

# Survey Report

of the

## City & County of San Francisco 2013 High Precision Network Survey

Prepared by  
McGee Surveying Consulting and F3 & Associates, Inc.  
February 28, 2014

### INDEX

<u>Page</u>	<u>Subject</u>
2	PROJECT OVERVIEW
3	PROJECT DATUMS, REFERENCE SYSTEM
4	GEOMETRIC COORDINATES OF CONTROLLING STATIONS (CORS & CGPS)
4	NETWORK DESCRIPTION
6	ADJUSTMENTS & ANALYSIS: IGS08(2005) Epoch 2013.54, NAD83(2011) Epoch 2013.54, NAD83(2011) Epoch 2010.00 and Geoid Model Analysis
10	DATA COLLECTION, PROCESSING and EQUIPMENT
11	ACCURACY: LOCAL & NETWORK
13	TRANSFORMATIONS: 1999 NAD83 (1991) SPCS to NAD83 (2011) 2010.00 SPC 1999 NAD83 (1991) SPCS to NAD83 (2011) 2010.00 CCSF-CS
14	RECOMMENDATIONS

### APPENDIX

15	Glossary
16	Geodetic Coordinate List: NAD83(2011) and IGS08(2005)
17	Plane Coordinate List: NAD83 SPCS & CCSF Coordinate System (Low Distortion Projection)
18	Map: CCSF 2013 Regional GNSS Network
19	Map: CCSF 2013 HPN GNSS Network
20	CORS Reference Data: Coordinates, HTDP Solutions, NGS Data Sheets and Short-Term Time Series



## PROJECT DATUMS, REFERENCE SYSTEM

**Geometric Datums:** North American Datum of 1983 - NAD83(2011) Epoch 2010.00 realization and IGS08(2005) Epoch 2013.54 (July 17, 2013 average date of field survey)

**Reference Network:** The survey is referenced to four NGS CORS stations (see NGS Data Sheets in Appendix)

**Vertical Datum:** CCSF 2013 NAVD88 Vertical Datum. Note, this survey evaluated the use of GNSS technology for establishing accurate orthometric heights and modeled the orthometric height of UCSF.

**Reference Network:** CCSF 2013 Second Order Leveling Network

**Projections:** The plane coordinates published in the survey are in units of meters and feet, and in two projections. Coordinates are provided in the California State Plane Coordinate System (SPCS) Zone III and in a local custom coordinate system created by this survey and referred to as the City & County of San Francisco Coordinate System (CCSF-CS).

The CCSF-CS is a low distortion grid projection designed for CCSF to be a ground coordinate system. CCSF varies from sea level to approximately 1000 feet in elevation. To minimize the differences in ground and grid distances, the projection surface was positioned at the most common ground height in the County taken at an ellipsoid height of 44.50 meters (146.0 feet). The average geoid height is -32.6 meters (-107 feet) and the NAVD88 height of the projection surface is 77 meters (253 feet). At this height the combined scale factor is 1.0 and the distortion is zero. Changes in height will increase or decrease the scale 4.8 ppm for every 30.5 meters (100 foot). This coordinate system provides a grid scale distortion of less than 1:100,000 (10 ppm) in most parts of CCSF except for the higher elevations. At the Central Meridian, North coincides with Geodetic North referenced to the GRS80 ellipsoid, centered in the NAD83(2011) 2010.00 Epoch reference frame. The Convergence Angle varies +/- two minutes as shown in the Appendix in the Plane Coordinate List. The projection specifications (similar to an SPCS projection) for input in user's software follow.

*Projection: Transverse Mercator, Ellipsoid: GRS-80, Scale: 1.000007, Latitude of Origin: 37°45'00", Central Meridian: -122°27'00", False Northing: 24000.0 meters, False Easting: 48000.0 meters.*

The average Scale Factor, Height Reduction Factor and Convergence Angles listed below for the 20 HPN points provide a general comparison of the two projections.

*State Plane Coordinates Zone 3:  
Combined Factor= 0.99992496  
Convergence Angle= -1-11-34  
San Francisco Coordinate System:  
Combined Factor= 1.00000275  
Convergence Angle= +0-00-04*

The specific values for each point are listed in the Appendix. Applying the average combined factors to a ground distance of 1000 foot equals 1000.003 feet in the CCSF-CS whereas in the SPCS it is 999.925 feet.

### **Historical CCSF Control Network:**

A map on file with the CCSF titled "City and County of San Francisco Precise Horizontal Survey Control" dated May 2001 depicts a GPS Survey based on NAD83 (1991) 1991.35 Epoch with State Plane Coordinates published in 1991, 1998 and 1999. The 1999 Network (red) and 2013 HPN (green) are shown in Figure 1. This 2013 survey supersedes the 1991-1998-1999 surveys.



**Figure 1: 1999 Network Points and 2013 HPN Points**

**Reference Network Velocity:** The North American Datum of 1983 is referenced to the North American Plate. CCSF sits on the Pacific Plate and is situated between the San Andreas Fault approximately 2 kilometers west of the southwest corner of CCSF and the Hayward Fault approximately 15 kilometers east of the northeast corner of CCSF. CCSF is moving 3.1 centimeters (0.10 feet) north and 2.1 centimeters (0.07 feet) west (N34°W 0.12 feet) per year relative to the North American Plate at the CGPS station UCSF as predicted by the NGS Horizontal Time Dependent Positioning (HTDP) model. Continued monitoring of the 2013 CCSF-HPN over time will develop a model of differential movements across the County.

**GEOMETRIC COORDINATES OF THE CONTROLLING CORS & CGPS STATIONS**

The following positions were constrained or derived in the Adjustments discussed hereafter.

**NAD83(2011) Epoch 2010.00 Positions per NGS Data Sheets (see Appendix)**

<u>ID</u>	<u>Latitude(dms)</u>	<u>W.Longitude(dms)</u>	<u>EH(mtrs)</u>	<u>NGS PID</u>	<u>NAME</u>	
P176	37-28-18.36834	122-21-25.65069	434.339	DN7544	MILLSCREEKCN2007	GRP
P224	37-51-50.01427	122-13-08.56363	407.873	DH3881	SIBLEYVOLCCN2005	GRP
TIBB	37-53-27.13938	122-26-51.31741	-20.565	AI4507	TIBURON PENINSUL	GRP
WINT	37-39-09.50579	122-08-25.99416	-28.259	AI4510	WINT_BARD_CN1991	GRP

**NAD83(2011) Epoch 2013.54\*\* per NAD83 velocities applied to Epoch 2010.00 Positions**

<u>ID</u>	<u>Latitude(dms)</u>	<u>W.Longitude(dms)</u>	<u>EH(mtrs)</u>	<u>Velocities (mm)</u>			
P176	37-28-18.37230	122-21-25.65398	434.334	N 34.5	E-22.9	Up	-1.3*
P224	37-51-50.01654	122-13-08.56563	407.869	N 19.8	E-13.8	Up	-1.2
TIBB	37-53-27.14260	122-26-51.31998	-20.570	N 28.1	E-17.7	Up	-1.4*
WINT	37-39-09.50872	122-08-25.99666	-28.264	N 25.5	E-17.3	Up	-1.3*

**NAD83(2011) Epoch 2013.54** Results of the Constrained Adjustment to the CORS positions listed above (see Adjustments & Analysis)

CCSF	37-44-55.64324	122-24-01.58597	-15.950
EBMD	37-48-54.01939	122-17-01.65016	-15.403
MHDL	37-50-32.35159	122-29-39.55028	66.403
P178	37-32-04.25894	122-19-56.46131	129.572
UCSF	37-45-46.67553	122-27-29.29178	155.123

**IGS08(2005) Epoch 2013.54 per IGS08 velocities applied to Epoch 2005 Positions**

<u>ID</u>	<u>Latitude(dms)</u>	<u>W.Longitude(dms)</u>	<u>EH(mtrs)</u>	<u>Velocities (mm)</u>			
P176	37-28-18.38315	122-21-25.71047	433.810	N 21.3	E-36.2	Up	0.0*
P224	37-51-50.02759	122-13-08.62234	407.349	N 6.8	E-27.5	Up	0.1
TIBB	37-53-27.15354	122-26-51.37682	-21.084	N 14.8	E-31.4	Up	0.0*
WINT	37-39-09.51974	122-08-26.05320	-28.790	N 12.5	E-31.0	Up	0.0*

\*HTDP v3.2.3 velocities applied to CORS with less than 2.5 years of data

\*\*Epoch of Survey

**NETWORK DESCRIPTION**

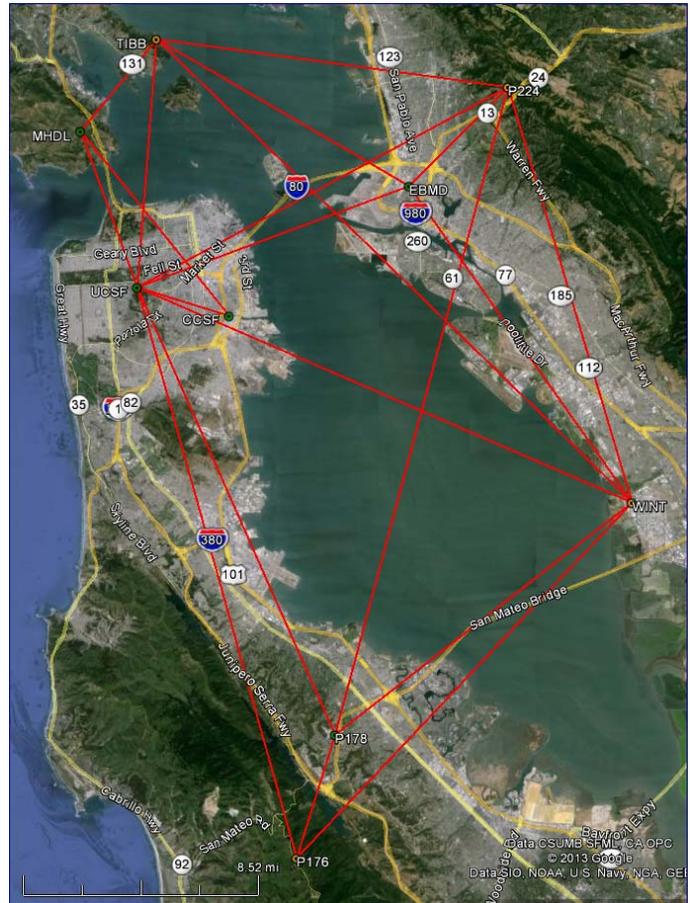
The CCSF GNSS Survey is comprised of a bay area Regional Network shown in Figure 2 and the CCSF High Precision Network shown in Figure 3. The Regional Network utilized four of the nearest operating NGS CORS stations (TIBB, P224, WINT and P176) as a basis for recovering IGS08(2005) Epoch 2013.54 and NAD83(2011) Epoch 2010.00 reference frames. Four CGPS stations (EBMD, MHDL, P178 and UCSF) were included to add strength and redundancy to the Regional Network. A private RTN station (CCSF) was included

to establish a position relative to the CCSF-HPN. Three vectors or baselines were computed for each connection shown in Figure 2 using 24 hour observations staggered every other day during the field campaign.

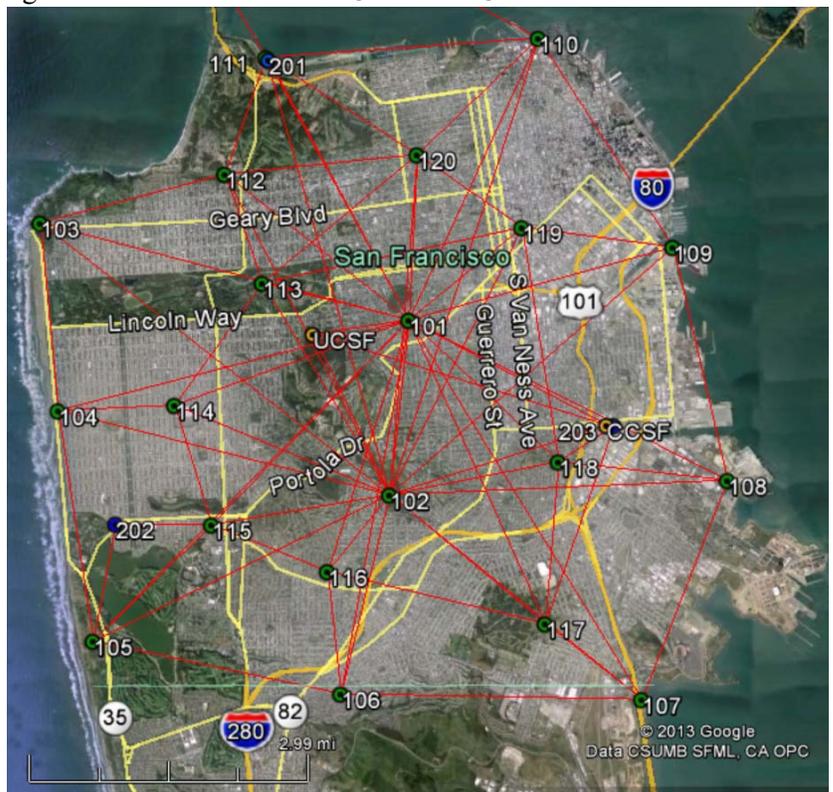
The 2013 CCSF-HPN (shown in Figure 3 and the Appendix) consists of 20 primary high precision points distributed across CCSF. The field campaign took place during the week of July 15-19, 2013 (average epoch 2013.54). Four crews operated four Leica GS15 GNSS receivers mounted on fixed-height poles. The receivers and fixed height poles were calibrated, and a validation survey of equipment and procedures took place prior to the field campaign.

