

## McGEE SURVEYING CONSULTING

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# Survey Report for the Channel Islands LiDAR QA/QC Survey in Ventura County, California for Dewberry

## OVERVIEW

**Surveyed by:** McGee Surveying Consulting (MSC) at 5290 Overpass Rd., Ste#107 Santa Barbara, CA 93111

**Survey Method:** GPS Static

**Client:** Dewberry, LLC; **Project. Number:** \_\_\_\_; **Project Name:** Channel Islands LiDAR/USGS

**Location:** San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara Islands

**County:** Ventura; **State:** California

**Attachments:** Find the following Documents

- Coordinate Listing Control Points with Geodetic, Ellipsoid Heights, UTM Grid Coordinate and NAVD88 Heights in meters
- NGS Data Sheets for Control Points Referenced in this Survey
- CSRC NGS Sanctioned Positions and Orthometric Heights (two files)
- Photos of Points

**Appendix:** GPS Network Control Network, aerial photos with point locations

This document serves as a summary report for the Channel Islands QAQC Survey. The purpose of this survey is to establish ground truthing points for validation of LiDAR measurements and the DEM. The lidar mapping was performed by TerraPoint in March 2010. There existed sufficient and CGPS (continuously operated GPS reference stations) Stations on the Islands to establish reliable horizontal positions and ellipsoid heights, and benchmarks on the mainland to establish vertical control for this project. This survey is based on the NAVD88 vertical datum utilizing the Geoid09 Model and the national re-adjustment of the NAD83 Datum published as the 2007.00 Epoch Adjustment. This Epoch supersedes the 1991.35 Epoch which differs by about 0.7 meters in position in this region due to the movement of the Pacific Plate relative to the North American Plate.

The project includes San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara Islands. The project required the establishment of 5 checkpoints on each of the five islands located on open (clear) level ground. The five points on Anacapa Island are concentrated on the easterly portion where there is a landing pad. At the time of the survey, winds were gusting 70mph, buffeting the helicopter, making the landing too dangerous. Photos of each location were taken and are named with the point number and direction of view.

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## PROJECT DATUMS, REFERENCE SYSTEM

**Horizontal Datum:** North American Datum of 1983 (NAD83); **Epoch:** 2007.00

**Reference Network:** The survey is referenced to California CGPS Stations (similar to CORS) which are continuously operating reference GPS receivers mounted on a stable platform. The positions were obtained from the California Spatial Reference Center (CSRC). CSRC provides NGS sanctioned positions on all California CGPS Stations.

**Vertical Datum:** NAVD88

**Reference Network:** NGS Published Heights on three CGPS Stations

**Geoid Model:** Geoid 09; **Projection:** UTM Zone 11; **Units for Deliverables:** Meters

## PROJECT CONTROL: List of Published Positions 2007.00 Epoch

ID		Latitude(dms)	W.Longitude(dms)	EH(mtrs)	Ortho.Ht.	NGS PID
<u>CGPS on the Islands</u>						
ANA1	Anacapa Is.	34-00-54.00540	119-21-48.43900	23.105		
BAR1	Santa Barbara Is.	33-28-49.61247	119-01-46.99915	15.496		
CRU1	Santa Cruz Is.	34-01-45.32143	119-47-05.26874	702.851		
MIG1	San Miguel Is.	34-02-17.71746	120-21-04.95701	131.563		
SRS1	Santa Rosa Is.	34-00-15.59465	120-03-54.74319	68.881		
<u>CGPS on the Mainland</u>						
COPR		34-24-53.65267	119-52-46.23946	-22.194	13.823	DH6817
TOST		34-14-52.62683	118-50-11.94154	275.065	310.016	AJ1931
VNDP		34-33-22.70724	120-36-59.17112	-10.907	25.428	AH7483
<u>1st Order Triangulation Station on 1991.35 Epoch</u>						
DY3066		33-28-19.43778	119-02-28.55212		191.5	DY3066

