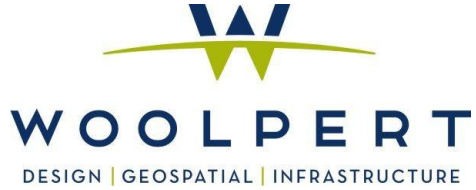
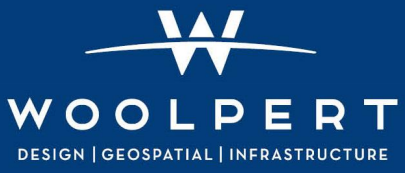
GROUND CONTROL SURVEY REPORT



UNITED STATES GEOLOGICAL SURVEY
FY15 ARS-USDA AZ WALNUT GULCH QL1 LIDAR

12/3/2015



WOOLPERT

DESIGN | GEOSPATIAL | INFRASTRUCTURE

QUALITY

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TRADEMARKS

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NOTICE OF PROPRIETARY INFORMATION

Table of Contents

SECTION 1: SURVEY REPORT

INTRODUCTION

Report Date:	12/3/2015
Project Name:	Walnut Gulch QL1 LIDAR
Client Information:	USGS
Contract Number:	G10PC00057
Requisition/Reference Number:	G15PD00889
Date of Contract:	9/3/2015
Delivery Date:	4/30/2016
Prepared By:	David Kuxhausen, PLS
Woolpert Project Number:	75861

This report contains a comprehensive outline of the LiDAR Ground Control Survey that supported Walnut Gulch QL1 LiDAR. All surveys were performed in such a way as to achieve ground control accuracies that meet or exceed the National Mapping Accuracy Standards.

PROJECT AREA

The project area consists of approximately 60 square miles situated 60 miles southeast of Tucson, AZ.

PURPOSE

The purpose of this survey was to establish three-dimensional coordinates for 22 ground control points (GCPs) and a minimum of 33 quality control (QC) points in each of the predetermined land cover classifications.

The GCPs were located on open, bare earth surfaces with a level slope to enable effective assessment of swath-to-swath reproducibility and absolute accuracy. The QC points were collected uniformly dispersed over the project area in the appropriate land cover categories to verify fundamental, supplemental, and consolidated vertical accuracies throughout the task order AOI.

DATE OF SURVEY

Ground control field operations took place on November 9th 2015 and November 10th 2015.

MONUMENTATION

Prior to aerial imagery acquisition, Woolpert field crews performed a field reconnaissance to verify the existence and suitability of pre-selected existing National Geodetic Survey (NGS) control stations. These existing bench marks were utilized as checks to ensure that quality *x*, *y*, and *z* coordinate values were computed for each of the newly established photogrammetric control stations. Recovery information sheets for the existing NGS control stations can be found in Section 5 of this report. A control diagram showing the ground control stations used to support this LiDAR mapping project can be found in Section 6 of this report.

ACCURACY STANDARDS

The data collected under this task order shall meet the National Standard for spatial Database Accuracy (NSSDA) standards. The NSSDA standards specify that vertical accuracy be reported at the 95 percent confidence level for data tested by an independent source of higher accuracy.

The Fundamental Vertical Accuracy (FVA): 18.13 cm at a 95% confidence level, derived according to NSSDA, i.e., based on $RMSE_Z$ of 9.25 cm in the "open terrain" land cover category.

The Supplemental Vertical Accuracy (SVA): The SVA will be reported for each of the land cover classes within the task order AOI. The target SVA is 26.9 cm at a 95^{th} percentile level, derived according to ASPRS Guidelines, Vertical Accuracy Reporting for Lidar Data, i.e., based on the 95^{th} percentile error for each required land cover class.

The Consolidated Vertical Accuracy (CVA): 26.9 cm at a 95^{th} percentile level, derived according to ASPRS Guidelines, Vertical Accuracy Reporting for Lidar Data, i.e., based on the 95^{th} percentile error in all land cover categories combined.

Automated and manual filtering for lidar products shall use the following minimum performance for artifact/feature removal from the bare earth model: The bare earth surface model shall have a minimum of 95% of surface canopy artifacts, including buildings, vegetation, bridges or overpass structures removed.

GPS EQUIPMENT

Woolpert utilized 4 Trimble Navigation R8 Model 3 GNSS dual-frequency GPS receivers with a Trimble TDL-450 radio as dual base stations. Additionally, Woolpert utilized a Trimble Navigation R8 Model 3 GNSS dual-frequency GPS receiver and a TSC3 data collector as a rover for this project.

