FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

FCD CONTRACT# 2008C020-1

SOUTHEAST PHOENIX – TEMPE

SURVEY & AEROTRIANGULATION REPORT

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An Evolution in Land Information

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VERTICAL MAPPING
RESOURCES, INC
An Evolution in Land Information

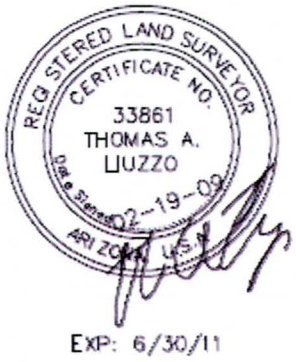
Project Report

Mapping Services

Southeast Phoenix – Tempe Area

Maricopa County Flood Control District

FCD Contract #2008C020-1



EXP: 6/30/11

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I. Executive Summary

In December of 2008, Vertical mapping resources worked in conjunction with the Flood District of Maricopa County in the placement of ground control for the development of aerial mapping. Aerial Data Services, Inc. acted as a sub-consultant in the performance of the aerial photography using airborne GPS and RST Land Surveying, Inc. acted as a sub-consultant in the performance of the placement of ground control. The project area was defined by the district and Vertical Mapping Resources determined the panel locations.

The project area consists of a combination of urban, suburban and agricultural land within the City of Phoenix, Arizona; Town of Guadalupe, Arizona; and the City Tempe, Arizona. Included within the project area are several irrigation canals, including the Western Canal, Highline Canal, North Branch San Francisco Canal and the Hayden Canal. With the project area being within the area controlled by the Maricopa County GDACS, the control for the project is readily available. Under the supervision of an Arizona Registered Land Surveyor, ground control panels were placed at the desired locations in order to orient the final project photographs.

Utilizing Global Positioning Systems, the existing geodetic control was densified and applied to the target locations. Real Time Kinematic efforts were used in the effort for the aerial targets. Additionally, four strategic locations were utilized for the placement of GPS units for the performance of the static session corresponding to the airborne GPS flight. Blind panel locations, profiles of the

canals and detailed locations of any structures were performed by the district and incorporated into the final product.

II. About the Project

The project is a combined effort in partnership with the Flood District of Maricopa County to develop aerial mapping that meets or exceeds the minimum FEMA criteria. All elevations have been modernized to meet the NAVD 88 vertical datum. The project area includes the southeastern portion of the City of Phoenix, Town of Guadalupe, western portion of the City of Tempe, and the foothills of South Mountain. The approximate boundaries of the Project were as follows:

- North – the south bank of the Salt River
- South – South Mountain Park and Guadalupe Road/Western Canal
- West – 22nd Street
- East – SR 101 Loop.

The Project Area was mapped to a scale of 1" = 200' with a contour interval of 2-feet. The mapping was divided into individual tiles consisting of 6,000 feet x 6,000 feet (international feet) grid elements, referenced to the Arizona State Plane Coordinate System Central Zone. The District will have the ability to use the results of a portion of the digital terrain model (DTM) prior to completion of the topographic mapping. Having initially compiled the DTM of the area between the existing Guadalupe FRS Mapping DTM (FCD 2001C052, dated 4/17/2002)

and the Western Canal, with delivery of the partial DTM of this area having been reviewed. Upon receipt of approval of the partial DTM for this area, we matched the approved partial DTM of this area to the existing Guadalupe FRS Mapping DTM and continued compiling the DTM, focusing on the area west of Rural Road. All of the ground efforts paid close attention and were considerate of the inhabited areas as well as being environmentally aware using biodegradable materials for the targets that have been placed.

III. Data Collection and Control

The data source for the survey control is the Maricopa County GDACS as verified as part of known National Geodetic Survey positions within the project area. As required, the horizontal survey data in this project is presented in State Plane Coordinates, North American Datum of 1983 (NAD 83) 2007 epoch, and Arizona Central Zone, International Foot. Elevations are referenced to the North American Vertical Datum of 1988 (NAVD88), International Foot. All survey measurements were made in the published datum for the survey control used, NAD 83(2007) NAVD88.