The field campaign began on July 15 (Day1) with a base receiver occupying Point #101 (Corona Heights) for the day while the three crews occupied all points for 45 minutes each developing a radial network. On Day 2, a second radial network was developed with a base receiver occupying Point #102 (Marrietta Drive) as a base station while three crews occupied points for 45 minutes completing a second independent occupation of all points. On Day 3 and 4, a tandem operation was conducted with four crews working in unison collecting 45 minutes in common at their assigned points to complete the inner network connections between all adjacent points. At the end of the field campaign, all HPN points were occupied three to four times on different days and under different constellations.

In addition to the 20 primary HPN control points, three secondary points 201 (Tidal), 202 (Sloat) and 203 (Army) shown on the map of the 1999 GPS Survey on file with the CCSF Public Works referred to above were occupied twice with a fifth receiver for 15-30 minutes. These points are not part of the HPN. These points were included to determine the relationship between the 1999 CCSF reference frame and the 2013 NAD83(2011) 2010.00 Epoch reference frame established by this survey. Transformations from the 1999 reference frame to this 2013 survey are provided hereafter.



**Figure 2: Regional Network**



**Figure 3: City & County 2013 High Precision Network**

## **ADJUSTMENTS & ANALYSIS**

Non-trivial vectors were processed from the observations and evaluated in the network adjustments listed below. The Regional Network connected nine stations including four CORS, four CGPS stations and one private continuously operated RTN station. The Regional Network contains 57 vectors averaging 20 kilometers in length with a maximum of 38 kilometers. The two-dimensional residuals averaged 0.002 meters with a standard deviation of 0.002 meters and a maximum of 0.010 meters. The absolute value of the vertical residuals averaged 0.002 meters with a standard deviation of 0.002 meters and a range of -0.007 to +0.008 meters. The 2013 CCSF-HPN connected 20 points, three secondary points, two CGPS stations and the private RTN station. The network contains 83 vectors averaging 4.3 kilometers in length with a maximum of 8.3 kilometers. The two-dimensional residuals averaged 0.003 meters with a standard deviation of 0.002 meters and a maximum of 0.010 meters. The absolute value of the vertical residuals averaged 0.003 meters with a standard deviation of 0.003 meters and a range of -0.009 to +0.016 meters.

Six network adjustments were processed to develop the geodetic and plane coordinates in two reference frames at different epochs. An overview of the adjustments follows with details thereafter.

Adjustment #1 and #2: Developed IGS08(2005) Epoch 2013.54 positions for referencing future secular and episodic movements of the region and CCSF. The IGS08(2005) positions of the four CORS were obtained from the NGS and moved to Epoch 2013.54 (epoch of this survey) using the NGS HTDP v3.2.3 velocity model. Adjustment #1 fixed WINT to evaluate the vector residuals and closures on the remaining three CORS. Adjustment #2 constrained the network to all four CORS to develop IGS08(2005) Epoch 2013.54 positions.

Adjustment #3 and #4: Developed NAD83(2011) Epoch 2013.54 positions for referencing the Regional Network. The NAD83(2011) Epoch 2010.00 positions of the four CORS were obtained from the NGS and moved to Epoch 2013.54 (epoch of this survey) using the HTDP v3.2.3 velocity model. Adjustment #3 fixed WINT to evaluate the closures on the remaining three CORS. Adjustment #4 constrained the network to all four CORS to develop NAD83(2011) Epoch 2013.54 positions on the four CGPS stations.

Adjustment #5: Developed NAD83(2011) Epoch 2010.00 positions for CCSF-HPN. The NAD83(2011) Epoch 2013.54 positions of stations UCSF, MHDL and CCSF, determined in Adjustment #4, were moved to Epoch 2010.00 using the HTDP v3.2.3 velocity model. Adjustment #5 fixed the CGPS station UCSF at the Epoch 2010.00 position to evaluate the closures on MHDL and CCSF, and to develop positions on the 2013 CCSF-HPN.

Adjustment #6: Analyzed the Geoid 2012A Model utilizing a seven parameter conformal transformation with the scale parameter fixed at 1.0 to best fit the GNSS measurements to the NAVD88 Heights of the HPN points determined in the CCSF 2013 Second Order Leveling Network Survey (Report on file with CCSF). The adjustment demonstrates the application and expected results of using GNSS survey technology to develop orthometric heights in CCSF.

### **IGS08(2005) Epoch 2013.54 Adjustments**

#### **Adjustment 1: 3D Minimally Constrained Adjustment**

The four nearest operating CORS form the basis for recovery of the IGS08 reference frame for this survey. IGS08(2005) Epoch positions and velocities were obtained from the NGS website for the CORS. The HTDP v3.2.3 model was used to update the CORS positions to the 2013.54 Epoch of this survey. Four CGPS stations and a private RTN station CCSF were included in the adjustments.

Station WINT was fixed in a Minimally Constrained Adjustment to determine preliminary latitude, longitude, ellipsoid heights at other stations and compute closures. The results follow with the coordinate differences (closures) from the IGS08 positions to the computed positions listed in meters below. The position for UCSF

was determined from the mean of three 24 hours observations submitted to OPUS and used as a check on the results of this adjustment as shown.

**Coordinate Differences: IGS08 to Computed**

<u>Station</u>	<u>dN</u>	<u>dE</u>	<u>dZ</u>	
P176	0.007	-0.004	0.006	
P224	0.012	0.003	0.002	
TIBB	0.003	-0.001	-0.015	
WINT	0.000	0.000	0.000	Fixed
UCSF	0.004	0.000	-0.018	OPUS IGS08 position to computed position

**Note:** The differences between the published and computed positions range 0.000 to 0.012 meters in north, -0.001 to +0.003 meters in east and -0.015 to +0.006 meters in the up direction. Network loop closures were less than a centimeter. The horizontal check on the OPUS position of UCSF is 0.004 meters.

**Adjustment 2A: 3D Adjustment Solving for Transformation Parameters from WGS84 to IGS08**

WGS84 is based on the IGS08 reference frame. In this adjustment the rotations and scale were solved to verify the consistency of the measured network in WGS84 and the IGS08 reference frame as represented by the positions of the CORS. The expectation are zero and the negligible results confirm the consistency of the two frames.

**WGS84 to IGS08(2005) Datum Transformation**

Scale Factor 1.000000068467 = -0.068 PPM (1:14,700,000)  
 Rotation Around North Axis = -0.071 Sec  
 Rotation Around East Axis = -0.055 Sec  
 Rotation Around Vert. Axis = -0.015 Sec

**Adjustment 2B: 3D Constrained Adjustment**

All four CORS were constrained for latitude, longitude and ellipsoid heights to develop IGS08(2005) 2013.54 Epoch positions on the network. The horizontal difference of 0.001 meters with the UCSF position obtained from the CORS Network utilizing the NGS OPUS Tool confirms the processes used in this survey.

**Coordinate Differences: IGS08(2005) 2013.54 Epoch to Computed**

<u>Station</u>	<u>dN</u>	<u>dE</u>	<u>dZ</u>	
UCSF	-0.001	0.001	-0.014	OPUS IGS08 position

Note: This Adjustment includes the CCSF-HPN. The results are listed in the Appendix Coordinate List.

**NAD83(2011) Epoch 2013.54 Adjustments**

**Adjustment 3: 3D Minimally Constrained Adjustment**

The four nearest operating CORS form the basis for recovery of the NAD83 reference frame for this survey. NAD83(2011) 2010.00 Epoch positions and velocities were obtained from the NGS website for the CORS. The HTDP v3.2.3 model was used to update the CORS to 2013.54 Epoch of this survey for this adjustment. Four CGPS stations and a private RTN station CCSF were included in the adjustment.

CORS station WINT was fixed in a Minimally Constrained Adjustment to determine preliminary latitude, longitude, ellipsoid heights at the three other CORS and compute closures. The results follow with the coordinate differences (closures) in meters from the NAD83(2011) 2013.54 Epoch to the computed positions listed below. The position for UCSF was determined by the SOPAC SECTOR utility and used as a check on the results of this adjustment as shown below.

**Coordinate Differences: NAD83(2011) 2013.54 Epoch to Computed**

<u>Station</u>	<u>dN</u>	<u>dE</u>	<u>dZ</u>	
P176	0.006	-0.004	0.005	
P224	0.012	0.004	0.006	
TIBB	0.004	-0.001	-0.010	
WINT	0.000	0.000	0.000	Fixed
UCSF	0.009	-0.001	-0.004	Difference from SOPAC SECTOR position to computed

**Note:** The differences between the published and computed positions range 0.000 to 0.012 meters in north, -0.001 to +0.004 meters in east and -0.010 to +0.006 meters up direction. The position of UCSF as determined by SECTOR is referenced to the NAD83(2007) Adjustment Epoch 2013.54 whereas this adjustment is referenced to NAD83(2011) Adjustment Epoch 2013.54. The horizontal difference of 0.009 meters is indicative of the similarities of the two national adjustments.

**Adjustment 4: 3D/Ellipsoid Heights – Constrained Adjustment**

All four CORS were constrained for latitude, longitude and ellipsoid heights to develop NAD83(2011) Epoch 2013.54 positions. Notwithstanding the 2007 versus the 2011 Adjustments, the horizontal difference of 0.004 meters at UCSF indicates the compatibility of these results with those obtained from the SECTOR utility.

**Coordinate Differences: NAD83(2011) 2013.54 Epoch to Computed**

Station	dN	dE	dZ
UCSF	0.004	-0.001	-0.004

Difference from SOPAC SECTOR position to computed

**NAD83(2011) Epoch 2010.00 Adjustments**

**Adjustment 5: 3D Minimally Constrained Adjustment of the CCSF-HPN**

The NAD83(2011) 2010.00 Epoch positions at CCSF, MHDL and UCSF were derived by applying HTDP v3.2.3 velocities to the 2013.54 Epoch positions resulting from Adjustment #4. UCSF was fixed in a minimally constrained adjustment to determine latitude, longitude, ellipsoid heights at other stations and compute closures. The results follow with the coordinate differences (closures) in meters from the record positions to the computed positions listed below. The source for the record positions of 107, 201 and 202 are the NGS Data Sheets for the listed PID's.

**Coordinate Differences: Record to Computed**

Station	dN	dE	dZ	NAD83 Epoch	Source
107	-0.034	0.007	-0.040	2010.00	NGS PID AB7679 = HPGND CA04GF
201	-0.029	0.002	-0.045	2010.00	NGS PID AE5209 = N TIDAL
202	-0.053	0.017	-0.031	2010.00	NGS PID AB7677 = HPGND CA04GE
203	0.537	-0.362	-	1991.35	1999 CCSF Control Survey-NAD83(1991)
CCSF	-0.005	0.002	0.007	2010.00	HTDP Applied to Adj#4 Position
MHDL	-0.003	0.003	-0.006	2010.00	HTDP Applied to Adj#4 Position
UCSF	-0.000	-0.000	-0.000	2010.00	HTDP Applied to Adj#4 Position, Fixed

Note: The differences at 203 reflect the difference between the 1991.35 and 2010.00 Epochs. The closures on the HTDP derived positions for CCSF and MHDL range 0.000 to -0.005 meters north, +0.002 to +0.003 meters east and -0.006 to +0.007 up direction and are at the noise level of the HTDP model; therefore, rather than distort the measured vectors in a constrained adjustment, the results of this adjustment were accepted to establish NAD83(2011) 2010.00 Epoch for the CCSF-HPN. Note: The Adjustment results are listed in the Appendix Coordinate List.

**Geoid Model Analysis: Adjustment of Ellipsoid Heights incorporating Geoid Heights to Determine NAVD88 Orthometric Heights:**

Two methods for determining NAVD88 Heights in a GPS/GNSS survey are discussed here. The first method approximates NAVD88 Heights by applying geoid heights to the measured ellipsoid heights using the equation  $H=h-N$  (Orthometric Height = Ellipsoid Height - Geoid Height). The accuracy of this method when applying the NGS Geoid 2012A to NAD83(2011) 2010.00 Epoch ellipsoid heights in San Francisco is approximately 0.06 meters as demonstrated below.

The second method takes advantage of the relative precision of modeled geoid heights. The Geoid 2012A Model was incorporated in a seven-parameter conformal transformation with the scale parameter fixed at 1.0 to best fit the NAVD88 Heights established on 20 HPN points determined by precise differential leveling (see the "Report on the City & County of San Francisco 2013 Second Order Leveling Network Survey and the 2013 NAVD88 Vertical Datum" on file with the County surveyor).

The NAD83(2011) 2010.00 Epoch Ellipsoid Height differences were combined with the Geoid 2012A Heights shown below in Column E and best fit to the leveled heights at the HPN points shown in Column B. This has the effect of best fitting the Geoid 2012A surface through the NAVD88 Heights at all 20 points. The results shown in Column A are the differences in meters from the leveled heights to the computed heights based on GNSS measurements. This is a best fit (least squares) solution therefore the mean of the differences is zero. The Standard Deviation of the differences is 0.004 meters (0.01') and the range is -0.007 to +0.007 meters (+/-0.02'). The solved rotations are +0.213 seconds around the north and +0.243 seconds around the east axis. The rotations represent the tilts applied to the Geoid 2012A model to best fit the HPN orthometric heights which represent a geoid surface. The maximum effect of this tilt if unaccounted for is 1.6 mm per kilometer (0.008' per mile) and is absorbed in a constrained adjustment. The orthometric height of UCSF was modeled in this adjustment. As an additional check on the differential leveling to the highest HPN points, a constrained adjustment was processed fixing HPN points with orthometric heights less than 8 meters around the north and east shoreline. As a result, points 101 and 102 were found at -0.005 and +0.001 meters respectively. A one way shortest distance from the north shoreline would allow 0.006 meters for First Order Class.