METHODOLOGY

REAL-TIME KINEMATIC (RTK) GPS

The field crew utilized Real-Time Kinematic (RTK) GPS surveying throughout most of the ground control data collection process. Using RTK GPS techniques, observations were performed on a total of 22 LiDAR control points and 33 ground control quality check points. The survey was conducted using a 5-second epoch rate, in a fixed solution RTK mode, with each observation lasting between 60 to 180 seconds. Each station was occupied twice to insure the necessary horizontal and vertical accuracies were being met for this photogrammetric project.

FAST-STATIC GPS

In addition to the RTK GPS techniques, the project field crew utilized Fast-static GPS surveying techniques on the three temporary survey marks that were established within the project area using a 5-second epoch collection rate.

Using Fast-Static GPS techniques, observations were performed on one (1) Temporary control point named 1001 and two (2) NGS marks named AIRPORT (PID# DN3616) and WALNUT (PID# CG1200). The survey was conducted at a 5-second sync rate with each observation lasting between 4-10 hours.

GPS DATA ANALYSIS AND PROCESSING

The field crew chief processed all session baselines each day using Trimble Navigation's Trimble Business Center (TBC) Version 3.61 baseline processor with the accompanying broadcast ephemeris. Daily processing ensured the integrity of the network as it was constructed, and allowed the field crews to immediately reschedule observations of poor baselines. Once the field work was complete, the processed baselines were then run through a rigorous loop closure analysis. As a result of this analysis, unacceptable GPS vectors were removed and field blunders, if any, were detected and eliminated. Once this process was completed, both unconstrained and constrained adjustments were conducted in order to effectively incorporate the static observation data.

The GPS base stations and constrained geodetic control stations consisted of the following:

Point Designation	NGS PID	TYPE	CONSTRAINED
1001	N/A	TSM	3d
AIRPORT	DN3616	NGS	3d
WALNUT	CG1200	NGS	3d

Station 1001 was used as a temporary control base station. This point was established by utilizing the 5-second epoch static data that was collected over a three day period. The raw data was sent to the NGS Online Positioning User System "OPUS" to establish the final

coordinates. The associated horizontal datasheet coordinates for the NGS marks AIRPORT and WALNUT were also used as the primary geodetic control marks on this project.

DATUM REFERENCE AND FINAL COORDINATES

The spatial reference system for the Walnut Gulch AZ QL1 LiDAR AOI is UTM, Zone 12N, WGS84 meters to 2 decimal places horizontal and NAVD88 meters vertical using the latest geoid model of 2012 (GEOID12A). Units for both the horizontal and vertical datums will be expressed in meters to two (2) decimal places. These coordinates for the LiDAR control survey can be found in Section 2 of this report.

QUALITY ASSURANCE

Existing NGS published bench marks were surveyed to assure that there were no discrepancies in the field observation data. Close examinations of the residuals showed no distortions in orientation or scale.

The ground control data meets positional accuracies necessary to support 1.0 point per 0.3 meters squared (1' GSD) data at 95% confidence level as outlined in the *Geospatial Positioning Accuracy Standards, Part 3: National Standard for Spatial Data Accuracy (NSSDA),* published by the Federal Geographic Data Committee (FGDC-STD-007.3-1998).

SECTION 2: GROUND/GEODETIC CONTROL COORDINATE LISTINGS

COORDINATE SYSTEM: GRID

HORIZONTAL DATUM: NAD83 2011 UTM Zone 12-N
VERTICAL DATUM: NAVD88
ZONE: 12-North
GEOID MODEL: GEOID 12A
UNITS: Meters

LiDAR GROUND CONTROL

Point	UTM Zone 12-North		Elevation (m)	Description
	Northing (m)	Easting (m)		
1001	3514341.16	605181.10	1653.99	LIDAR CONTROL
1002	3513045.57	602772.32	1595.26	LIDAR CONTROL
1003	3514982.10	603774.98	1611.83	LIDAR CONTROL
1004	3510106.10	576225.27	1175.70	LIDAR CONTROL
1005	3510513.50	577759.70	1190.07	LIDAR CONTROL
1006	3512863.41	585513.76	1307.55	LIDAR CONTROL
1007	3503412.85	591864.75	1458.28	LIDAR CONTROL
1008	3504704.22	595017.79	1446.14	LIDAR CONTROL
1009	3509496.51	597888.37	1440.70	LIDAR CONTROL
1010	3511949.33	596472.82	1474.38	LIDAR CONTROL
1011	3506676.60	591078.84	1434.13	LIDAR CONTROL
1012	3508840.86	588940.33	1394.51	LIDAR CONTROL
1013	3512539.05	600734.69	1549.29	LIDAR CONTROL
1014	3511563.38	586762.46	1327.64	LIDAR CONTROL
1015	3512533.40	582509.74	1272.25	LIDAR CONTROL
1016	3510771.77	580193.58	1230.35	LIDAR CONTROL
1017	3507092.46	585537.89	1378.50	LIDAR CONTROL
1018	3513855.82	594897.03	1443.89	LIDAR CONTROL
1019	3512555.34	593002.26	1414.41	LIDAR CONTROL
1020	3510360.00	591363.33	1384.90	LIDAR CONTROL
1021	3509246.83	595158.80	1417.88	LIDAR CONTROL
1022	3510884.40	584925.50	1314.01	LIDAR CONTROL