III.1 Horizontal control

This survey was tied to geodetic control monuments established by the Maricopa County Department of Transportation (MCDOT). These points were observed by MCDOT between 1998 and 2000 as a part of their Geodetic Densification and Cadastral Survey (GDACS) project. The horizontal positions of these monuments have been accepted by the National Geodetic Survey (NGS) and

given a horizontal order of B. The published values are related to NAD83 (2007). These values are available on the World Wide Web at www.ngs.noaa.gov/datasheets. The NGS provides current information for survey control for use by the public as part of their outreach program.

Ties were made to the following monuments

- ✓ 1AG2 (PID AJ3663)
- ✓ 2AF4 (PID AJ3746).
- ✓ 1BH1 (PID AJ3669)
- ✓ 1BF1 (PID AJ3668)
- ✓ COT2 (PID AI1917)

III.2 Vertical control

The same monuments that were used for horizontal control have a vertical component provided by MCDOT. The elevations were established by determining an ellipsoidal height by GPS observation and referencing to NAVD88. The orthometric height was then determined using a high-resolution geoid model (geoid 03) with precise GPS observation and processing techniques. The NGS publishes these results as Third Order Class II ellipsoidal heights.

III.3 Survey Procedures

One half-inch rebar 18 inches long were set at the center of the aerial targets. The blind panels as well as the canal profiles and structure locations were established by the district. A GPS base station was set up on 1AG1 and an observation was made to the remaining NGS checkpoints to verify a match to control datum. At each of the aerial targets, two GPS observations were made on the set rebar. Each observation was made under an independent initialization. The results of the two observations were analyzed to see that any difference between them was within tolerance. The observations were then merged to generate one coordinate value for the target. A third known point initialization was performed on each position as an additional check. Fieldwork was performed using Trimble 5000 series receivers (5700 and 5800). Zephyr antennas were used where external antennas were needed. All antennas used collect L1/L2 and p-code. These antennas are designed to help eliminate multipath and unwanted noise from the observation data. Trim mark III radios were used for RTK work. Trimble Geomatics Office version 1.62 software was used to process field data. The target placement with respect to the project control is visualized in Figure 1. Successful baselines are detailed from the point of origin to each of the targets and the existing control checkpoints.