**Reference Network Stability:** The NAD83, 2007.00 Epoch adjustment is referenced to the North American Plate. This survey is situated on the Pacific Plate which is moving northwesterly relative to the North American Plates. The Islands are moving on average 3.4 cm. north and -3.1 cm. east per year, or northwesterly 4.6 centimeters per year base on the CGPS Stations situated on the five Islands listed below. The largest difference in the north and east velocities is 0.3 cm. and 0.1 cm. The maximum differential movement of the CGPS stations between 2007.0 and 2010.2 the date of this survey (3.2 years) is estimated at 1.0 cm. north and 0.3 cm. east. The deformation of one centimeter in the control network of CGPS Stations does not impact the accuracy requirements of this survey and the CGPS stations were constrained in the final adjustment to the 2007.00 Epoch.

Station	Annual Velocities (mtrs)		
	N.Vel	E.Vel	Up_Vel
<u>Islands</u>			
ANA1	0.034	-0.030	-0.000
BAR1	0.033	-0.031	-0.002
CRU1	0.034	-0.030	-0.001
MIG1	0.036	-0.031	-0.001
SRS1	0.035	-0.031	-0.001
<u>Mainland</u>			
COPR	0.028	-0.030	-0.000
TOST	0.029	-0.028	-0.002
VNDP	0.034	-0.032	-0.001

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### NETWORK

The survey was conducted as a static radial network. A Base GPS Receiver was set on a new point on each Island for 3-4 hours while a Roving Receiver occupied other points on the Island for 10-15 minutes. A second occupation was made on each point generally about an hour or more apart in time. In the processing, the Base was positioned relative to the CGPS Station on each island and vectors were computed from the Base and the CGPS to each point. This resulted in four vectors to each point. The vectors agreed less than 5 centimeters in the vertical component

The network included 39 points consisting of 31 points established by this survey and 8 CGPS Stations as shown below. The Primary Control stations are the 8 CGPS Stations taking their assigned four letter ID. Three of the CGPS on the mainland are published NGS benchmarks. Points established by this survey have a four digit identification consisting of two alpha characters to identify the island and a number for the point. For example, AC01 is point number one on Anacapa Island. Some eccentric points were created and designated by an appended X. See the attached Coordinate Listing for additional information. A network detail of each Island is included in the Appendix with aerial photos showing the locations of the QAQC Test Points

### ACCURACY

Observations of the GPS Constellation were processed into vectors and evaluated in a minimally constrained adjustment with the following results.

**CGPS Network Vectors:** Four vectors with 2D residuals up to 7 centimeters and vertical residuals up 11 centimeters were removed. The remaining 29 vectors average 62.5 kilometers in length with a maximum of 137.2 kilometers. The two dimensional residuals average 0.2 centimeters with a standard deviation of 0.4 centimeters and a maximum of 2.0 centimeters. The absolute value of the vertical residuals average 1.0 centimeters with a standard deviation of 0.9 centimeters and a range of -2.0 to +3.7 centimeters.

**QAQC Vectors:** 83 vectors average 5.1 kilometers in length with a maximum of 20.7 kilometers. The two dimensional residuals average 0.4 centimeters with a standard deviation of 0.3 centimeters and a maximum of 1.8 centimeters. The absolute value of the vertical residuals average 0.5 centimeters with a standard deviation of 0.6 centimeters and a range of -2.2 to +4.0 centimeters.

**Accuracy:** Relative and absolute is expected to be better than 2 centimeters horizontal and vertical. The accuracy of the NAVD88 Heights is limited to the accuracy of the Geoid 09 Model extended from the Mainland.