QUALITY CONTROL POINTS

Point	UTM Zone 12-North		Elevation (m)	Description
	Northing (m)	Easting (m)		
2001	3509909.78	577136.76	1181.42	NVA
2002	3510784.58	580196.70	1230.54	NVA
2003	3512552.94	582507.58	1273.97	NVA
2004	3512879.68	585531.64	1307.60	NVA
2005	3511583.95	586760.46	1329.08	NVA
2006	3510907.18	584935.16	1314.19	NVA
2007	3507110.48	585528.97	1377.71	NVA
2008	3508861.74	588841.25	1393.33	NVA
2009	3506681.20	591098.42	1433.18	NVA
2010	3503954.79	591855.38	1450.68	NVA
2011	3504719.61	595038.05	1445.17	NVA
2012	3509236.02	595177.41	1419.59	NVA
2013	3509488.63	597908.87	1440.36	NVA
2014	3510364.54	591350.98	1384.76	NVA
2015	3512583.86	593010.05	1415.00	NVA
2016	3513882.95	594924.98	1444.51	NVA
2017	3511920.53	596472.71	1474.16	NVA
2018	3512552.60	600796.74	1552.02	NVA
2019	3512972.76	602638.23	1597.13	NVA
2020	3515010.41	603922.78	1619.08	NVA
2021	3513330.46	589045.27	1355.58	NVA
2022	3508130.90	593221.49	1416.38	NVA
2023	3510059.06	582354.96	1285.49	NVA
2024	3510644.86	599457.23	1486.83	NVA
2025	3505743.20	587692.76	1496.57	NVA
3001	3514947.14	603789.85	1608.82	VVA
3002	3509847.32	577000.21	1178.29	VVA
3003	3504752.55	595067.23	1443.88	VVA
3004	3511933.72	596775.81	1471.97	VVA
3005	3509017.92	589151.17	1380.81	VVA
3006	3512566.78	582467.54	1274.22	VVA
3007	3507304.97	585379.71	1368.88	VVA
3008	3513306.91	589061.54	1355.04	VVA

CONTROL BASE STATIONS

Point	UTM Zone 12-North		Elevation (m)	Description
	Northing (m)	Easting (m)		
1001	3508197.10	589580.98	1405.96	TSM
AIRPORT	3504572.91	591787.57	1448.85	NGS
WALNUT	3512451.55	581191.60	1269.47	NGS