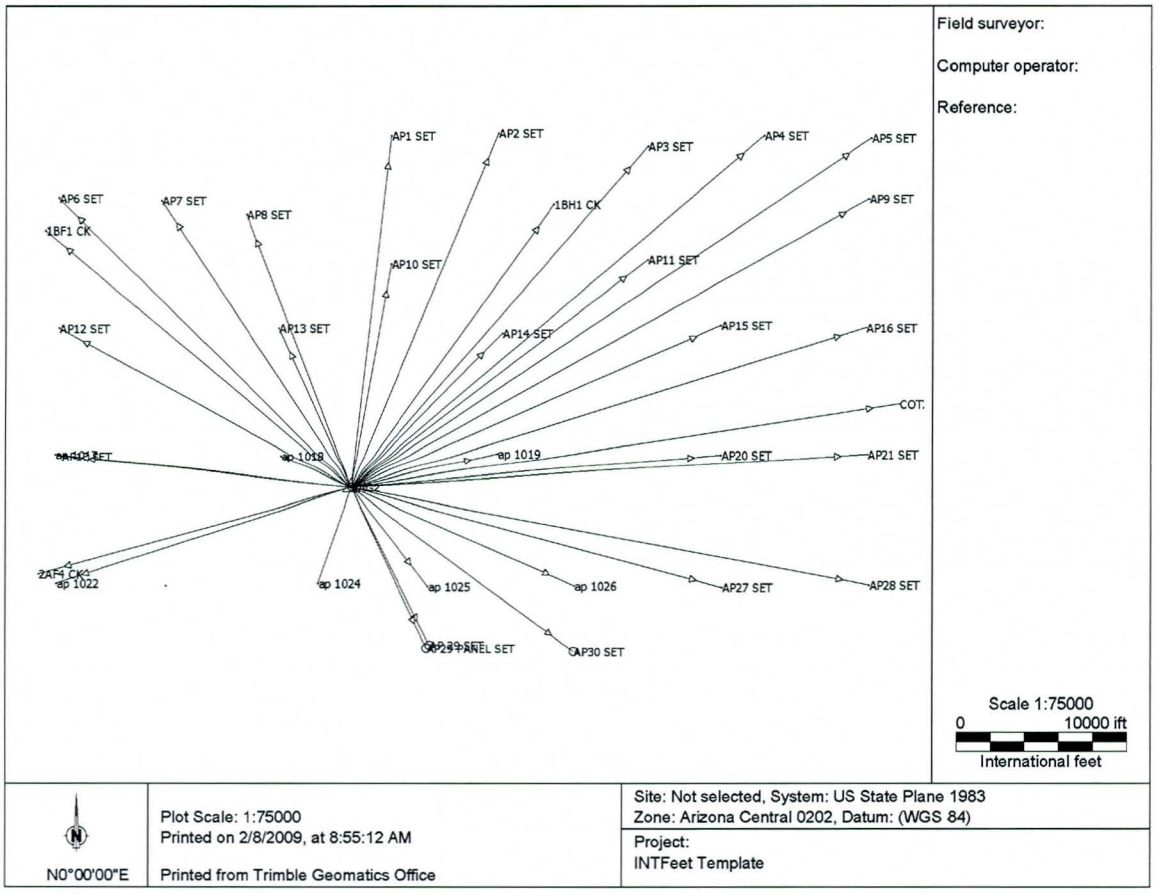

Figure 1 – Target Disbursement

Fixed width point lat/long/height listing

Project : MC FLOOD TEMPE

User name	Thomas	**Date & Time**	12:43:13 PM 2/7/2009
Coordinate System	US State Plane 1983	**Zone**	Arizona Central 0202
Project Datum	(WGS 84)		
Vertical Datum		**Geoid Model**	G03AZ.ggf
Coordinate Units	International feet		
Distance Units	International feet		
Height Units	International feet		