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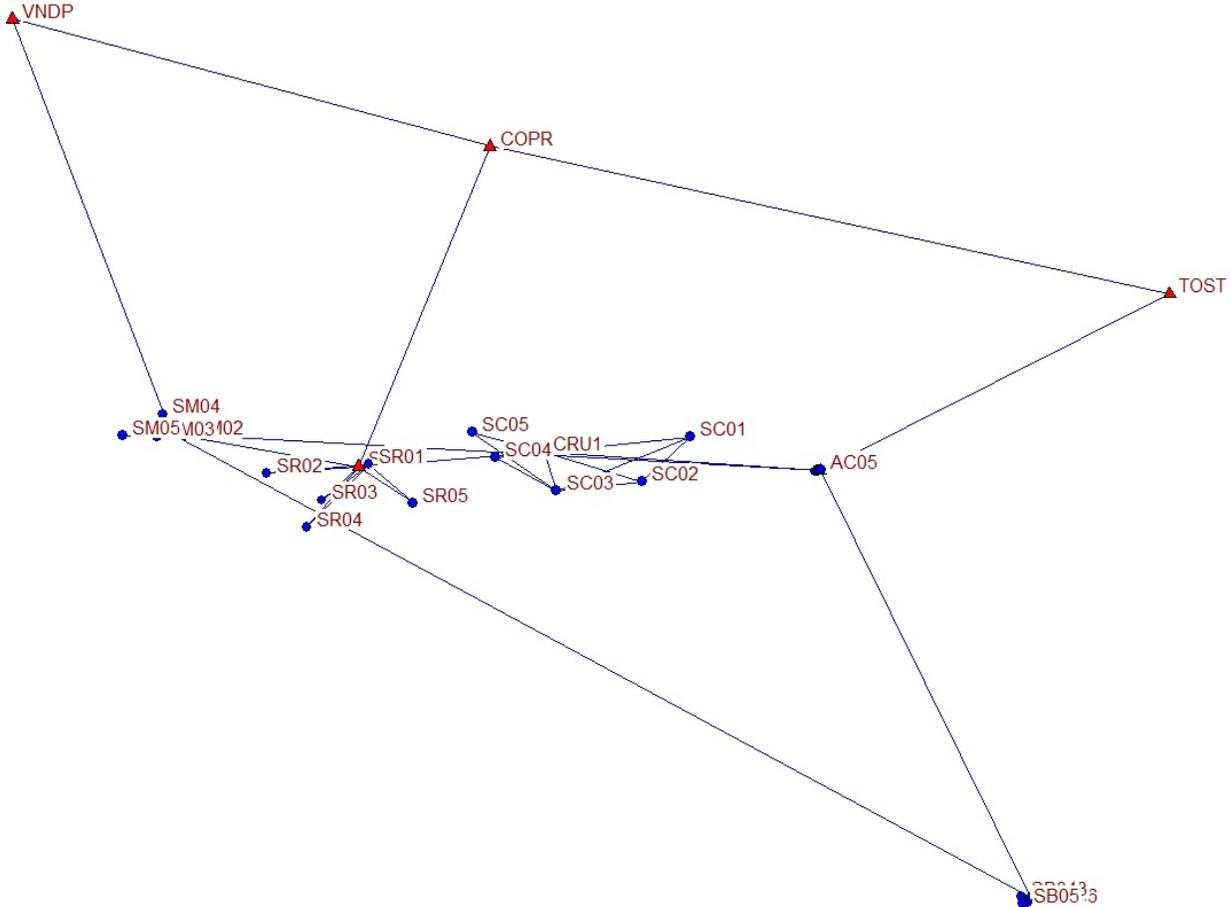
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## ADJUSTMENTS & ANALYSIS

### GPS Network (north up; see Appendix for Detail Maps of each Island)

(Red Symbol = CGPS Stations, Blue = QAQC Points)



#### **Adjustment 1: 3D/Ellipsoid Heights - Minimally Constrained Adjustment**

CGPS Station COPR was on the mainland was fixed in a 3D Minimally Constrained Adjustment to determine preliminary latitude, longitude, ellipsoid heights. The adjustment results follow with the coordinate differences from published to computed positions listed below in meters.