COORDINATE SYSTEM: GEODETIC

HORIZONTAL DATUM: NAD83 (2011) Epoch 2010.00
VERTICAL DATUM: NAVD88
UNITS: Meters
DATE: 12/3/2015

LiDAR GROUND CONTROL

Point	NAD83 (2011) Epoch 2010.00		Ellipsoid Ht. (m)	Description
	N Latitude	W Longitude		
1001	31°45'35.04274"	-109°53'21.71068"	1626.69	LIDAR CONTROL
1002	31°44'53.75881"	-109°54'53.75312"	1567.89	LIDAR CONTROL
1003	31°45'56.31937"	-109°54'14.90829"	1584.51	LIDAR CONTROL
1004	31°43'25.77721"	-110°11'43.49861"	1147.82	LIDAR CONTROL
1005	31°43'38.63633"	-110°10'45.07989"	1162.22	LIDAR CONTROL
1006	31°44'52.95992"	-110°05'49.71030"	1279.86	LIDAR CONTROL
1007	31°39'44.27554"	-110°01'51.53676"	1430.74	LIDAR CONTROL
1008	31°40'25.28851"	-109°59'51.36845"	1418.64	LIDAR CONTROL
1009	31°43'00.04756"	-109°58'00.63878"	1413.23	LIDAR CONTROL
1010	31°44'20.13520"	-109°58'53.54565"	1446.89	LIDAR CONTROL
1011	31°41'30.49352"	-110°02'20.28576"	1406.57	LIDAR CONTROL
1012	31°42'41.38406"	-110°03'40.80168"	1366.91	LIDAR CONTROL
1013	31°44'37.96294"	-109°56'11.37760"	1521.88	LIDAR CONTROL
1014	31°44'10.40187"	-110°05'02.66916"	1299.99	LIDAR CONTROL
1015	31°44'43.03716"	-110°07'43.97881"	1244.51	LIDAR CONTROL
1016	31°43'46.41941"	-110°09'12.52320"	1202.56	LIDAR CONTROL
1017	31°41'45.53637"	-110°05'50.60993"	1350.84	LIDAR CONTROL
1018	31°45'22.52262"	-109°59'52.75878"	1416.38	LIDAR CONTROL
1019	31°44'40.85035"	-110°01'05.21975"	1386.87	LIDAR CONTROL
1020	31°43'30.03192"	-110°02'08.24259"	1357.33	LIDAR CONTROL
1021	31°42'52.76796"	-109°59'44.42519"	1390.37	LIDAR CONTROL
1022	31°43'48.84759"	-110°06'12.68602"	1286.32	LIDAR CONTROL

QUALITY CONTROL POINTS

Point	NAD83 (2011) Epoch 2010.00		Ellipsoid Ht. (m)	Description
	N Latitude	W Longitude		
2001	31°43'19.18154"	-110°11'08.92144"	1153.56	NVA
2002	31°43'46.83452"	-110°09'12.40097"	1202.74	NVA
2003	31°44'43.67225"	-110°07'44.05508"	1246.22	NVA
2004	31°44'53.48356"	-110°05'49.02560"	1279.92	NVA
2005	31°44'11.07036"	-110°05'02.73860"	1301.43	NVA
2006	31°43'49.58492"	-110°06'12.31207"	1286.51	NVA
2007	31°41'46.12399"	-110°05'50.94309"	1350.05	NVA
2008	31°42'42.08984"	-110°03'44.55904"	1365.73	NVA
2009	31°41'30.63726"	-110°02'19.54040"	1405.63	NVA
2010	31°40'01.87802"	-110°01'51.70974"	1423.14	NVA
2011	31°40'25.78218"	-109°59'50.59383"	1417.67	NVA
2012	31°42'52.41131"	-109°59'43.72199"	1392.08	NVA
2013	31°42'59.78540"	-109°57'59.86280"	1412.89	NVA
2014	31°43'30.18289"	-110°02'08.71022"	1357.19	NVA
2015	31°44'41.77437"	-110°01'04.91415"	1387.46	NVA
2016	31°45'23.39552"	-109°59'51.68727"	1417.01	NVA
2017	31°44'19.19989"	-109°58'53.56001"	1446.67	NVA
2018	31°44'38.38320"	-109°56'09.01453"	1524.61	NVA
2019	31°44'51.43774"	-109°54'58.87661"	1569.77	NVA
2020	31°45'57.19033"	-109°54'09.27976"	1591.76	NVA
2021	31°45'07.15693"	-110°03'35.34289"	1327.96	NVA
2022	31°42'17.10189"	-110°00'58.40696"	1388.84	NVA
2023	31°43'22.72040"	-110°07'50.61167"	1257.76	NVA
2024	31°43'36.85268"	-109°57'00.61662"	1459.39	NVA
2025	31°41'01.13154"	-110°04'29.19514"	1468.97	NVA
3001	31°45'55.17915"	-109°54'14.35643"	1581.49	VVA
3002	31°43'17.18595"	-110°11'14.12744"	1150.43	VVA
3003	31°40'26.84323"	-109°59'49.47418"	1416.38	VVA
3004	31°44'19.53600"	-109°58'42.03762"	1444.49	VVA
3005	31°42'47.07524"	-110°03'32.73385"	1353.21	VVA
3006	31°44'44.13220"	-110°07'45.57252"	1246.47	VVA
3007	31°41'52.48064"	-110°05'56.55172"	1341.22	VVA
3008	31°45'06.38746"	-110°03'34.73236"	1327.42	VVA

CONTROL BASE STATIONS

Point	NAD83 (2011) Epoch 2010.00		Ellipsoid Ht. (m)	Description
	N Latitude	W Longitude		
1001	31°42'20.29799"	-110°03'16.67596"	1378.38	TSM
AIRPORT	31°40'21.97138"	-110°01'54.07632"	1421.31	NGS
WALNUT	31°44'40.71868"	-110°08'34.09833"	1241.70	NGS

SECTION 3: GROUND/GEODETIC CONTROL LOGS AND PHOTOS

This section contains the station recovery information sheets and photographs for the ground control, geodetic control and checkpoint stations established for the project. The stations appear as they are ordered in the final coordinate listing of Section 2.

