to their geodetic positions of latitude and longitude and then converting these geodetic positions to the CCS83 coordinates (Northing and Easting) for the second zone. The conversion of coordinates from one zone to another zone must be done by your District Surveys unit.