Point listing

Name	Latitude	Longitude	Height	Feature Code
132	33°22'30.10484"N	111°59'19.74689"W	1177.799	1AG2
100	33°22'30.43185"N	111°59'19.50790"W	1177.606	CK SPIDER
101	33°25'55.44582"N	111°58'52.59172"W	1016.353	AP1 SET
102	33°25'56.85827"N	111°57'38.23085"W	1048.559	AP2 SET
103	33°25'49.20634"N	111°55'54.63148"W	1054.534	AP3 SET
104	33°25'55.43447"N	111°54'34.09819"W	1075.675	AP4 SET
105	33°25'53.91149"N	111°53'19.65589"W	1087.857	AP5 SET
106	33°25'18.63828"N	111°53'21.13675"W	1092.120	AP9 SET
107	33°24'03.62749"N	111°53'23.08914"W	1098.355	AP16 SET
108	33°24'04.95667"N	111°55'03.80836"W	1085.202	AP15 SET
109	33°24'43.29840"N	111°55'54.68416"W	1070.110	AP11 SET
110	33°25'09.62349"N	112°00'32.59746"W	1010.921	AP8 SET
111	33°25'17.59569"N	112°01'31.47354"W	1007.038	AP7 SET
112	33°25'18.85936"N	112°02'42.36274"W	988.929	AP6 SET
113	33°24'03.12529"N	112°02'41.91096"W	1002.327	AP12 SET
114	33°24'03.47591"N	112°00'10.12909"W	1029.353	AP13 SET
115	33°24'40.75925"N	111°58'52.49794"W	1036.078	AP10 SET
116	33°25'15.57049"N	111°56'59.59523"W	1056.857	1BH1 CK
117	33°21'40.37264"N	112°02'55.75173"W	1207.199	2AF4 CK
118	33°23'18.79058"N	111°52'59.87300"W	1098.512	COT2 CK
119	33°22'49.73632"N	111°53'21.96650"W	1099.327	AP21 SET
120	33°22'49.36033"N	111°55'03.67635"W	1086.052	AP20 SET
121	33°21'32.84723"N	111°55'02.90384"W	1087.430	AP27 SET
122	33°21'34.24304"N	111°53'20.82162"W	1095.418	AP28 SET
123	33°22'49.36105"N	111°55'03.67580"W	1085.824	AP20 CK
124	33°25'00.03595"N	112°02'51.35520"W	994.494	1BF1 CK
125	33°22'30.43216"N	111°59'19.50773"W	1177.597	CK SPIDER CK
126	33°22'48.51085"N	112°02'40.04458"W	1067.368	AP17 SET
127	33°20'59.46440"N	111°58'25.22585"W	1175.163	AP 29 SET
128	33°20'55.93624"N	111°56'45.44886"W	1103.189	AP30 SET
129	33°21'33.97096"N	111°56'45.11575"W	1100.665	AP26 CK
130	33°24'00.50823"N	111°57'35.21347"W	1060.485	AP14 SET
131	33°20'57.65258"N	111°58'27.34823"W	1167.423	AP29 PANEL SET
CK	33°22'30.43159"N	111°59'19.50778"W	1177.608	CK
133	33°22'49.52782"N	112°02'44.46298"W	1069.845	ap 1017
136	33°21'35.19961"N	112°02'43.37937"W	1495.040	ap 1022
138	33°21'33.38683"N	111°58'26.43969"W	1202.172	ap 1025
137	33°21'35.19943"N	111°59'42.60139"W	1428.647	ap 1024
134	33°22'48.80469"N	112°00'08.43001"W	1081.045	ap 1018

135	33°22'50.22734"N 111°57'38.49654"W	1099.756	ap 1019
139	33°21'33.97106"N 111°56'45.11594"W	1100.809	ap 1026
140	33°21'34.06451"N 112°01'28.01278"W	1774.498	ap 1023

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Table 1 – Target WGS Positioning

Points

Project : MC FLOOD TEMPE

User name	Thomas	**Date & Time**	12:41:29 PM 2/7/2009
Coordinate System	US State Plane 1983	**Zone**	Arizona Central 0202
Project Datum	(WGS 84)		
Vertical Datum		**Geoid Model**	G03AZ.ggf
Coordinate Units	International feet		
Distance Units	International feet		
Height Units	International feet		