The data is assembled on the following pages.

1001, 3N, 10NOV2015

Woolpert Aeronautical Surveys - Aerial Control

Aerial Control point #	General location	Airport LID
1001A	Tombstone, AZ	

Latitude	Longitude	Calendar Date	Observer Initials
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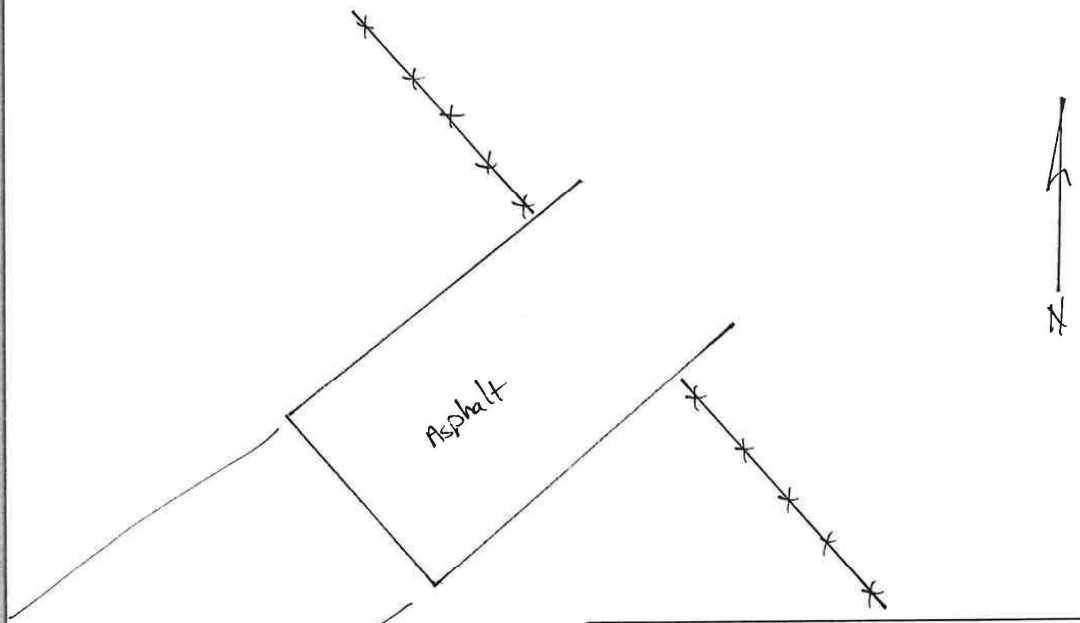