<u>Station</u>	<u>dN</u>	<u>dE</u>	<u>dZ</u>	<u>Description</u>
<b>Islands</b>				
ANA1	0.005	-0.000	-0.023	CGPS on Anacapa Island
BAR1	0.009	-0.005	-0.034	CGPS on Santa Barbara Island
CRU1	0.008	-0.002	0.058	CGPS on Santa Cruz Island
MIG1	0.032	0.009	0.044	CGPS on San Miguel Island
SRS1	0.017	-0.000	0.010	CGPS on Santa Rosa Island
<b>Mainland</b>				
COPR	-0.000	-0.000	-0.000	CGPS on Mainland
TOST	-0.007	0.005	0.020	CGPS on Mainland
VNDP	0.028	0.008	0.053	CGPS on Mainland

**Notes:** The differences range in the North 0.5 to 3.2 centimeters, East -0.5 to 0.9 centimeters, and Up -3.4 to 5.8 centimeters. Loop closures and vector residuals indicate the relative accuracy of the computed positions based on measurements returned by this survey are expected to be about 1 centimeter horizontal by 2 centimeters vertical. The differences with the published heights are outside the expected range.

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### Adjustment 2: 3D/Ellipsoid Heights - Constrained Adjustment

For the purposes of this survey, all CGPS stations were fixed horizontally and COPR on the mainland was fixed for ellipsoid heights in a Constrained Adjustment to determine final latitude, longitude, ellipsoid heights, and UTM plane coordinates. The results of this adjustment are listed below in meters and in the attached Coordinate Listing

<u>Station</u>	<u>dN</u>	<u>dE</u>	<u>dZ</u>
ANA1	-0.000	-0.000	-0.018
BAR1	-0.000	-0.000	-0.028
COPR	-0.000	-0.000	-0.000
CRU1	-0.000	-0.000	0.062
MIG1	-0.000	-0.000	0.051
SRS1	-0.000	-0.000	0.014
TOST	-0.000	-0.000	0.019
VNDP	-0.000	-0.000	0.061
DY3066	0.250	-0.357	
Tri-Station			(Free) 1991.35 Epoch First Order

**Notes:** DY3066 was set free in the adjustment. The horizontal difference is consistent with the velocities for the difference in the Epochs at a First Order Triangulation Station. Ellipsoid height is not available.

### Adjustment 3: Orthometric Heights - Minimally Constrained

CGPS Station COPR was fixed horizontally and vertically at its published NAVD88 height in a Minimally Constrained Adjustment to determine NAVD88 orthometric heights by combining the measured ellipsoid height differences with Geoid 09. The differences from the published to computed orthometric heights are listed below in meters.

<u>Station</u>	<u>dZ</u>	
<u>Mainland</u>		
COPR	-0.000	Fixed 2 <sup>nd</sup> Order Orthometric Height
TOST	-0.024	2 <sup>nd</sup> Order Orthometric Height
VNDP	-0.023	2 <sup>nd</sup> Order Orthometric Height
<u>Islands</u>		
DY3066	2.953	low accuracy Orthometric

**Notes:** The height of DY3066 is derived from classical triangulation and vertical angles from the mainland 60 kilometers northeasterly which may explain the 2.95 meter difference.

### Adjustment 4: Orthometric Heights - Partially Constrained

In a Partially Constrained Adjustment, COPR was fixed horizontally and COPR, TOST and VNDB were fixed vertically at their published NAVD88 Heights to determine orthometric heights by combining the measured ellipsoid height differences with Geoid 09. The results of this adjustment are listed in the attached Coordinate Listing under "Ortho. Ht.".

## TIDAL DATUM RELATIONSHIP

It will be useful to know the relationship to the mean tide and the range of tides for utilizing the DEM prepared from the Lidar Survey of the Channel Islands. This survey was able to provide this relationship based on two Tidal Benchmarks (listed below) included in a 2007 survey for the NPS on the north side of Santa Rosa Island. Tide Station #9410962 was observed by NOAA for 8 months in 1977-78 on the old wharf at Bechers Bay. The heights above MLLW on the 1983-2001 Tidal Epoch are listed with their NAVD88 heights determined by this survey. NAVD88 heights are equal to MLLW heights minus 0.05 meters. The height of the Mean Tide Level is equivalent to 0.77 meters on NAVD88. Other Tide levels referenced to MLLW are listed below.