Point listing

Name	Northing	Easting	Elevation	Feature Code
132	863987.412	677974.125	1275.401	1AG2
100	864020.448	677994.414	1275.209	CK SPIDER
101	884739.434	680289.699	1113.931	AP1 SET
102	884878.900	686591.253	1146.081	AP2 SET
103	884103.030	695370.324	1152.031	AP3 SET
104	884732.240	702194.973	1173.175	AP4 SET
105	884579.377	708503.408	1185.370	AP5 SET
106	881014.315	708378.858	1189.660	AP9 SET
107	873433.026	708215.350	1195.965	AP16 SET
108	873566.304	699677.158	1182.774	AP15 SET
109	877441.788	695364.887	1167.643	AP11 SET
110	880114.612	671810.890	1108.603	AP8 SET
111	880925.178	666821.721	1104.791	AP7 SET
112	881059.745	660813.853	1086.775	AP6 SET
113	873405.343	660842.703	1100.132	AP12 SET
114	873427.524	673709.650	1126.998	AP13 SET
115	877190.937	680292.959	1133.665	AP10 SET
116	880704.770	689863.967	1154.378	1BH1 CK
117	858979.036	659651.078	1304.917	2AF4 CK
118	868901.998	710184.886	1196.188	COT2 CK
119	865964.988	708312.472	1197.031	AP21 SET
120	865925.901	699688.274	1183.703	AP20 SET
121	858192.871	699753.717	1185.164	AP27 SET
122	858335.053	708411.567	1193.218	AP28 SET
123	865925.975	699688.320	1183.475	AP20 CK
124	879158.232	660049.330	1092.345	1BF1 CK
125	864020.479	677994.428	1275.200	CK SPIDER CK
126	865863.978	660991.665	1165.125	AP17 SET
127	854823.701	682592.359	1272.807	AP 29 SET
128	854463.614	691055.531	1200.887	AP30 SET
129	858307.692	691084.863	1198.332	AP26 CK
130	873119.430	686842.077	1158.046	AP14 SET
131	854640.683	682412.233	1265.067	AP29 PANEL SET
CK	864020.421	677994.424	1275.211	CK
133	865967.224	660617.144	1167.607	ap 1017
136	858454.894	660699.743	1592.741	ap 1022
138	858252.224	682491.285	1299.795	ap 1025
137	858439.631	676031.939	1526.254	ap 1024
134	865880.501	673847.474	1178.669	ap 1018

135	866016.369	686560.758	1197.351	ap 1019
139	858307.702	691084.846	1198.477	ap 1026
140	858332.918	667091.640	1872.134	ap 1023

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Table 2 – Target Coordinate Positions

IV. Airborne Global Positioning Survey

Aerial Data Services was responsible for the development, performance and implementation of all Airborne GPS services. Vertical Mapping resources assisted in the on the ground static operation performed in conjunction with the aerial flight. The below points and coordinates for the three base stations was furnished to ADS by Vertical Mapping Resources.

Base Station #	Antenna Height in International Ft
124-1BF1	5.827
132-1AG2	6.668
118-COT2	5.863

The ABGPS/IMU data is a proprietary format to Applanix's software and the date of Photography 12-11-08.

Aerial Data Services for use in this report provided the following Graphs and Plots to Vertical Mapping Resources.