	A	B	C	D	E	F
Point	Diff's	NAVD88 Hts	NAD83 EH	Meas'd GH	2012A GH	E - D
101	-0.003	150.799	118.188	-32.611	-32.548	0.063
102	0.004	170.991	138.344	-32.647	-32.587	0.060
103	0.004	46.352	13.592	-32.760	-32.712	0.048
104	0.000	7.550	-25.278	-32.828	-32.771	0.057
105	-0.004	56.489	23.607	-32.882	-32.817	0.065
106	-0.007	110.302	77.575	-32.727	-32.653	0.074
107	0.006	3.698	-28.944	-32.642	-32.574	0.068
108	0.000	4.484	-28.109	-32.593	-32.523	0.070
109	-0.004	3.461	-29.098	-32.559	-32.491	0.068
110	0.003	3.279	-29.261	-32.540	-32.486	0.054
111	0.003	4.000	-28.605	-32.605	-32.555	0.050
112	-0.004	54.344	21.692	-32.652	-32.593	0.059
113	-0.001	74.816	42.159	-32.657	-32.598	0.059
114	-0.001	99.656	66.915	-32.741	-32.681	0.060
115	0.003	61.448	28.692	-32.756	-32.697	0.059
116	0.007	89.985	57.292	-32.693	-32.635	0.058
117	-0.004	117.172	84.526	-32.646	-32.572	0.074
118	0.003	78.553	45.947	-32.606	-32.543	0.063
119	-0.003	18.941	-13.634	-32.575	-32.511	0.064
120	-0.002	85.887	53.304	-32.583	-32.524	0.059

Geoid 2012A is a “hybrid” geoid model. Hybrid means it is based on GPS measured ellipsoid heights on a sampling of NAVD88 benchmarks over a large area to estimate the height of the NAD83(2011) zero ellipsoid surface above the NAVD88 zero surface. The measured NAD83(2011) 2010.00 Epoch Ellipsoid Heights (Column C) minus the leveled NAVD88 Heights (Column B) are the measured geoid heights at the HPN points (Column D) determined by this survey. The error in the Geoid 2012A hybrid model in San Francisco is 0.06 meters (Column F) being the difference in the computed Geoid 2012A Heights (Column E) and the measured geoid heights (Column D).

The recommended approach for determining orthometric heights with GNSS is to surround a project with three CCSF-HPN points (four preferred for redundancy) and compute a seven-parameter transformation that includes the Geoid 2012A Model to best fit the HPN 2013 NAVD88 Heights. The accuracy will depend on the combined accuracy of the NAVD88 heights of the HPN points, the GNSS measured ellipsoid height differences, the geoid heights and the effects of the tilt between the geoid model surface and the actual geoid surface. The largest source of error is usually in the measured ellipsoid heights. Following the specifications and procedures used in this survey, an orthometric height accuracy of 0.007 meters (0.02 feet) is obtainable.

As a matter of information, the NGS publishes the US Gravimetric Geoid 2012 (USGG2012) which is a gravimetric model referenced to the GRS80 ellipsoid, centered in the IGS08(2005.00) reference frame, and is the best geo-potential surface that approximates Mean Sea Level (MSL). USGG2012 is applied to WGS84 = IGS08 Ellipsoid Heights to obtain estimated heights referenced to global mean sea level (geoid). Utilizing the USGG2012 Model in a transformation to best fit the NAVD88 heights of the HPN points (described above) returned essentially the same results as the hybrid model; however, the rotations were +0.138 and +0.120 seconds around the north and east axis respectively, representing a negligible improvement. A new North American Vertical Datum is expected to be introduced in less than ten years. The origin or zero height is expected to be the geo-potential surface described above which is approximately 0.9 meters lower than the NAVD88 Datum and approximates the NGVD29 Datum.

## **DATA COLLECTION, PROCESSING and EQUIPMENT**

Five Leica GS15 geodetic GNSS receivers/antennas listed below were mounted on fixed height poles to collect, and store satellite signal data. The GS15 receivers tracked Navstar GPS and GLONASS satellites. Prior to initiating the field observations a calibration of the fixed height poles was conducted with a theodolite to verify their heights and plumb. The top of the poles were found to be plumb within 1 millimeter of the point. There were no equipment failures during the survey.

**Date of Field Surveys:** July 15 to July 19, 2013 (Average Date 2013.54)

### **GNSS Survey Parameters:**

**Observations:** Static occupations collected GPS and GLONASS signal data at a 15 second epoch rate for 45 minutes at all points with 8 hours at the base station setups for the radial observations on the first two days of the field campaign. Observations at the CORS and CGPS stations were GPS only for 24 hour at a 15 second epoch rate and downloaded from the Internet.

**Constellation:** 32 healthy US Navstar GPS satellites; 24 healthy Russian GLONASS satellites.

**Satellite Observations:** 12-21 satellites observed with a minimum of 6 GPS and 6 GLONASS at any time; GDOP < 2; Elevation Mask for Data Collection set at 10° and post processed at 15°.

**Observables:** GPS L1 & L2 Carrier wave, GLONASS L1 & L2.

**Ephemeris:** Precise GPS and GLONASS for static post processing.

**Weather Conditions:** Generally overcast marine layer and mild temperatures.

**Space Weather:** Boulder K Index = 1-3 (gauges ionospheric activity on a scale of 0-9, <5 preferred). The K Index was 1-2 on all days except on July 15 it was 3.

### **Equipment:**

**GNSS Base Receiver Unit No.:** B, **Operator:** JTM, RA;

**Receiver Make & Model:** Leica GS15; **Antenna Make & Model:** Leica GS15

**Antenna Mount:** Fixed Ht. Pole B; **Antenna Height:** 1.800m

**GNSS Base Receiver Unit No.:** C, **Operator:** DPL;

**Receiver Make & Model:** Leica GS15; **Antenna Make & Model:** Leica GS15

**Antenna Mount:** Fixed Ht. Pole C; **Antenna Height:** 1.800m

**GNSS Base Receiver Unit No.:** D, **Operator:** GP;

**Receiver Make & Model:** Leica GS15; **Antenna Make & Model:** Leica GS15

**Antenna Mount:** Fixed Ht. Pole D; **Antenna Height:** 1.800m

**GNSS Base Receiver Unit No.:** E, **Operator:** AV;

**Receiver Make & Model:** Leica GS15; **Antenna Make & Model:** Leica GS15

**Antenna Mount:** Fixed Ht. Pole E; **Antenna Height:** 1.800m

**GNSS Base Receiver Unit No.:** F, **Operator:** MM, PC;

**Receiver Make & Model:** Leica GS15; **Antenna Make & Model:** Leica GS15

**Antenna Mount:** Fixed Ht. Pole F; **Antenna Height:** 1.800m

## CORS & CGPS National Geodetic Survey Antennas

Note, absolute antenna models were used in the baseline processing and measurements were referenced to the monument not the antenna reference point (ARP).

Stat.	Antenna	Radome
CCSF	AX1202 GG	NONE
EBMD	LEIAR10	NONE
MHDL	ASH700936C_M	SNOW
P176	TRM29659.00	SCIT
P224	TRM29659.00	SCIT
P178	TRM29659.00	SCIT
TIBB	ASH701945B_M	SCIT
UCSF	ASH701945B_M	SCIT
WINT	ASH700936D_M	CAFG <no model available, substituted "ASH700936D_M NONE"

**Rinex Data, Antenna Models, Precise Ephemeris and Processing Software:** Rinex files for the CORS and CGPS were imported from the NGS and SOPAC. Absolute antenna models were imported from the NGS and the Precise Ephemeris was imported from the NGS for the GPS and IGS for the GLONASS constellations. The Precise Ephemeris was used for all static post-processing in IGS08. The Baseline Processing was performed in Leica Geomatics Office (LGO) v8.1. The Network Adjustments were performed in Starnet v7.2.

## ACCURACY: LOCAL & NETWORK

This survey conforms to the requirements of Public Resources Code Section 8801 through 8819 and 8850 through 8880. These geodetic control data meet the 5-millimeter Local Accuracy Standard for the horizontal coordinate values, the 5-millimeter Local Accuracy Standard for the vertical coordinate values (heights), the 1-centimeter Network Accuracy Standard for the horizontal coordinate values, and the 1-centimeter Network Accuracy Standard for the vertical coordinate values (heights) at the 95-percent confidence level according to the reporting standard published by FGDC in "Geospatial Positioning Accuracy Standard, Part 2, Geodetic Control Networks", FGDC-Std-007, 2-1998. This survey conforms to the intent of the FGCC "Geometric Geodetic Accuracy Standards and Specifications for Using GPS Positioning Techniques" (1989), the California Geodetic Control Committee (CGCC) "Specifications for High-Production GPS Surveying Techniques" (1993), and NOAA Technical Memorandum NOS NGS 58 "Guidelines for Establishing GPS-Derived Ellipsoid Heights".

**Vector Residuals:** The number of vectors, two-dimensional vector residuals and the absolute value of the vertical residuals resulting from the minimally constrained adjustment are listed below in meters.

	No.	Two Dimensional Residuals			Vertical Residuals (absolute values)		
		Average	Std.Dev.	Maximum	Average	Std.Dev.	Range
CCSF HPN	83	0.003	0.002	0.010	0.003	0.003	-0.009 to +0.016
Regional CORS	57	0.002	0.002	0.010	0.002	0.002	-0.007 to +0.008

The vector residuals and the closures on control points addressed above in ADJUSTMENTS & ANALYSIS are good indications of the accuracies obtained by this survey.

**Local Accuracy:** The local vector lengths, precisions, relative distance accuracy and relative vertical accuracy resulting from the minimally constrained adjustment at the 95% Level of Confidence are listed below in meters.

Network	Lengths		PPM Precisions		Relative Distance Error			Rel.Vert. Error	
	Vary	Average	Vary	Average	Average	Maximum	Precision	Average	Maximum
CCSF HPN	1675-8291	4267	0.4-2.3	1.1 ppm	0.004	0.005	1:1,067,000	0.003	0.004
Regional	5322-37896	20224	0.1-0.6	0.2 ppm	0.003	0.003	1:6,741,000	0.003	0.004

Following the criteria of the former FGCC classification system described in "Geometric Geodetic Accuracy Standards and Specifications for Using GPS Positioning Techniques" (1989), the maximum allowable relative error at the 95% confidence level is defined as  $s = \sqrt{(e^2 + (0.1pd)^2)}$  where  $e$  is the base error,  $p$  is the ppm and  $d$  is the distance in kilometers. For the CCSF-HPN, B-Order is equivalent to  $\sqrt{(.8^2 + (0.1 \cdot 1 \cdot 4.3)^2)} = 0.9$  centimeters and A-Order is equivalent to  $\sqrt{(.5^2 + (0.1 \cdot 0.1 \cdot 4.3)^2)} = 0.5$  centimeters. Loop closures for the HPN vary between 1

ppm and 5 ppm. In conclusion, this survey exceeds a B-Order classification (1:1,000,000) under the former system and the Regional Network exceeds an A-Order classification (1:10,000,000).

**Network Accuracy:** The Standard Deviations (68% Level of Confidence) of the latitude, longitude and ellipsoid heights and the 95% Level of Confidence of the Horizontal Positions and Ellipsoid Heights for the Regional Network and the HPN are listed below in meters. This table allows users to calculate the propagated error for future surveys based on the HPN positions.

For P176, TIBB and WINT the NGS Data Sheets state “Formal positional accuracy estimates are not available for this CORS because its coordinates were determined in part using modeled velocities. Approximate one-sigma accuracies for latitude, longitude, and ellipsoid height can be obtained from the short-term time series”. Standard Deviations were only available for P224 (more than 2.5 years of data). Therefore, for consistency the positional accuracy estimates for all CORS stations (P176, P224, TIBB and WINT) were taken from the “Short Term Time Series” available at the NGS website. These one-sigma accuracy estimates were used for weighting the constrained adjustment to develop Network Accuracies.