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## Tidal Bench Mark Elevation Heights in meters

Designation	MLLW	-	=	NAVD88
4 1946	7.299	0.049		7.24
0962 C 1977	15.576	0.056		15.52

## Elevations of tidal datums referred to Mean Lower Low Water (MLLW) in meters

MEAN HIGHER HIGH WATER (MHHW)	=	1.567
MEAN HIGH WATER (MHW)	=	1.346
MEAN TIDE LEVEL (MTL)	=	0.820 = 0.77 NAVD88
MEAN SEA LEVEL (MSL)	=	0.814
MEAN LOW WATER (MLW)	=	0.295
MEAN LOWER LOW WATER (MLLW)	=	0.000

## DATA COLLECTION & PROCESSING

**Date of Field Surveys:** March 7-16, 2010

**GPS Survey Parameters:**

**Epoch Rate (seconds):** 15" for 15-20 minute static occupations on QAQC Points and 24 hours between CGPS

**Minimum Satellites:** 5 ; **GDOP**=< 5; **Elevation Mask for Data Collection & Processing (degrees):** 10

**GPS Observables:** L1 & L2 Carrier wave, C/A Code and P-Code; **Boulder K Index:** 1-2

**Equipment:**

**GPS Base Receiver Unit No.:** M3, **Operator:** McGee; **Station Identification:** vary

**Receiver Make & Model:** Leica 530 ; **Antenna Make & Model:** Leica AT502

**Antenna Mount:** Tribrach/Tripod; **Antenna Height:** varies

**GPS Rover Receiver Unit No.:** M4, **Operator:** McGee, **Station Identification:** varies

**Receiver Make & Model:** Leica 530 ; **Antenna Make & Model:** Leica AT502

**Antenna Mount:** Fixed Pole; **Antenna Height:** 1.885 or 2.085m

**CGPS & Ephemeris Data:** The rapid ephemeris, precise ephemeris and rinex files for the CGPS were imported from the NGS and SOPAC. Precise ephemeris used for static post-processing between CGPS Stations.

**QAQC ANALYSIS-** Not included here, see Dewberry for analysis

**NGS STATIONS and CGPS DESCRIPTIONS** (see attached file)

## SURVEYOR'S STATEMENT

This Report on the criteria and procedures used on this QAQC Survey was prepared by me on May 27, 2010 for the purpose of validating LiDAR data and the digital elevation model (DEM) at the request of Tim Blak of Dewberry.

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Michael R. McGee, PLS 3945 (CA)

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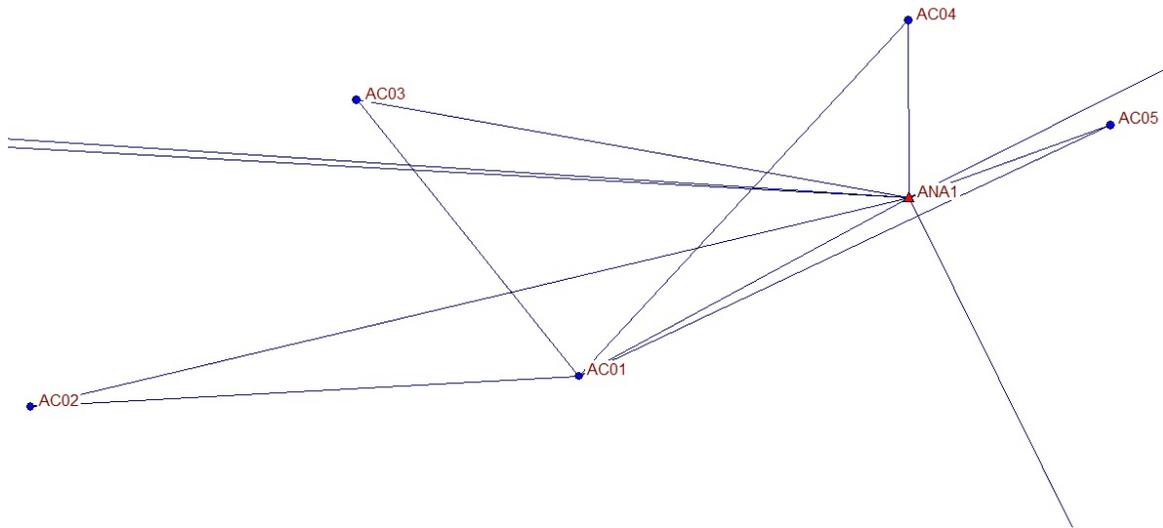
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**APPENDIX:** GPS Networks: Anacapa Island; Santa Barbara Island; and San Miguel, Santa Rosa and Santa Cruz Islands