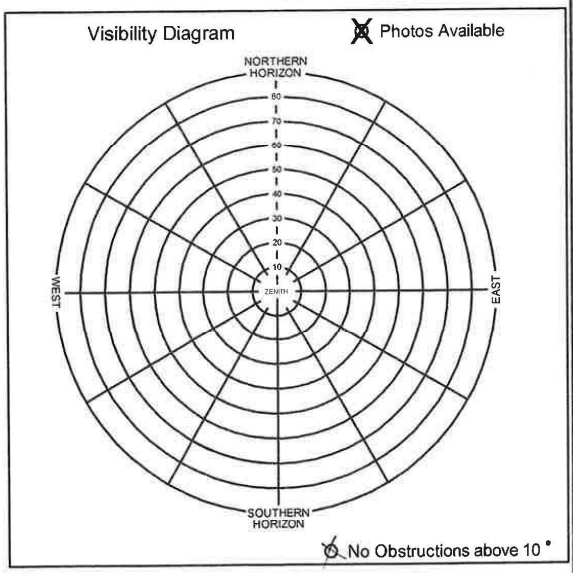

1002, 3N, 10NOV2015

Woolpert Aeronautical Surveys - Aerial Control

Aerial Control point #	General location	Airport LID
1002, 2019	Tombstone Az	

Latitude	Longitude	Calendar Date	Observer Initials
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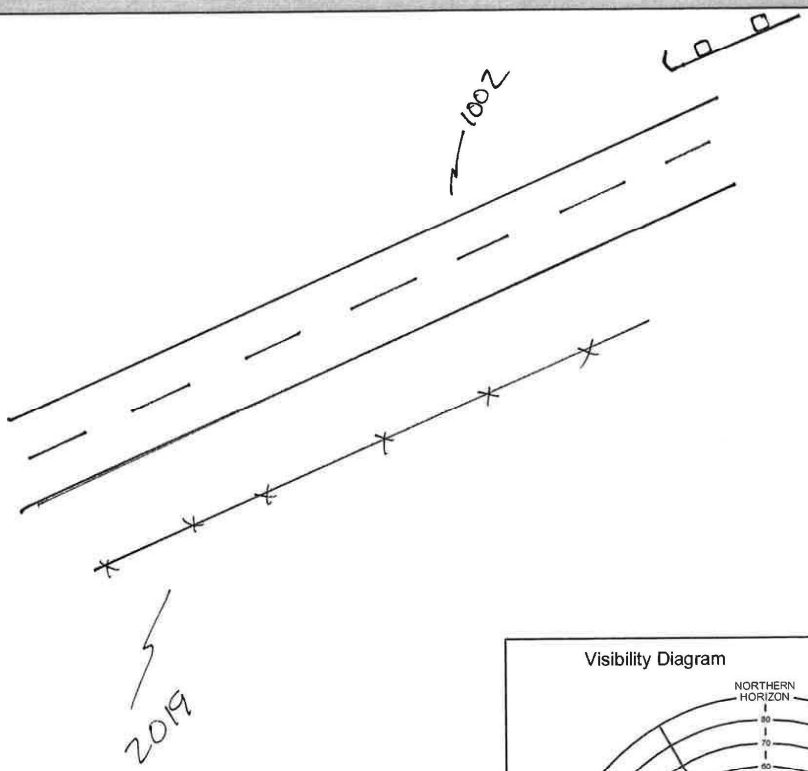
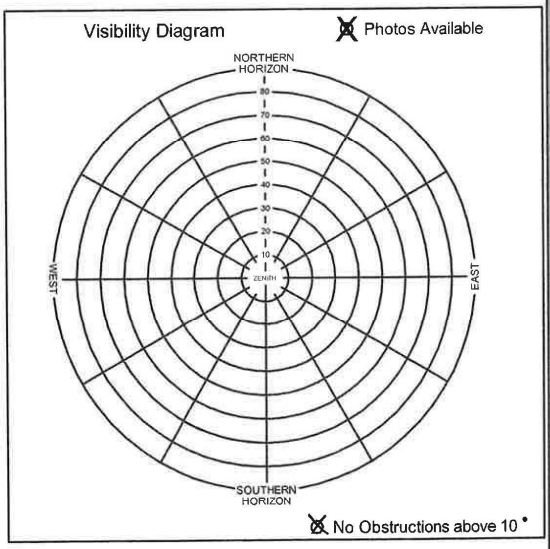
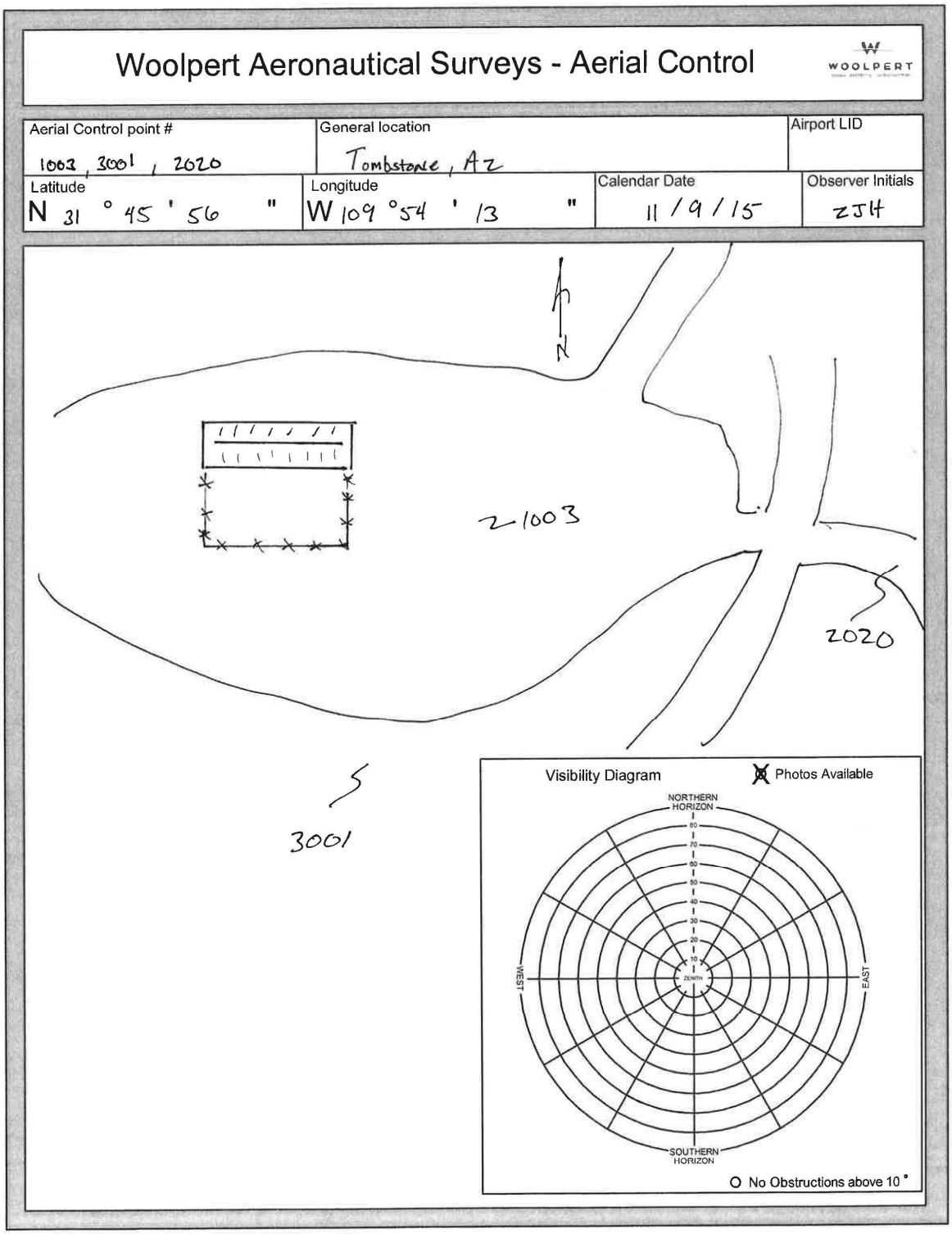