NETWORK ACCURACY in Meters					
Station	Coordinate Std. Deviations			Network Accy. 95% Confidence	
	Latitude	Longitude	Ellipsoid Ht	Horizontal	Ellipsoid Ht
101	0.002	0.002	0.004	0.005	0.008
102	0.002	0.002	0.004	0.005	0.008
103	0.003	0.003	0.004	0.006	0.009
104	0.003	0.003	0.004	0.006	0.009
105	0.002	0.002	0.004	0.006	0.009
106	0.003	0.003	0.004	0.006	0.009
107	0.003	0.003	0.004	0.006	0.009
108	0.002	0.002	0.004	0.006	0.009
109	0.003	0.002	0.004	0.006	0.009
110	0.002	0.002	0.004	0.006	0.008
111	0.002	0.002	0.004	0.006	0.008
112	0.002	0.002	0.004	0.006	0.008
113	0.002	0.002	0.004	0.006	0.008
114	0.003	0.002	0.004	0.006	0.009
115	0.002	0.002	0.004	0.006	0.008
116	0.003	0.002	0.004	0.006	0.009
117	0.002	0.002	0.004	0.006	0.009
118	0.002	0.002	0.004	0.006	0.008
119	0.002	0.002	0.004	0.006	0.008
120	0.002	0.002	0.004	0.006	0.008
CCSF	0.002	0.002	0.004	0.005	0.008
EBMD	0.002	0.002	0.004	0.004	0.008
MHDL	0.002	0.002	0.004	0.004	0.008
P176	0.001	0.001	0.004	0.004	0.008
P178	0.002	0.002	0.004	0.004	0.008
P224	0.001	0.001	0.004	0.003	0.008
TIBB	0.001	0.001	0.004	0.004	0.008
UCSF	0.001	0.001	0.004	0.003	0.008
WINT	0.001	0.001	0.004	0.003	0.008

**Transformation 1999 NAD83(1991.35 Epoch) SPCS > 2013 NAD83(2011) 2010.00 Epoch SPCS**

A map is on file with CCSF titled "City and County of San Francisco Precise Horizontal Survey Control" dated May 2001. The survey is based on NAD83 (1991) 1991.35 Epoch with adjustments published in 1991, 1998 and 1999. The 1999 State Plane Coordinate values shown on Sheets 4 & 5 of 7 for ARMY=203, CANDLESTICK=107, SLOAT=202 and TIDAL=201 were used to compute a four parameter conformal transformation to convert 1999 State Plane Coordinates in feet to this 2013 survey.

INPUT COORDINATES (Feet)					
1999 NAD83(1991)1991.35 SPCS			2013 NAD83(2011)2010.00 SPCS		
PT#	North(1)	East(1)	PT#	North(2)	East(2)
CANDLESTICK	2085128.546	6013911.480	107	2085130.260	6013910.280
TIDAL	2121772.462	5993470.060	201	2121774.233	5993468.889
SLOAT	2095678.561	5984226.406	202	2095680.395	5984225.175
ARMY	2100667.364	6012652.104	203	2100669.127	6012650.919

TRANSFORMATION SOLUTION RESIDUALS (Feet)				
1999	2013	North	East	N.Azim & Dist
CANDLESTICK	107	-0.019	+0.018	138° 0.026
TIDAL	201	-0.031	-0.009	197° 0.032
SLOAT	202	+0.034	-0.011	342° 0.036
ARMY	203	+0.015	+0.003	11° 0.016

Root Mean Square of the North and East Residuals = 0.02  
 Scale Factor = 1.00000077 Standard Deviation = 0.00000078  
 Rotation = +0° 00' 00.4" Standard Deviation = 0° 00' 00.2"  
 TRANSFORMATION EQUATIONS: N2=A1\*N1-A2\*E1+A4 E2=A2\*N1+A1\*E1+A3  
 A1= 1.0000007745 A2= 0.0000019602 A3= -9.96251 A4= 11.90684

The scale and rotation are negligible as expected between epochs of the same datum. The transformation primarily accounts for the north 1.7± feet and west 1.2± feet shift between the 1991.35 and the 2010.00 Epochs. Utilize the Transformation Equations and constants listed to convert 1999 NAD83 (1991) Epoch 1991.35 SPCS to NAD83 (2011) Epoch 2010.00 SPCS in CCSF. The horizontal accuracy of the computed positions is estimated at 0.05 feet at the 95% level of confidence based on the residuals.

To convert the 1999 Survey NAD83(1991) 1991.35 Epoch SPCS in feet to NAD83(2011) 2010.00 Epoch of the City & County of San Francisco Coordinate System (CCSF-CS) in feet use the following transformation.

**Transformation: 1999 NAD83(1991) SPCS > NAD83(2011) 2010.00 Epoch CCSF-CS**

INPUT COORDINATES (Feet)					
1999 NAD83(1991)1991.35 SPCS			2010.00 CCSF-CS		
PT#	North(1)	East(1)	PT#	North(2)	East(2)
CANDLESTICK	2085128.546	6013911.480	107	62778.214	173801.613
TIDAL	2121772.462	5993470.060	201	98991.152	152599.533
SLOAT	2095678.561	5984226.406	202	72708.341	143900.815
ARMY	2100667.364	6012652.104	203	78288.679	172218.652

TRANSFORMATION SOLUTION RESIDUALS (Feet)				
1999	2013	North	East	N.Azim & Dist
CANDLESTICK	107	-0.020	+0.016	140° 0.026
TIDAL	201	-0.032	-0.009	195° 0.033
SLOAT	202	+0.034	-0.012	340° 0.036
ARMY	203	+0.018	+0.004	13° 0.018

Root Mean Square of the North and East Residuals = 0.02  
 Scale Factor = 1.00007856 Standard Deviation = 0.00000079  
 Rotation = -1° 11' 37.4" Standard Deviation = 0° 00' 00.2"  
 TRANSFORMATION EQUATIONS N2=A1\*N1-A2\*E1+A4 E2=A2\*N1+A1\*E1+A3  
 A1= 0.9998615081 A2= -0.0208347280 A3= -5795833.91914 A4= -2147359.74825

**RECOMMENDATION - SUMMARY**

As stated previously, CCSF sits between two major faults and it is expected that future re-surveys of the HPN will be conducted to determine secular and episodic movements within the area. If future surveys of the HPN follow the specifications and procedures adopted for this survey, the relative accuracy of measured shifts is expected to approach 5-6 millimeters at the 95% level of confidence. Statistically, this means the probability at the 95% level of confidence is that movement (signal) has occurred if the movement between two epochs is greater than the relative 95% error (noise). The differences in successive coordinates could be used to estimate movements but do not provide statistical information about the relative accuracies of movements. Measurements of temporal movements should be based on a rigorous simultaneous least squares adjustment of multiple redundant observations at two different epochs for each point to compute the movement and relative accuracy. The success of this process is predicated on the absolute recovery of the reference frame in this survey which is the IGS08(2005) 2013.54 Epoch based on the National Spatial Reference System (NSRS) CORS.

**SURVEYOR'S STATEMENT**

This Report on the criteria, procedures and results of the City and County of San Francisco High Precision GNSS Survey was prepared by me on February 28, 2014 at the request of Bruce R. Storrs, PLS City and County Surveyor of San Francisco.

  
Michael R. McGee, PLS3945



## APPENDIX

### GLOSSARY

CCSF	City and County of San Francisco
CCSF-CS	City and County of San Francisco Coordinate System
CGPS	Continuously GPS Stations in California
CORS	Continuously Operated Reference Stations in the National Spatial Reference System
FGCC	Federal Geodetic Control Committee
FGDC	Federal Geographic Data Committee
GIS	Geographic Information System
GLONASS	Globalnaya Navigatsionnaya Sputnikovaya Sistema (Russian GPS system)
GNSS	Global Navigation Satellite System (GPS and GLONASS used in this survey)
GPS	Global Positioning System
HPN	High Precision Network
IGS08	International GNSS Service 2008 Reference Frame
K INDEX	Space weather index ranging from 0-9, 1 being calm and 5 indicating a geomagnetic storm
LDP	Low Distortion Projection
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NGS	National Geodetic Survey
RTN	Real-Time Network
SOPAC	Scripps Orbit and Permanent Array Center
GDOP	Geometric Dilution of Precision
L1	Carrier frequency @ 1575.42 MHz
L2	Carrier frequency @1227.60 MHz
NAVD29	North American Vertical Datum of 1929
GRS80	Geodetic Reference System of 1980
HTDP	Horizontal Time-Dependent Positioning Program
PLS	Professional Land Surveyor
NOAA	National Oceanic and Atmospheric Administration

“2013 NAD83(2011) 2010.00 Epoch” represents the 2011 Adjustment of the North American Datum at Epoch 2010.00 established in CCSF in 2013

NAD83 GEODETIC COORDINATE LIST

DATUM & REFERENCE FRAME: NAD83(2011) Epoch 2010.00

POINT	N. LATITUDE ° ' "	W. LONGITUDE ° ' "	ELLIPSOID HT meters	ELLIPSOID HT feet
101	37-45-54.52969	122-26-21.55646	118.188	387.754
102	37-44-16.70006	122-26-35.16804	138.344	453.883
103	37-46-48.82346	122-30-42.69982	13.592	44.594
104	37-45-03.75809	122-30-29.78795	-25.278	-82.931
105	37-42-54.76774	122-30-04.94280	23.607	77.449
106	37-42-25.30199	122-27-09.62037	77.575	254.510
107	37-42-22.15117	122-23-36.90485	-28.944	-94.959
108	37-44-24.76543	122-22-36.10746	-28.109	-92.221
109	37-46-35.29523	122-23-14.65957	-29.098	-95.467
110	37-48-32.30625	122-24-49.85029	-29.261	-96.002
111	37-48-21.50380	122-28-02.95054	-28.605	-93.848
112	37-47-16.23698	122-28-31.85392	21.692	71.168
113	37-46-15.21109	122-28-05.24080	42.159	138.316
114	37-45-06.84452	122-29-07.34048	66.915	219.538
115	37-43-59.89229	122-28-41.12920	28.692	94.135
116	37-43-33.80444	122-27-19.05616	57.292	187.966
117	37-43-04.59553	122-24-45.07281	84.526	277.316
118	37-44-35.20539	122-24-35.75058	45.947	150.745
119	37-46-46.37693	122-25-01.43682	-13.634	-44.731
120	37-47-27.12564	122-26-15.67191	53.304	174.881
CCSF	37-44-55.63969	122-24-01.58310	-15.938	-52.290
MHDL	37-50-32.34805	122-29-39.54740	66.402	217.855
UCSF	37-45-46.67199	122-27-29.28890	155.128	508.949

IGS08 GEODETIC COORDINATE LIST

DATUM & REFERENCE FRAME: IGS08(2005) Epoch 2013.54

POINT	N. LATITUDE ° ' "	W. LONGITUDE ° ' "	ELLIPSOID HT meters
101	37-45-54.54414	122-26-21.61608	117.665
102	37-44-16.71449	122-26-35.22764	137.821
103	37-46-48.83787	122-30-42.75949	13.072
104	37-45-03.77249	122-30-29.84759	-25.798
105	37-42-54.78214	122-30-05.00241	23.085
106	37-42-25.31641	122-27-09.67995	77.053
107	37-42-22.16562	122-23-36.96440	-29.467
108	37-44-24.77990	122-22-36.16703	-28.633
109	37-46-35.30971	122-23-14.71918	-29.621
110	37-48-32.32072	122-24-49.90994	-29.783
111	37-48-21.51824	122-28-03.01021	-29.126
112	37-47-16.25141	122-28-31.91358	21.171
113	37-46-15.22552	122-28-05.30044	41.637
114	37-45-06.85894	122-29-07.40011	66.394
115	37-43-59.90670	122-28-41.18882	28.171
116	37-43-33.81887	122-27-19.11576	56.770
117	37-43-04.60998	122-24-45.13238	84.003
118	37-44-35.21984	122-24-35.81017	45.424
119	37-46-46.39139	122-25-01.49644	-14.157
120	37-47-27.14010	122-26-15.73155	52.782
CCSF	37-44-55.65415	122-24-01.64269	-16.461
EBMD	37-48-54.03039	122-17-01.70688	-15.922
MHDL	37-50-32.36248	122-29-39.60710	65.888
P176	37-28-18.38315	122-21-25.71047	433.810
P178	37-32-04.26983	122-19-56.51784	129.049
P224	37-51-50.02759	122-13-08.62234	407.349
TIBB	37-53-27.15354	122-26-51.37682	-21.084
UCSF	37-45-46.68643	122-27-29.34853	154.606
WINT	37-39-09.51974	122-08-26.05320	-28.790

**PLANE COORDINATE LIST**

California State Plane Coordinates Zone 3: NAD83(2011) 2010.00 Epoch and NAVD88 Heights per CCSF 2013 2<sup>nd</sup> Order Leveling Survey