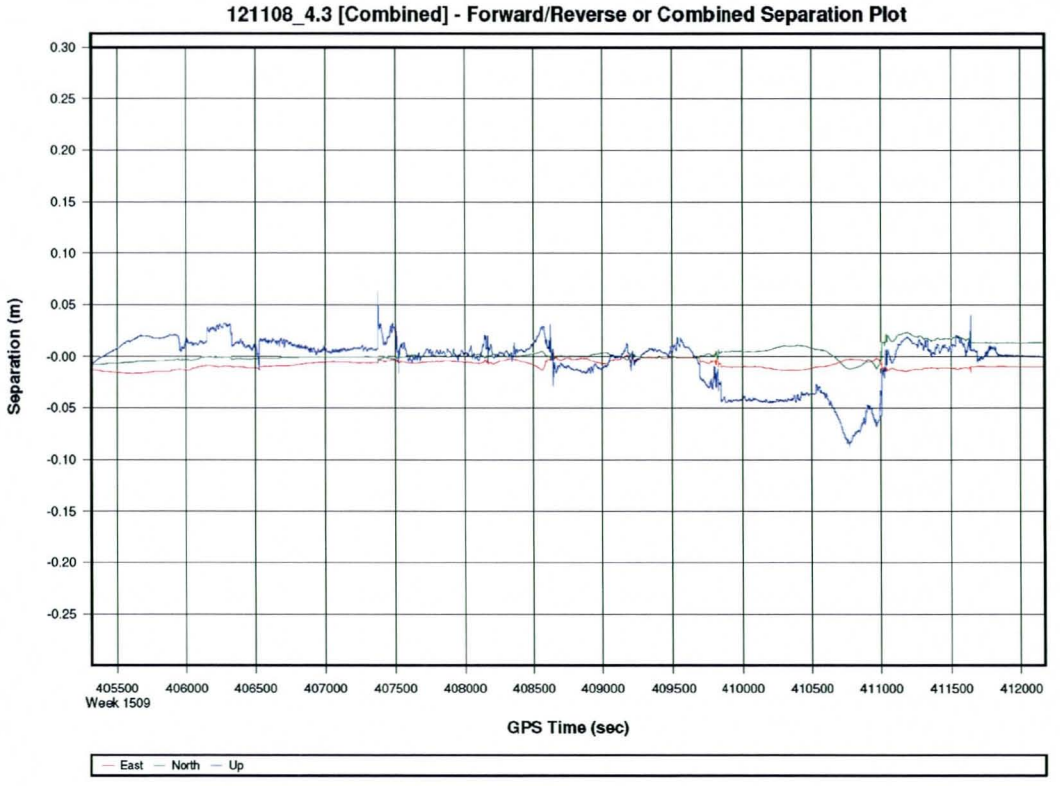

Figure 2 – ABGPS Combined Separation Plot

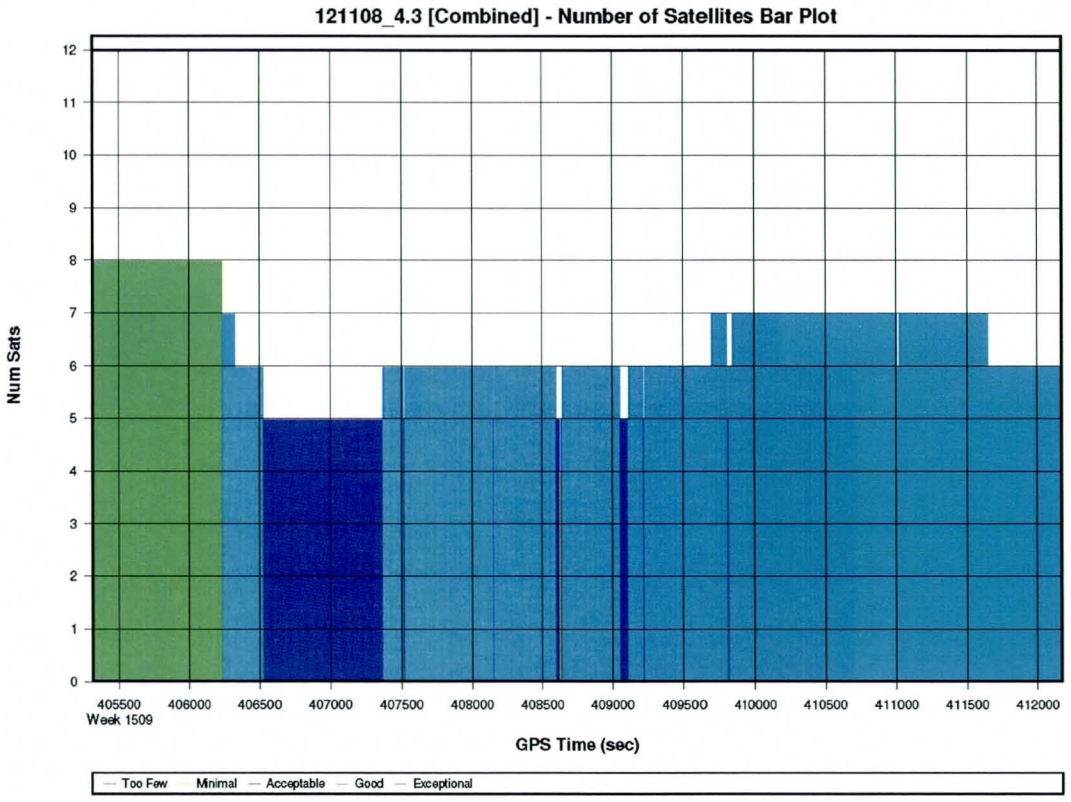

Figure 3 – ABGPS Satellite Bar Plot

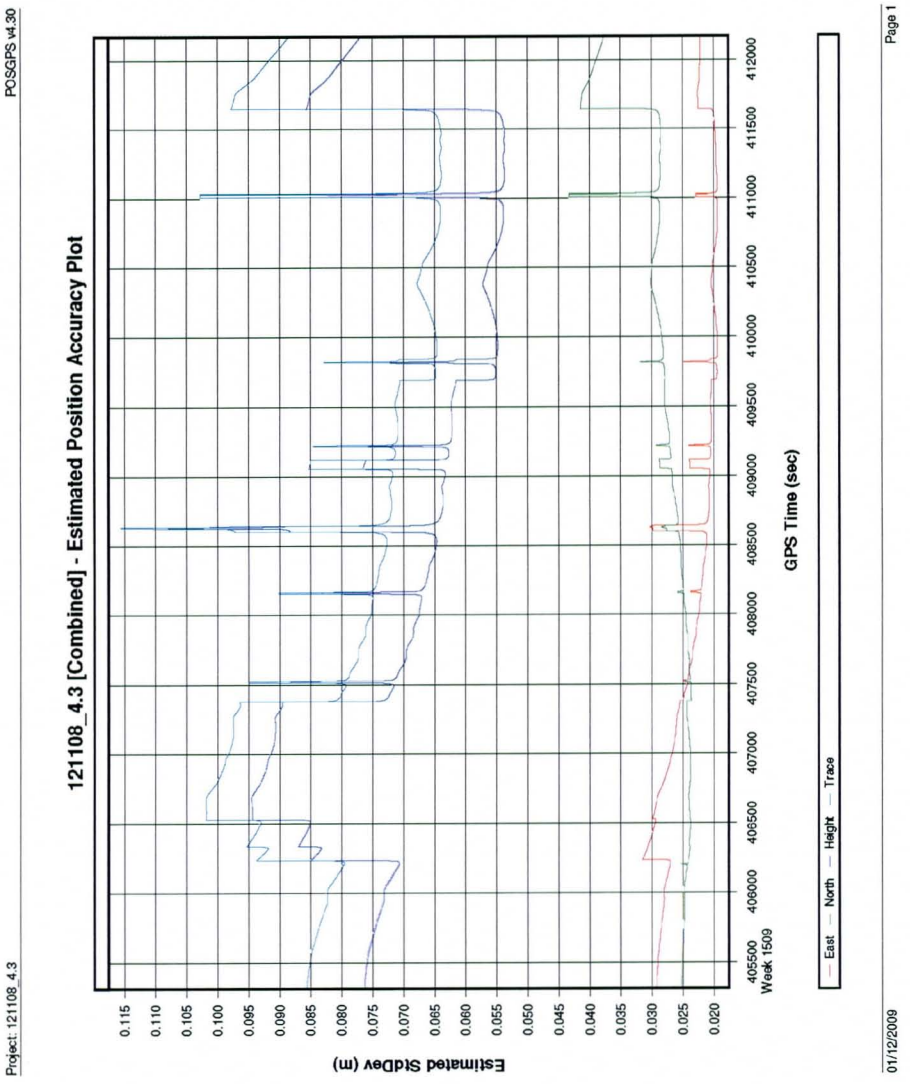

Figure 4 – ABGPS – Estimated Position Accuracy Plot

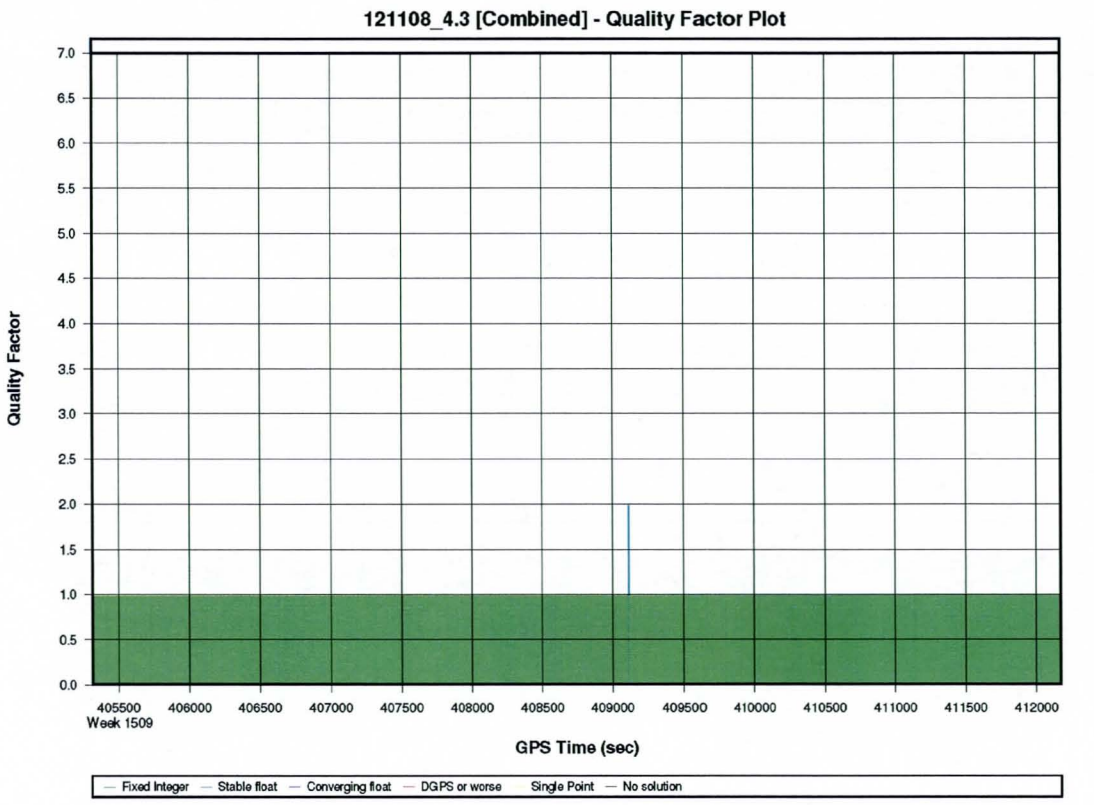

Figure 5 – ABGPS Quality Factor Plot

AEROTRIANGULATION REPORT

FCD Contract# 2008C020-1
Southeast Phoenix – Tempe

Summary of Block Adjustments

Parameter	X/Omega	Y/Phi	Z/Kappa	XY
RMS Control	0.002	0.002	0.007	0.002
Max Ground Residual	0.020	0.026	0.091	
Mean Std Dev Object	0.037	0.044	0.073	
RMS Photo Position	0.443	0.133	0.171	
RMS Photo Attitude	0.005	0.004	0.012	
Mean Std Dev Photo Position	0.092	0.093	0.039	
Mean Std Dev Photo Attitude	0.001	0.001	0.000	

Summary of Maximum and Mean Errors

	VX	VY	VZ	V(XYZ)	RMS - X	RMS - Y	RMS - Z
Maximum Error	0.020	0.026	0.091	0.092	0.088	0.098	0.141
Mean Tolerance	0.000230	0.000196	0.002046	0.002894	0.037247	0.044184	0.073379

Additional Details
Sigma (Project RMS): 2.800 um
Control Points Used: 34
Photos Used: 177
Image Points Used: 3336