1003, 3E, 10NOV2015


Woolpert Aeronautical Surveys - Aerial Control
WOOLPERT
Aerial Control point #
1003, 3001, 2020
General location
Tombstone, AZ
Airport LID
Latitude
N 31 ° 45 ' 56 "
Longitude
W 109 °54 ' 13 "
Calendar Date
11/9/15
Observer Initials
ZJH
N
1003
2020
3001
Visibility Diagram
Photos Available
NORTHERN HORIZON
EAST
SOUTHERN HORIZON
WEST
ZENITH
No Obstructions above 10 °

1004, 3E, 10NOV2015

Woolpert Aeronautical Surveys - Aerial Control

Aerial Control point #	General location	Airport LID
1004	Tombstone, Az	

Latitude	Longitude	Calendar Date	Observer Initials
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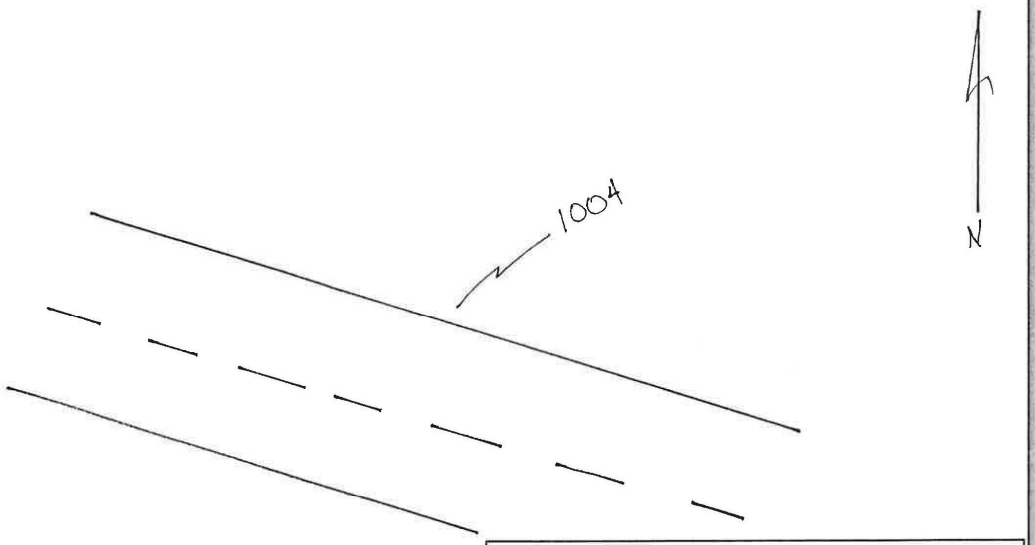