POINT#	STATE PLANE COORD.		NAVD88 HEIGHT(m)	STATE PLANE COORD.		NAVD88 HEIGHT(ft)	Convergence Angle	----- Factors -----			
	NORTH(m)	EAST(m)		NORTH(ft)	EAST(ft)			Scale	x Ellipsoid =	Combined	
101	642177.520	1829147.188	150.799	2106877.414	6001127.064	494.746	-1-11-14.3	0.99992921	0.99998145	0.99991066	
102	639169.103	1828751.516	170.991	2097007.299	5999828.933	560.993	-1-11-22.7	0.99992920	0.99997829	0.99990750	
103	643985.863	1822793.428	46.352	2112810.286	5980281.439	152.073	-1-13-54.2	0.99992931	0.99999787	0.99992718	
104	640740.769	1823039.791	7.550	2102163.674	5981089.714	24.770	-1-13-46.3	0.99992918	1.00000397	0.99993315	
105	636752.037	1823562.786	56.489	2089077.308	5982805.572	185.331	-1-13-31.1	0.99992937	0.99999630	0.99992567	
106	635753.146	1827836.561	110.302	2085800.113	5996827.116	361.882	-1-11-43.8	0.99992947	0.99998783	0.99991730	
107	635548.974	1833043.520	3.698	2085130.260	6013910.280	12.133	-1-09-33.5	0.99992948	1.00000454	0.99993403	
108	639298.261	1834608.138	4.484	2097431.045	6019043.533	14.711	-1-08-56.3	0.99992920	1.00000441	0.99993361	
109	643340.513	1833745.648	3.461	2110693.000	6016213.847	11.355	-1-09-19.9	0.99992928	1.00000457	0.99993384	
110	646994.405	1831490.574	3.279	2122680.811	6008815.324	10.758	-1-10-18.2	0.99992969	1.00000459	0.99993428	
111	646759.384	1826761.484	4.000	2121909.745	5993299.969	13.123	-1-12-16.4	0.99992964	1.00000449	0.99993412	
112	644762.606	1826012.184	54.344	2115358.651	5990841.639	178.294	-1-12-34.1	0.99992938	0.99999660	0.99992598	
113	642867.936	1826623.601	74.816	2109142.554	5992847.597	245.459	-1-12-17.8	0.99992924	0.99999338	0.99992262	
114	640792.840	1825059.534	99.656	2102334.511	5987716.154	326.955	-1-12-55.8	0.99992918	0.99998950	0.99991868	
115	638715.658	1825657.369	61.448	2095519.621	5989677.550	201.601	-1-12-39.8	0.99992923	0.99999550	0.99992472	
116	637869.351	1827649.621	89.985	2092743.029	5996213.798	295.226	-1-11-49.5	0.99992927	0.99999101	0.99992028	
117	636891.154	1831400.952	117.172	2089533.729	6008521.289	384.422	-1-10-15.3	0.99992935	0.99998674	0.99991608	
118	639679.300	1831686.204	78.553	2098681.170	6009457.154	257.719	-1-10-09.5	0.99992919	0.99999279	0.99992198	
119	643735.185	1831140.342	18.941	2111987.853	6007666.271	62.142	-1-10-25.3	0.99992930	1.00000214	0.99993144	
120	645028.567	1829350.275	85.887	2116231.223	6001793.361	281.781	-1-11-10.7	0.99992942	0.99999164	0.99992106	
201	646718.080	1826812.971	3.659	2121774.233	5993468.889	12.005	-1-12-15.1	0.99992963	1.00000454	0.99993417	
202	638764.662	1823995.481	23.761	2095680.395	5984225.175	77.956	-1-13-21.4	0.99992923	1.00000142	0.99993065	
203	640285.230	1832659.665		2100669.127	6012650.919		-1-09-45.5	0.99992918	1.00000434	0.99993352	
CCSF	640292.109	1832535.278		2100691.693	6012242.824		-1-09-48.6	0.99992918	1.00000250	0.99993168	
MHDL	650842.310	1824485.178		2135305.146	5985831.789		-1-13-15.5	0.99993044	0.99998958	0.99992002	
UCSF	641969.844	1827484.810	187.77	2106196.063	5995673.081	616.04	-1-11-55.8	0.99992920	0.99997566	0.99990486	
							Average	-1-11-33.7	0.99992936	0.99999560	0.99992496

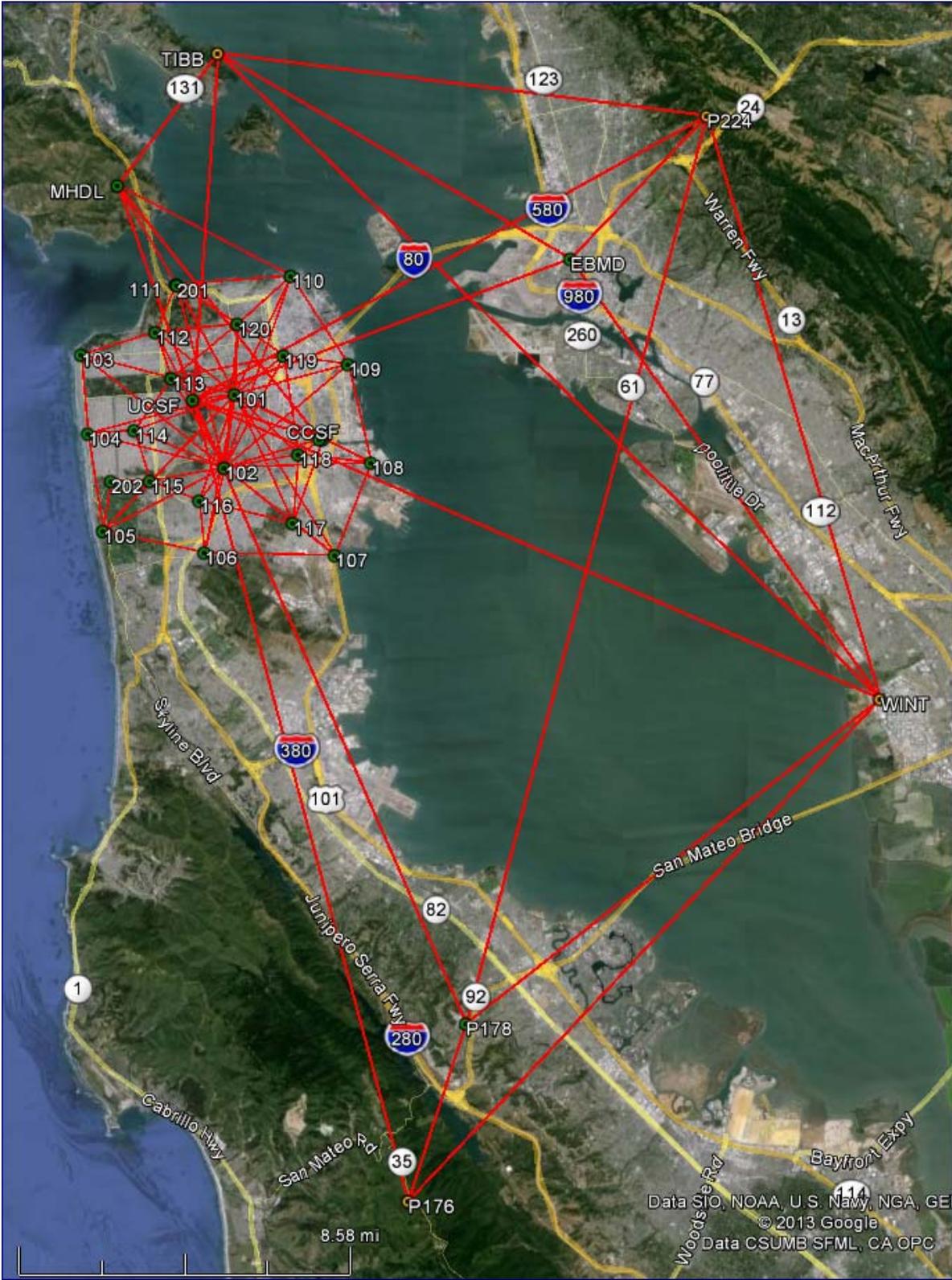
CCSF Plane Coordinates: NAD83(2011) 2010.00 Epoch and NAVD88 Heights per CCSF 2013 2<sup>nd</sup> Order Leveling Survey

POINT#	CCSF PLANE COORD.		NAVD88 HEIGHT(m)	CCSF PLANE COORD.		NAVD88 HEIGHT(ft)	Convergence Angle	----- Factors -----			
	NORTH(m)	EAST(m)		NORTH(ft)	EAST(ft)			Scale	x Ellipsoid =	Combined	
101	25681.275	48940.932	150.799	84255.983	160567.041	494.746	0-00-23.5	1.00000701	0.99998145	0.99998847	
102	22665.032	48608.002	170.991	74360.193	159474.752	560.993	0-00-15.2	1.00000700	0.99997829	0.99998530	
103	27356.975	42550.378	46.352	89753.676	139600.697	152.073	-0-02-16.4	1.00000737	0.99999787	1.00000523	
104	24117.466	42864.322	7.550	79125.385	140630.698	24.770	-0-02-08.4	1.00000732	1.00000397	1.00001129	
105	20140.186	43470.358	56.489	66076.592	142618.999	185.331	-0-01-53.1	1.00000725	0.99999630	1.00000355	
106	19230.486	47764.351	110.302	63092.021	156706.874	361.882	-0-00-05.9	1.00000700	0.99998783	0.99999483	
107	19134.838	52974.838	3.698	62778.214	173801.613	12.133	0-02-04.2	1.00000730	1.00000454	1.00001185	
108	22916.205	54461.117	4.484	75184.248	178677.849	14.711	0-02-41.5	1.00000751	1.00000441	1.00001192	
109	26939.924	53514.519	3.461	88385.400	175572.218	11.355	0-02-18.0	1.00000737	1.00000457	1.00001194	
110	30546.317	51183.622	3.279	100217.376	167924.933	10.758	0-01-19.8	1.00000712	1.00000459	1.00001172	
111	30212.789	46460.090	4.000	99123.126	152427.813	13.123	-0-00-38.6	1.00000703	1.00000449	1.00001152	
112	28200.678	45752.500	54.344	92521.723	150106.327	178.294	-0-00-56.3	1.00000706	0.99999660	1.00000366	
113	26319.011	46403.311	74.816	86348.290	152241.529	245.459	-0-00-40.0	1.00000703	0.99999338	1.00000042	
114	24211.614	44882.700	99.656	79434.271	147252.657	326.955	-0-01-18.0	1.00000712	0.99998950	0.99999662	
115	22147.178	45523.733	61.448	72661.199	149355.781	201.601	-0-01-01.9	1.00000708	0.99999550	1.00000257	
116	21342.501	47533.342	89.985	70021.189	155948.974	295.226	-0-00-11.7	1.00000700	0.99999101	0.99999801	
117	20442.606	51304.532	117.172	67068.783	168321.620	384.422	0-01-22.5	1.00000713	0.99998674	0.99999387	
118	23236.307	51531.650	78.553	76234.451	169066.754	257.719	0-01-28.3	1.00000715	0.99999279	0.99999994	
119	27280.254	50901.352	18.941	89501.966	166998.851	62.142	0-01-12.6	1.00000710	1.00000214	1.00000924	
120	28536.156	49084.584	85.887	93622.371	161038.340	281.781	0-00-27.1	1.00000701	0.99999164	0.99999865	
201	30172.563	46512.431	3.659	98991.152	152599.533	12.005	-0-00-37.3	1.00000703	1.00000454	1.00001157	
202	22161.547	43861.056	23.761	72708.341	143900.815	77.956	-0-01-43.4	1.00000721	1.00000142	1.00000863	
203	23862.437	52492.350		78288.679	172218.652		0-01-52.3	1.00000725	1.00000434	1.00001159	
CCSF	23866.723	52367.837		78302.739	171810.144		0-01-49.2	1.00000723	1.00000250	1.00000974	
MHDL	34247.715	44099.030		112361.043	144681.568		-0-01-37.9	1.00000719	0.99998958	0.99999677	
UCSF	25438.989	47283.113	187.77	83461.083	155128.014	616.04	-0-00-17.9	1.00000701	0.99997566	0.99998266	
							Average	0-00-04.1	1.00000715	0.99999560	1.00000275

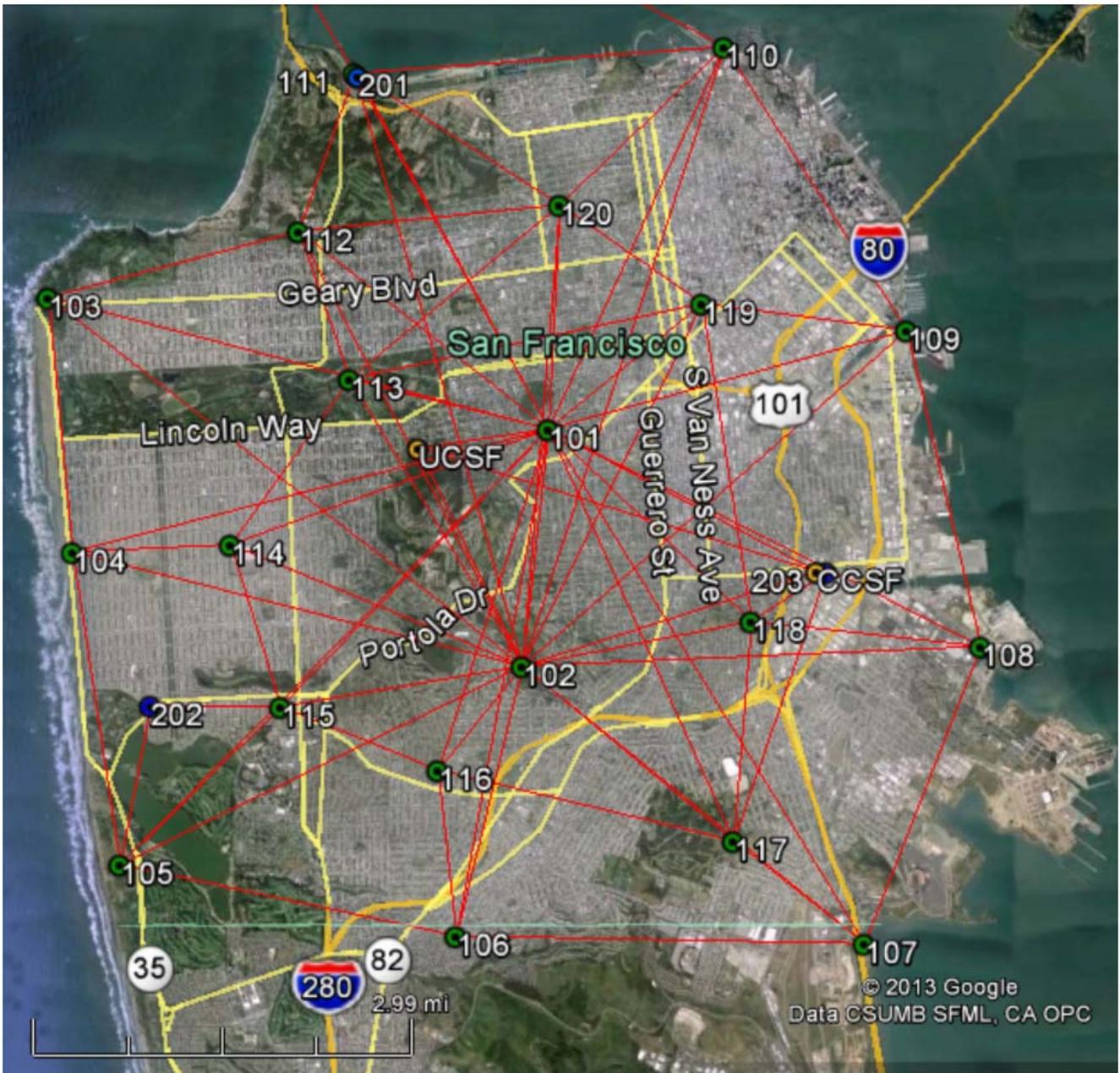
Projection Specifications:

Projection: Transverse Mercator, Ellipsoid: GRS-80, Scale: 1.000007, Latitude of Origin: 37°45'00",  
Central Meridian: -122°27'00", False Northing: 24000.0 meters, False Easting: 48000.0 meters.