## **GPS Network: Anacapa Island (north up)**

(Red Symbol = CGPS Stations, Blue = QAQC Points)



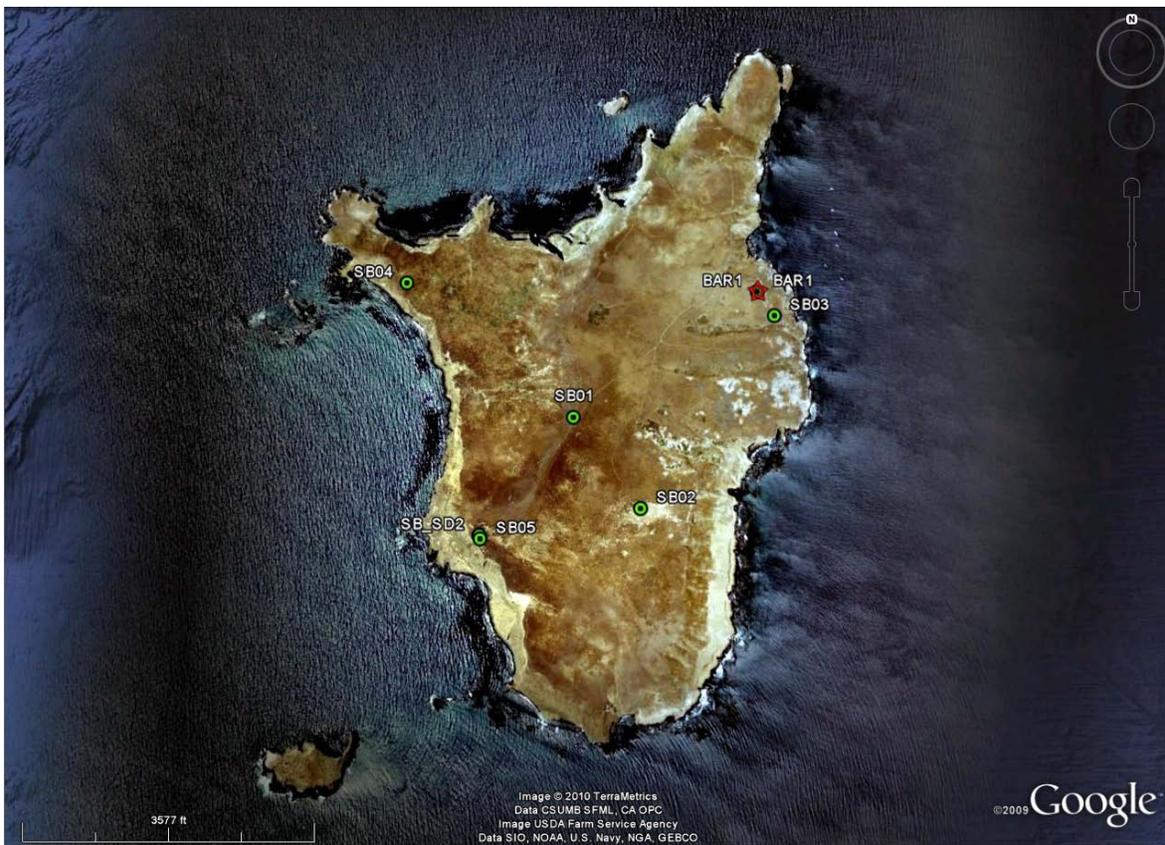
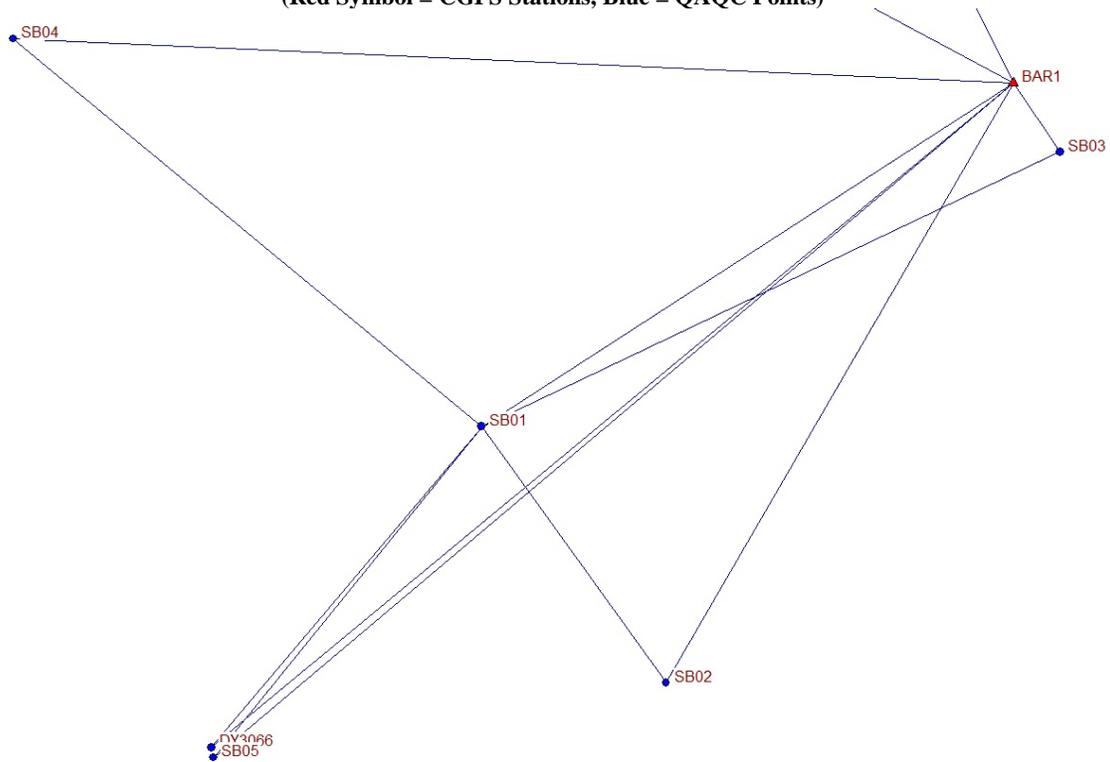
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## GPS Network: Santa Barbara Island (North Up)