**City & County of San Francisco Regional Network & High Precision Network**  
(north up)



**City & County of San Francisco High Precision Network**  
(north up)



**NGS STATION DESCRIPTIONS - CORS NGS Reference Data for P176, P224, TIBB & WINT**

CORS Coordinates, HTDP Solutions for NAD83(2011) 2010.00 to 2013.54, and NGS Data Sheets (retrieved at the time of this survey) and short-term time series graphs

**P176**

```

MILLSCREEKCN2007 (P176), CALIFORNIA
PID = DN7542

IGS08 VELOCITY
Predicted with HTDP_3.1.2 Apr 2012.
  VX = -0.0237 m/yr      northward = 0.0213 m/yr
  VY = 0.0303 m/yr      eastward = -0.0362 m/yr
  VZ = 0.0169 m/yr      upward = 0.0000 m/yr

NAD_83 (2011) VELOCITY
Transformed from IGS08 velocity in Apr 2012.
  VX = -0.0074 m/yr      northward = 0.0344 m/yr
  VY = 0.0307 m/yr      eastward = -0.0227 m/yr
  VZ = 0.0265 m/yr      upward = -0.0013 m/yr

-----
Monument: MILLSCREEKCN2007 GRP
-----
PID = DN7544

IGS08 POSITION (EPOCH 2005.0)
Computed in Apr 2012 using 29 days of data.
  X = -2712719.288 m      latitude = 37 28 18.37726 N
  Y = -4281638.058 m      longitude = 122 21 25.69787 W
  Z = 3859341.975 m      ellipsoid height = 433.810 m

NAD_83 (2011) POSITION (EPOCH 2010.0)
Transformed from IGS08 (epoch 2005.0) position in Apr 2012.
  X = -2712718.623 m      latitude = 37 28 18.36834 N
  Y = -4281639.174 m      longitude = 122 21 25.65069 W
  Z = 3859342.078 m      ellipsoid height = 434.339 m

* The position & velocity were revised in Apr 2012.

```

HTDP (version 3.2.3) OUTPUT  
HTDP UPDATED POSITIONS IN NAD\_83(2011/CORS96/2007)  
FROM 1-01-2010 TO 7-17-2013 (month-day-year)  
FROM 2010.000 TO 2013.541 (decimal years)

	OLD COORDINATE	NEW COORDINATE	VELOCITY	DISPLACEMENT
P176				
LATITUDE	37 28 18.36834 N	37 28 18.37230 N	34.53 mm/yr	0.122 m north
LONGITUDE	122 21 25.65069 W	122 21 25.65398 W	-22.87 mm/yr	-0.081 m east
ELLIP. HT.	434.339	434.334	-1.35 mm/yr	-0.005 m up
X	-2712718.623	-2712718.650	-7.50 mm/yr	-0.027 m
Y	-4281639.174	-4281639.065	30.89 mm/yr	0.109 m
Z	3859342.078	3859342.172	26.58 mm/yr	0.094 m

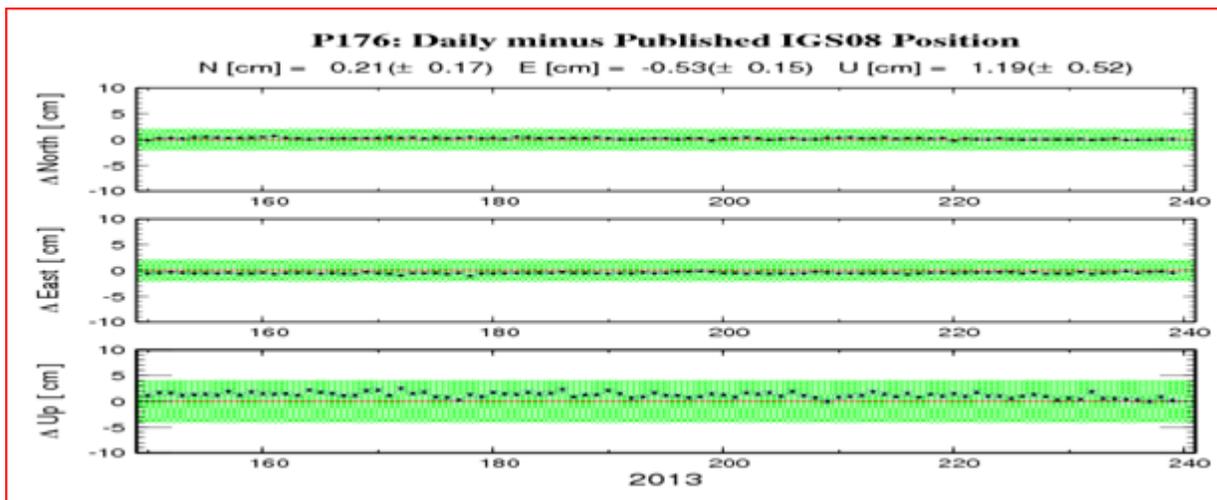
```

DN7544 NGS Data Sheet *****
DN7544 CORS - This is a GPS Continuously Operating Reference Station.
DN7544 DESIGNATION - MILLSCREEKCN2007 GRP
DN7544 CORS_ID - P176
DN7544 PID - DN7544
DN7544 STATE/COUNTY- CA/SAN MATEO
DN7544 COUNTRY - US

```

DN7544 USGS QUAD - WOODSIDE (1997)  
 DN7544 \*CURRENT SURVEY CONTROL  
 DN7544  
 DN7544\* NAD 83(2011) POSITION- 37 28 18.36834(N) 122 21 25.65069(W) ADJUSTED  
 DN7544\* NAD 83(2011) ELLIP HT- 434.339 (meters) (04/??/12) ADJUSTED  
 DN7544\* NAD 83(2011) EPOCH - 2010.00  
 DN7544\* [NAVD 88](#) ORTHO HEIGHT - \*(meters) \*(feet)  
 DN7544  
 DN7544 NAD 83(2011) X - -2,712,718.623 (meters) COMP  
 DN7544 NAD 83(2011) Y - -4,281,639.174 (meters) COMP  
 DN7544 NAD 83(2011) Z - 3,859,342.078 (meters) COMP  
 DN7544 LAPLACE CORR - 5.29 (seconds) DEFLEC12A  
 DN7544 GEOID HEIGHT - -32.59 (meters) GEOID12A  
 DN7544 HORZ ORDER - SPECIAL (CORS)  
 DN7544 ELLP ORDER - SPECIAL (CORS)  
 DN7544

DN7544. Formal positional accuracy estimates are not available for this CORS  
 DN7544. because its coordinates were determined in part using modeled  
 DN7544. velocities. Approximate one-sigma accuracies for latitude, longitude,  
 DN7544. and ellipsoid height can be obtained from the [short-term time series](#).  
 DN7544. Additional information regarding modeled velocities is available on  
 DN7544. the [CORS Coordinates](#) and [Multi-Year CORS Solution FAQ](#) web pages.



DN7544  
 DN7544. The horizontal coordinates were established by GPS observations  
 DN7544. and adjusted by the National Geodetic Survey in April 2012.  
 DN7544  
 DN7544. NAD 83(2011) refers to NAD 83 coordinates where the reference  
 DN7544. frame has been affixed to the stable North American Tectonic Plate.  
 DN7544  
 DN7544. The horizontal coordinates are valid at the epoch date displayed above  
 DN7544. which is a decimal equivalence of Year/Month/Day.  
 DN7544  
 DN7544. The XYZ, and position/ellipsoidal ht. are equivalent.  
 DN7544  
 DN7544. The Laplace correction was computed from DEFLEC12A derived deflections.  
 DN7544  
 DN7544. The ellipsoidal height was determined by GPS observations  
 DN7544. and is referenced to NAD 83.

DN7544  
 DN7544. The following values were computed from the NAD 83(2011) position.  
 DN7544

DN7544;		North	East	Units	Scale	Factor	Converg.
DN7544;SPC CA 3	-	609,477.407	1,835,741.550	MT	0.99994099	-1 08 13.2	
DN7544;SPC CA 3	-	1,999,593.79	6,022,762.07	sFT	0.99994099	-1 08 13.2	
DN7544;UTM 10	-	4,147,403.346	556,845.451	MT	0.99963980	+0 23 28.0	

```

DN7544
DN7544!          - Elev Factor x Scale Factor = Combined Factor
DN7544!SPC CA 3  - 0.99993185 x 0.99994099 = 0.99987284
DN7544!UTM 10    - 0.99993185 x 0.99963980 = 0.99957167
DN7544
DN7544          SUPERSEDED SURVEY CONTROL
DN7544
DN7544 NAD 83(CORS)- 37 28 18.35942(N)    122 21 25.64286(W) AD(2002.00) A
DN7544 ELLIP H (04/??/12) 434.346 (m)      GP(2002.00) 4 1
DN7544
DN7544.Superseded values are not recommended for survey control.
DN7544
DN7544.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
DN7544.See file dsdata.txt to determine how the superseded data were derived.
DN7544
DN7544_U.S. NATIONAL GRID SPATIAL ADDRESS: 10SEG5684547403(NAD 83)
DN7544
DN7544_STAMPING: UNKNOWN
DN7544          STATION DESCRIPTION
DN7544'THIS MONUMENT IS ASSOCIATED WITH CORS SITE 'P176'
DN7544'LATEST INFORMATION INCLUDING POSITIONS AND VELOCITIES
DN7544'ARE AVAILABLE IN THE COORDINATE AND LOG FILES ACCESSIBLE
DN7544'BY ANONYMOUS FTP OR THE WORLDWIDE WEB.
DN7544' ftp://cors.ngs.noaa.gov/cors/README.txt
DN7544' ftp://cors.ngs.noaa.gov/cors/coord/coord_08
DN7544' ftp://cors.ngs.noaa.gov/cors/station_log
DN7544' http://geodesy.noaa.gov/CORS

```

## P224

---

```

          SIBLEYVOLCCN2005 (P224), CALIFORNIA
| IGS08 VELOCITY
| Computed in Aug 2011 using data through gpswk 1631.
|   VX = -0.0211 m/yr      northward = 0.0068 m/yr
|   VY = 0.0181 m/yr      eastward  = -0.0275 m/yr
|   VZ = 0.0054 m/yr      upward    = 0.0001 m/yr
|
| NAD_83 (2011) VELOCITY
| Transformed from IGS08 velocity in Aug 2011.
|   VX = -0.0047 m/yr      northward = 0.0198 m/yr
|   VY = 0.0185 m/yr      eastward  = -0.0138 m/yr
|   VZ = 0.0149 m/yr      upward    = -0.0012 m/yr
|
|-----|
| Monument: SIBLEYVOLCCN2005 GRP
|-----|
| IGS08 POSITION (EPOCH 2005.0)
| Computed in Aug 2011 using data through gpswk 1631.
|   X = -2688201.251 m      latitude  = 37 51 50.02572 N
|   Y = -4265643.690 m      longitude = 122 13 08.61274 W
|   Z = 3893778.570 m      ellipsoid height = 407.348 m
|
| NAD_83 (2011) POSITION (EPOCH 2010.0)
| Transformed from IGS08 (epoch 2005.0) position in Aug 2011.
|   X = -2688200.572 m      latitude  = 37 51 50.01427 N
|   Y = -4265644.864 m      longitude = 122 13 08.56363 W
|   Z = 3893778.614 m      ellipsoid height = 407.873 m
|
* The position & velocity were revised in Aug 2011.

```

---

```

HTDP (version 3.2.3) OUTPUT
UPDATED POSITIONS IN NAD_83(2011/CORS96/2007)
FROM 1-01-2010 TO 7-17-2013 (month-day-year)

```

FROM 2010.000 TO 2013.541 (decimal years)

	OLD COORDINATE	NEW COORDINATE	VELOCITY	DISPLACEMENT
P224				
LATITUDE	37 51 50.01427 N	37 51 50.01666 N	20.82 mm/yr	0.074 m north
LONGITUDE	122 13 8.56363 W	122 13 8.56557 W	-13.38 mm/yr	-0.047 m east
ELLIP. HT.	407.873	407.868	-1.36 mm/yr	-0.005 m up
X	-2688200.572	-2688200.586	-3.94 mm/yr	-0.014 m
Y	-4265644.864	-4265644.797	18.85 mm/yr	0.067 m
Z	3893778.613	3893778.669	15.60 mm/yr	0.055 m

Used HTDP and the CORS velocities to compute the 2013.54 Epoch below

	OLD COORDINATE	NEW COORDINATE	VELOCITY	DISPLACEMENT
P224				
LATITUDE	37 51 50.01427 N	37 51 50.01654 N	19.80 mm/yr	0.070 m north
LONGITUDE	122 13 8.56363 W	122 13 8.56563 W	-13.80 mm/yr	-0.049 m east
ELLIP. HT.	407.873	407.869	-1.20 mm/yr	-0.004 m up
X	-2688200.572	-2688200.589	-4.69 mm/yr	-0.017 m
Y	-4265644.864	-4265644.799	18.44 mm/yr	0.065 m
Z	3893778.613	3893778.666	14.89 mm/yr	0.053 m

DH3881 NGS Data Sheet \*\*\*\*\*

DH3881 CORS - This is a GPS Continuously Operating Reference Station.  
 DH3881 DESIGNATION - SIBLEYVOLCCN2005 GRP  
 DH3881 CORS\_ID - P224  
 DH3881 PID - DH3881  
 DH3881 STATE/COUNTY- CA/CONTRA COSTA  
 DH3881 COUNTRY - US  
 DH3881 USGS QUAD - OAKLAND EAST (1997)

DH3881 \*CURRENT SURVEY CONTROL

DH3881  
 DH3881\* NAD 83(2011) POSITION- 37 51 50.01427(N) 122 13 08.56363(W) ADJUSTED  
 DH3881\* NAD 83(2011) ELLIP HT- 407.873 (meters) (08/??/11) ADJUSTED  
 DH3881\* NAD 83(2011) EPOCH - 2010.00  
 DH3881\* NAVD 88 ORTHO HEIGHT - \*(meters) \*(feet)  
 DH3881  
 DH3881 NAD 83(2011) X - -2,688,200.572 (meters) COMP  
 DH3881 NAD 83(2011) Y - -4,265,644.864 (meters) COMP  
 DH3881 NAD 83(2011) Z - 3,893,778.614 (meters) COMP  
 Laplace CORR - 2.51 (seconds) DEFLEC12A  
 DH3881 GEOID HEIGHT - -32.17 (meters) GEOID12A  
 DH3881 HORZ ORDER - SPECIAL (CORS)  
 DH3881 ELLP ORDER - SPECIAL (CORS)

DH3881  
 DH3881 FGDC Geospatial Positioning Accuracy Standards (95% confidence, cm)  
 DH3881 Type Horiz Ellip Dist(km)  
 -----  
 DH3881 NETWORK 2.02 6.62  
 -----

DH3881 NOTE: Click [here](#) for information on individual local accuracy values and other accuracy information.

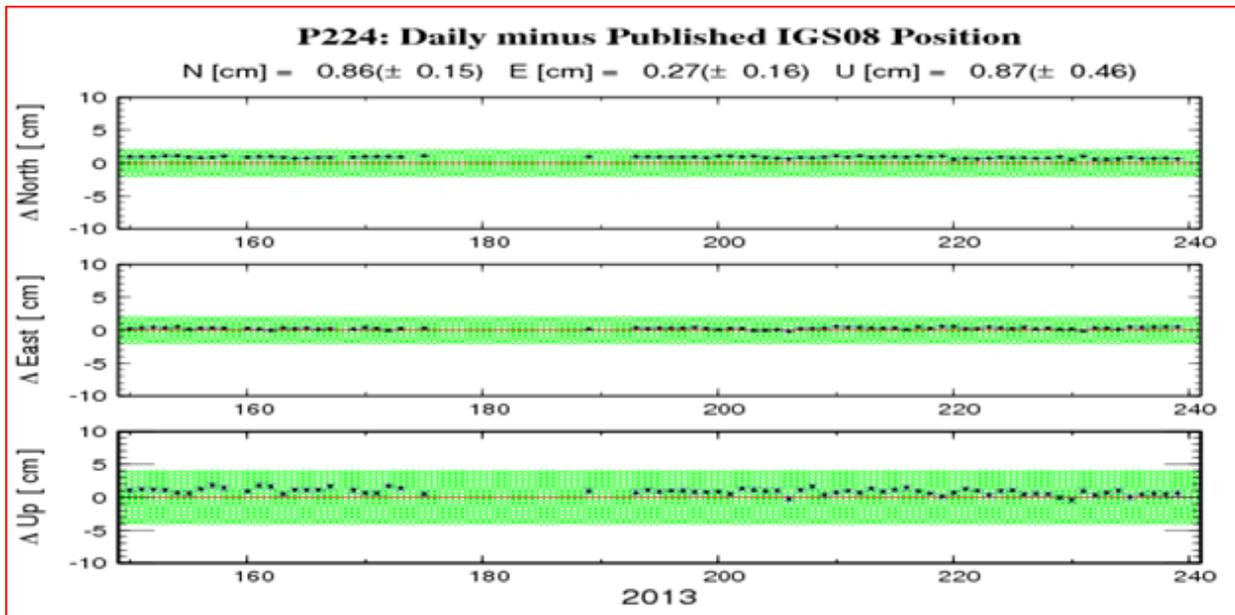
DH3881 \*\*\*\*\*

DH3881 ACCURACIES - Complete network and local accuracy information.  
 DH3881 CORS - This is a GPS Continuously Operating Reference Station.  
 DH3881 DESIGNATION - SIBLEYVOLCCN2005 GRP  
 DH3881 PID - DH3881

DH3881 Statistical Information, in cm, for point DH3881 follows.

DH3881 Note that Horz and Ellip values are the official 95%  
 DH3881 FGDC accuracy standards. The values of StdN, StdE and Stdh are the  
 DH3881 standard deviations (one sigma) of the coordinates (NETWORK) or  
 DH3881 of the difference in the coordinates (LOCAL) in Latitude, Longitude

DH3881 and Ellipsoid Height. The value CorrNE is the correlation  
DH3881 coefficient between the latitude and longitude components of either  
DH3881 the coordinate (NETWORK) or coordinate difference (LOCAL).  
DH3881  
DH3881 Type/PID Horz Ellip Dist(km) StdN StdE Stdh CorrNE  
DH3881 -----  
DH3881 NETWORK 2.02 6.62 0.00 0.91 0.71 3.38 +0.04283161  
DH3881 -----



DH3881  
DH3881.The horizontal coordinates were established by GPS observations  
DH3881.and adjusted by the National Geodetic Survey in August 2011.  
DH3881  
DH3881.NAD 83(2011) refers to NAD 83 coordinates where the reference  
DH3881.frame has been affixed to the stable North American Tectonic Plate.  
DH3881  
DH3881.The horizontal coordinates are valid at the epoch date displayed above  
DH3881.which is a decimal equivalence of Year/Month/Day.  
DH3881  
DH3881.The XYZ, and position/ellipsoidal ht. are equivalent.  
DH3881  
DH3881.The Laplace correction was computed from DEFLEC12A derived deflections.  
DH3881  
DH3881.The ellipsoidal height was determined by GPS observations  
DH3881.and is referenced to NAD 83.  
DH3881  
DH3881. The following values were computed from the NAD 83(2011) position.  
DH3881  
DH3881;  

	North	East	Units	Scale	Factor	Converg.
DH3881;SPC CA 3	- 652,755.675	1,848,752.302	MT	0.99993111	-1	03 08.8
DH3881;SPC CA 3	- 2,141,582.58	6,065,448.18	sFT	0.99993111	-1	03 08.8
DH3881;UTM 10	- 4,191,001.178	568,692.783	MT	0.99965812	+0	28 45.7

DH3881  
DH3881!  

	Elev Factor	x	Scale Factor	=	Combined Factor
DH3881!SPC CA 3	- 0.99993600	x	0.99993111	=	0.99986712
DH3881!UTM 10	- 0.99993600	x	0.99965812	=	0.99959414

DH3881  
DH3881  

SUPERSEDED SURVEY CONTROL

DH3881  
DH3881 NAD 83(CORS)- 37 51 50.00906(N) 122 13 08.55850(W) AD(2002.00) A  
DH3881 ELLIP H (06/??/05) 407.864 (m) GP(2002.00) 4 1  
DH3881  
DH3881.Superseded values are not recommended for survey control.

DH3881  
DH3881.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.  
DH3881.[See file dsdata.txt](#) to determine how the superseded data were derived.  
DH3881  
DH3881\_U.S. NATIONAL GRID SPATIAL ADDRESS: 10SEG6869291001(NAD 83)  
DH3881  
DH3881\_STAMPING: UNKNOWN  
DH3881  
DH3881 STATION DESCRIPTION  
DH3881  
DH3881'THIS MONUMENT IS ASSOCIATED WITH CORS SITE 'P224'  
DH3881'LATEST INFORMATION INCLUDING POSITIONS AND VELOCITIES  
DH3881'ARE AVAILABLE IN THE COORDINATE AND LOG FILES ACCESSIBLE  
DH3881'BY ANONYMOUS FTP OR THE WORLDWIDE WEB.  
DH3881' ftp://cors.ngs.noaa.gov/cors/README.txt  
DH3881' ftp://cors.ngs.noaa.gov/cors/coord/coord\_08  
DH3881' ftp://cors.ngs.noaa.gov/cors/station\_log  
DH3881' http://geodesy.noaa.gov/CORS

## TIBB

---

TIBURON PENINSUL (TIBB), CALIFORNIA

---

IGS08 VELOCITY  
Predicted with HTDP\_3.2.3 Dec 2012.  
VX = -0.0216 m/yr      northward = 0.0148 m/yr  
VY = 0.0245 m/yr      eastward = -0.0314 m/yr  
VZ = 0.0117 m/yr      upward = 0.0000 m/yr

NAD\_83 (2011) VELOCITY  
Transformed from IGS08 velocity in Dec 2012.  
VX = -0.0052 m/yr      northward = 0.0280 m/yr  
VY = 0.0249 m/yr      eastward = -0.0177 m/yr  
VZ = 0.0213 m/yr      upward = -0.0013 m/yr

---

Monument: TIBURON PENINSUL GRP  
-----  
PID = AI4507

IGS08 POSITION (EPOCH 2005.0)  
Computed in Dec 2012 using 13 days of data.  
X = -2704026.807 m      latitude = 37 53 27.14944 N  
Y = -4253050.099 m      longitude = 122 26 51.36586 W  
Z = 3895879.226 m      ellipsoid height = -21.084 m

NAD\_83 (2011) POSITION (EPOCH 2010.0)  
Transformed from IGS08 (epoch 2005.0) position in Dec 2012.  
X = -2704026.130 m      latitude = 37 53 27.13938 N  
Y = -4253051.240 m      longitude = 122 26 51.31741 W  
Z = 3895879.300 m      ellipsoid height = -20.565 m

---

### HTDP (version 3.2.3) OUTPUT

UPDATED POSITIONS IN NAD\_83(2011/CORS96/2007)  
FROM 1-01-2010 TO 7-17-2013 (month-day-year)  
FROM 2010.000 TO 2013.541 (decimal years)

	OLD COORDINATE	NEW COORDINATE	VELOCITY	DISPLACEMENT
<b>TIBB</b>				
LATITUDE	37 53 27.13938 N	37 53 27.14260 N	28.06 mm/yr	0.099 m north
LONGITUDE	122 26 51.31741 W	122 26 51.31998 W	-17.72 mm/yr	-0.063 m east
ELLIP. HT.	-20.565	-20.570	-1.36 mm/yr	-0.005 m up
X	-2704026.130	-2704026.148	-5.13 mm/yr	-0.018 m
Y	-4253051.240	-4253051.152	24.96 mm/yr	0.088 m
Z	3895879.300	3895879.376	21.31 mm/yr	0.075 m

AI4507 NGS Data Sheet \*\*\*\*\*

AI4507 CORS - This is a GPS Continuously Operating Reference Station.