(Red Symbol = CGPS Stations, Blue = QAQC Points)



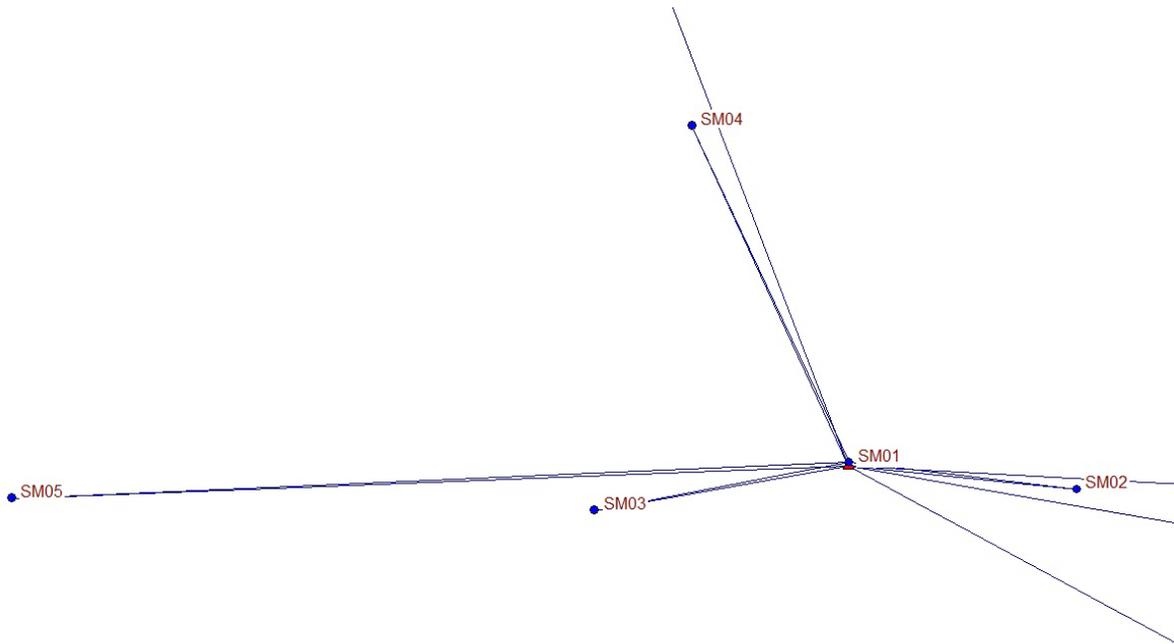
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## GPS Network: San Miguel Island (north up)