AI4507 DESIGNATION - TIBURON PENINSUL GRP

AI4507 CORS\_ID - TIBB

AI4507 PID - AI4507

AI4507 STATE/COUNTY- CA/MARIN

AI4507 COUNTRY - US

AI4507 USGS QUAD - SAN QUENTIN (1995)

AI4507 \*CURRENT SURVEY CONTROL

---

AI4507\* NAD 83(2011) POSITION- 37 53 27.13938(N) 122 26 51.31741(W) ADJUSTED

AI4507\* NAD 83(2011) ELLIP HT- -20.565 (meters) (12/??/12) ADJUSTED

AI4507\* NAD 83(2011) EPOCH - 2010.00

---

AI4507\* NAVD 88 ORTHO HEIGHT - 11.8 (meters) 39. (feet) GPS OBS

---

AI4507 NAD 83(2011) X - -2,704,026.130 (meters) COMP

AI4507 NAD 83(2011) Y - -4,253,051.240 (meters) COMP

AI4507 NAD 83(2011) Z - 3,895,879.300 (meters) COMP

AI4507 LAPLACE CORR - 0.01 (seconds) DEFLEC12A

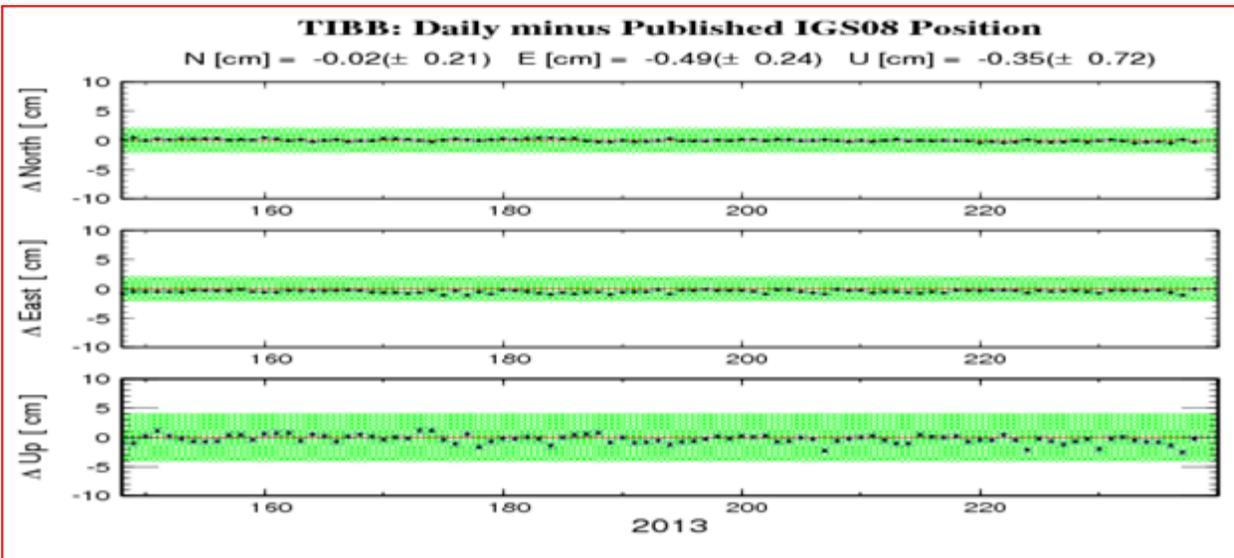
AI4507 GEOID HEIGHT - -32.38 (meters) GEOID12A

AI4507 HORIZ ORDER - SPECIAL (CORS)

AI4507 ELLP ORDER - SPECIAL (CORS)

AI4507

AI4507. Formal positional accuracy estimates are not available for this CORS because its coordinates were determined in part using modeled velocities. Approximate one-sigma accuracies for latitude, longitude, and ellipsoid height can be obtained from the [short-term time series](#). Additional information regarding modeled velocities is available on the [CORS Coordinates](#) and [Multi-Year CORS Solution FAQ](#) web pages.



AI4507

AI4507. The horizontal coordinates were established by GPS observations and adjusted by the National Geodetic Survey in December 2012.

AI4507

AI4507. NAD 83(2011) refers to NAD 83 coordinates where the reference frame has been affixed to the stable North American Tectonic Plate.

AI4507

AI4507. The horizontal coordinates are valid at the epoch date displayed above which is a decimal equivalence of Year/Month/Day.

AI4507

AI4507. The orthometric height was determined by GPS observations and a high-resolution geoid model.



```
VX = -0.0222 m/yr    northward = 0.0125 m/yr
VY = 0.0229 m/yr    eastward = -0.0310 m/yr
VZ = 0.0099 m/yr    upward = 0.0000 m/yr
```

NAD\_83 (2011) VELOCITY

Transformed from IGS08 velocity in Dec 2012.

```
VX = -0.0058 m/yr    northward = 0.0255 m/yr
VY = 0.0233 m/yr    eastward = -0.0173 m/yr
VZ = 0.0194 m/yr    upward = -0.0013 m/yr
```

Monument: WINT\_BARD\_CN1991 GRP

PID = AI4510

IGS08 POSITION (EPOCH 2005.0)

Computed in Dec 2012 using 16 days of data.

```
X = -2689810.025 m    latitude = 37 39 09.51629 N
Y = -4281187.927 m    longitude = 122 08 26.04241 W
Z = 3874973.479 m    ellipsoid height = -28.791 m
```

NAD\_83 (2011) POSITION (EPOCH 2010.0)

Transformed from IGS08 (epoch 2005.0) position in Dec 2012.

```
X = -2689809.352 m    latitude = 37 39 09.50579 N
Y = -4281189.079 m    longitude = 122 08 25.99416 W
Z = 3874973.548 m    ellipsoid height = -28.259 m
```

HTDP (version 3.2.3) OUTPUT

UPDATED POSITIONS IN NAD\_83(2011/CORS96/2007)

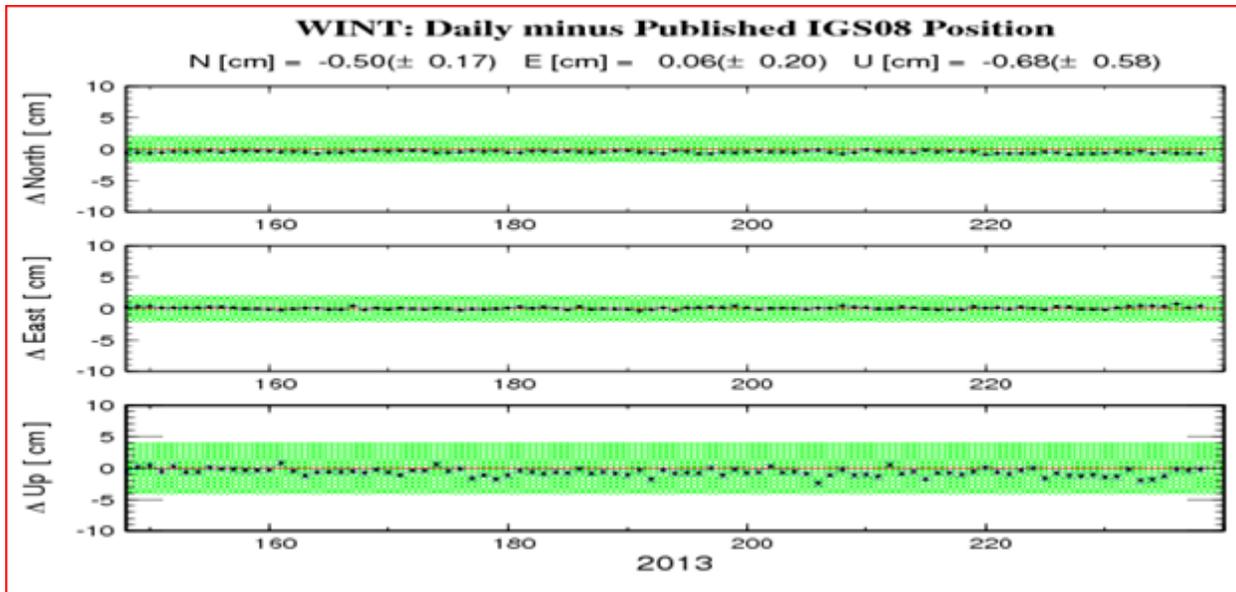
FROM 1-01-2010 TO 7-17-2013 (month-day-year)

FROM 2010.000 TO 2013.541 (decimal years)

	OLD COORDINATE	NEW COORDINATE	VELOCITY	DISPLACEMENT
WINT				
LATITUDE	37 39 9.50579 N	37 39 9.50872 N	25.54 mm/yr	0.090 m north
LONGITUDE	122 08 25.99416 W	122 08 25.99666 W	-17.33 mm/yr	-0.061 m east
ELLIP. HT.	-28.259	-28.264	-1.35 mm/yr	-0.005 m up
X	-2689809.352	-2689809.373	-5.80 mm/yr	-0.021 m
Y	-4281189.080	-4281188.997	23.34 mm/yr	0.083 m
Z	3874973.548	3874973.617	19.40 mm/yr	0.069 m

```
AI4510 NGS Data Sheet *****
AI4510 HT_MOD - This is a Height Modernization Survey Station.
AI4510 CORS - This is a GPS Continuously Operating Reference Station.
AI4510 DESIGNATION - WINT_BARD_CN1991 GRP
AI4510 CORS_ID - WINT
AI4510 PID - AI4510
AI4510 STATE/COUNTY- CA/ALAMEDA
AI4510 COUNTRY - US
AI4510 USGS QUAD - SAN LEANDRO (1993)
AI4510 *CURRENT SURVEY CONTROL
AI4510
AI4510* NAVD 88 ORTHO HEIGHT - 4.30 (meters) 14.1 (feet) GPS OBS
AI4510
AI4510 NAVD 88 orthometric height was determined with geoid model GEOID03
AI4510 GEOID HEIGHT - -32.47 (meters) GEOID03
AI4510 GEOID HEIGHT - -32.52 (meters) GEOID12A
AI4510 NAD 83(2011) X - -2,689,809.352 (meters) COMP
AI4510 NAD 83(2011) Y - -4,281,189.079 (meters) COMP
AI4510 NAD 83(2011) Z - 3,874,973.548 (meters) COMP
AI4510 LAPLACE CORR - 2.63 (seconds) DEFLEC12A
AI4510 HORZ ORDER - SPECIAL (CORS)
AI4510 ELLP ORDER - SPECIAL (CORS)
AI4510
```

AI4510. Formal positional accuracy estimates are not available for this CORS  
 AI4510. because its coordinates were determined in part using modeled  
 AI4510. velocities. Approximate one-sigma accuracies for latitude, longitude,  
 AI4510. and ellipsoid height can be obtained from the [short-term time series](#).  
 AI4510. Additional information regarding modeled velocities is available on  
 AI4510. the [CORS Coordinates](#) and [Multi-Year CORS Solution FAQ](#) web pages.



AI4510. The horizontal coordinates were established by GPS observations  
 AI4510. and adjusted by the National Geodetic Survey in December 2012.  
 AI4510

AI4510. NAD 83(2011) refers to NAD 83 coordinates where the reference  
 AI4510. frame has been affixed to the stable North American Tectonic Plate.  
 AI4510

AI4510. The horizontal coordinates are valid at the epoch date displayed above  
 AI4510. which is a decimal equivalence of Year/Month/Day.  
 AI4510

AI4510. The orthometric height was determined by GPS observations and a  
 AI4510. high-resolution geoid model using precise GPS observation and  
 AI4510. processing techniques.

AI4510. The XYZ, and position/ellipsoidal ht. are equivalent.  
 AI4510

AI4510. The Laplace correction was computed from DEFLEC12A derived deflections.  
 AI4510

AI4510. The ellipsoidal height was determined by GPS observations  
 AI4510. and is referenced to NAD 83.  
 AI4510

AI4510. The following values were computed from the NAD 83(2011) position.  
 AI4510

	North	East	Units	Scale Factor	Converg.
AI4510; SPC CA 6	- 1,123,770.181	1,478,989.373	MT	1.00283790	-3 14 13.1
AI4510; SPC CA 6	- 3,686,902.67	4,852,317.63	sFT	1.00283790	-3 14 13.1
AI4510; UTM 10	- 4,167,623.257	575,812.323	MT	0.99967079	+0 31 30.1
AI4510!	- Elev Factor	x Scale Factor	=	Combined Factor	
AI4510! SPC CA 6	- 1.00000443	x 1.00283790	=	1.00284235	
AI4510! UTM 10	- 1.00000443	x 0.99967079	=	0.99967522	

SUPERSEDED SURVEY CONTROL					
AI4510	NAVD 88 (04/03/01)	4.2	(m)	UNKNOWN model used	GPS OBS
AI4510	NAVD 88 (04/06/00)	4.3	(m)	GEOID99 model used	GPS OBS
AI4510					

AI4510. Superseded values are not recommended for survey control.

AI4510  
 AI4510.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.  
 AI4510.[See file dsdata.txt](#) to determine how the superseded data were derived.  
 AI4510  
 AI4510\_U.S. NATIONAL GRID SPATIAL ADDRESS: 10SEG7581267623(NAD 83)  
 AI4510\_MARKER: Z = SEE DESCRIPTION  
 AI4510\_SETTING: 0 = UNSPECIFIED SETTING  
 AI4510\_STAMPING: UNKNOWN  
 AI4510\_MARK LOGO: NONE  
 AI4510\_MAGNETIC: N = NO MAGNETIC MATERIAL  
 AI4510\_STABILITY: A = MOST RELIABLE AND EXPECTED TO HOLD  
 AI4510+STABILITY: POSITION/ELEVATION WELL  
 AI4510\_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR  
 AI4510+SATELLITE: SATELLITE OBSERVATIONS - 1998  
 AI4510  

AI4510	HISTORY	- Date	Condition	Report By
AI4510	HISTORY	- 1998	MONUMENTED	NGS

 AI4510 STATION DESCRIPTION  
 AI4510'DESCRIBED BY NATIONAL GEODETIC SURVEY 1998  
 AI4510'THIS MONUMENT IS ASSOCIATED WITH CORS SITE 'WINT'  
 AI4510'LATEST INFORMATION INCLUDING POSITIONS AND VELOCITIES  
 AI4510'ARE AVAILABLE IN THE COORDINATE AND LOG FILES ACCESSIBLE  
 AI4510'BY ANONYMOUS FTP OR THE WORLDWIDE WEB.  
 AI4510' ftp://cors.ngs.noaa.gov/cors/README.txt  
 AI4510' ftp://cors.ngs.noaa.gov/cors/coord/coord\_08  
 AI4510' ftp://cors.ngs.noaa.gov/cors/station\_log  
 AI4510' http://geodesy.noaa.gov/CORS

---