(Red Symbol = CGPS Stations, Blue = QAQC Points)



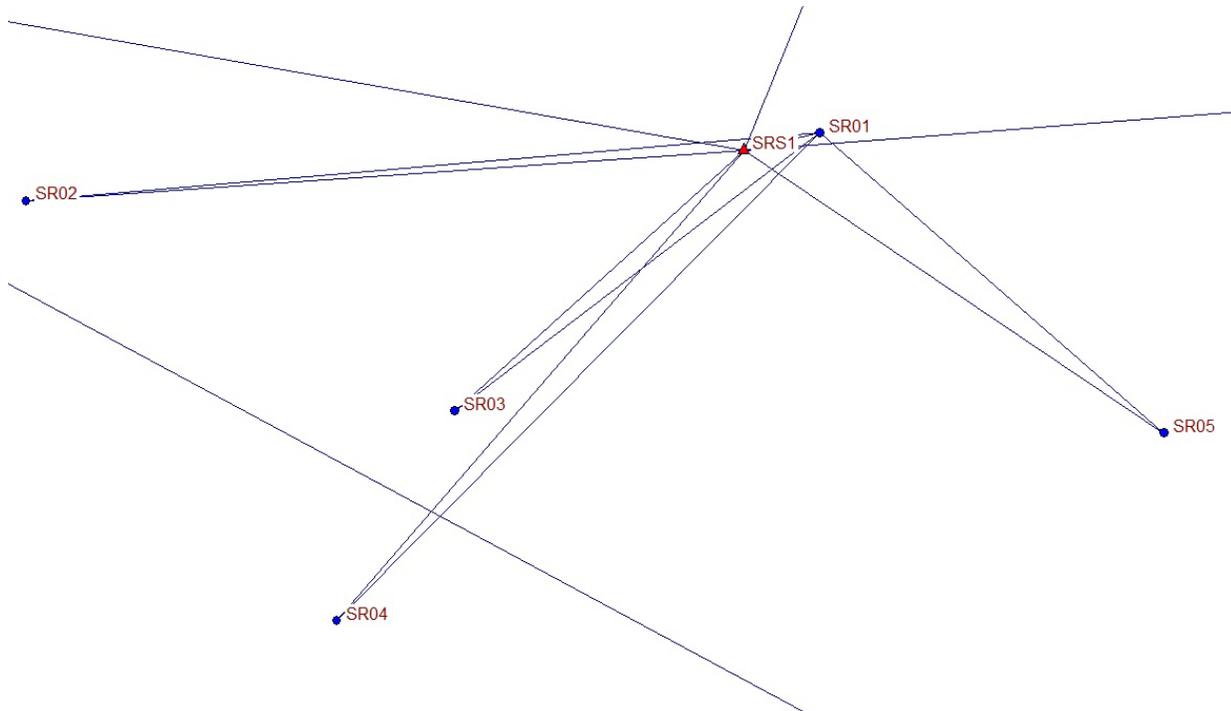
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## GPS Network: Santa Rosa Island (north up)

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## GPS Network: Santa Cruz Island (north up)

(Red Symbol = CGPS Stations, Blue = QAQC Points)