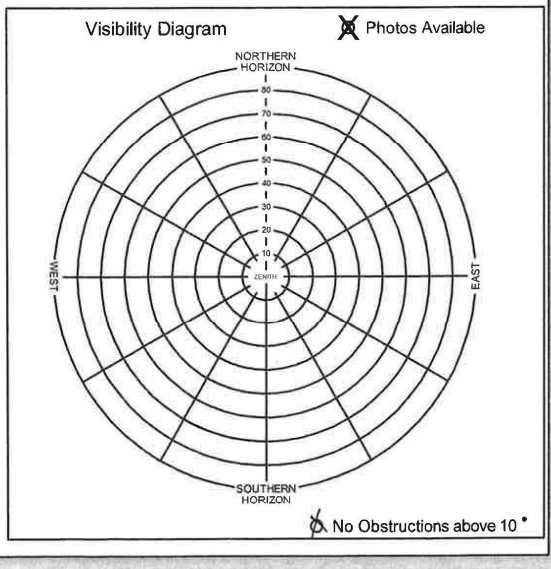

1005, 3W, 10NOV2015

Woolpert Aeronautical Surveys - Aerial Control

Aerial Control point #	General location	Airport LID
1005	Tombstone Az	

Latitude	Longitude	Calendar Date	Observer Initials
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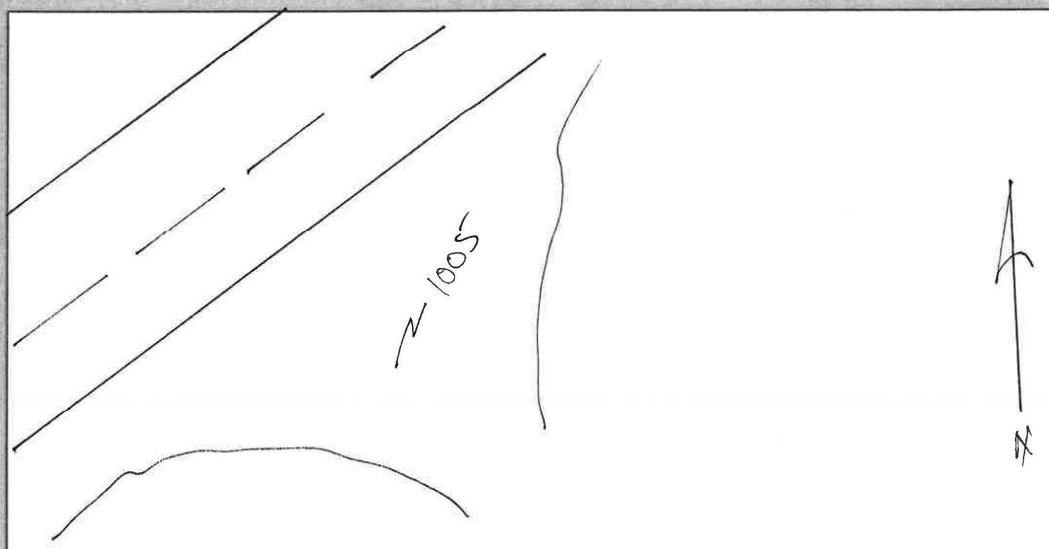
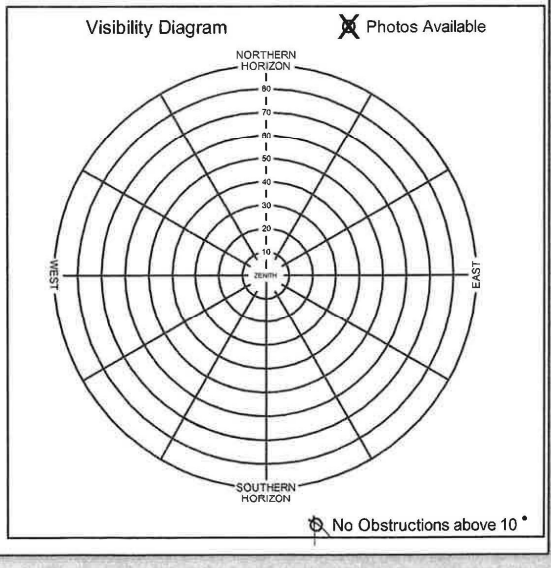
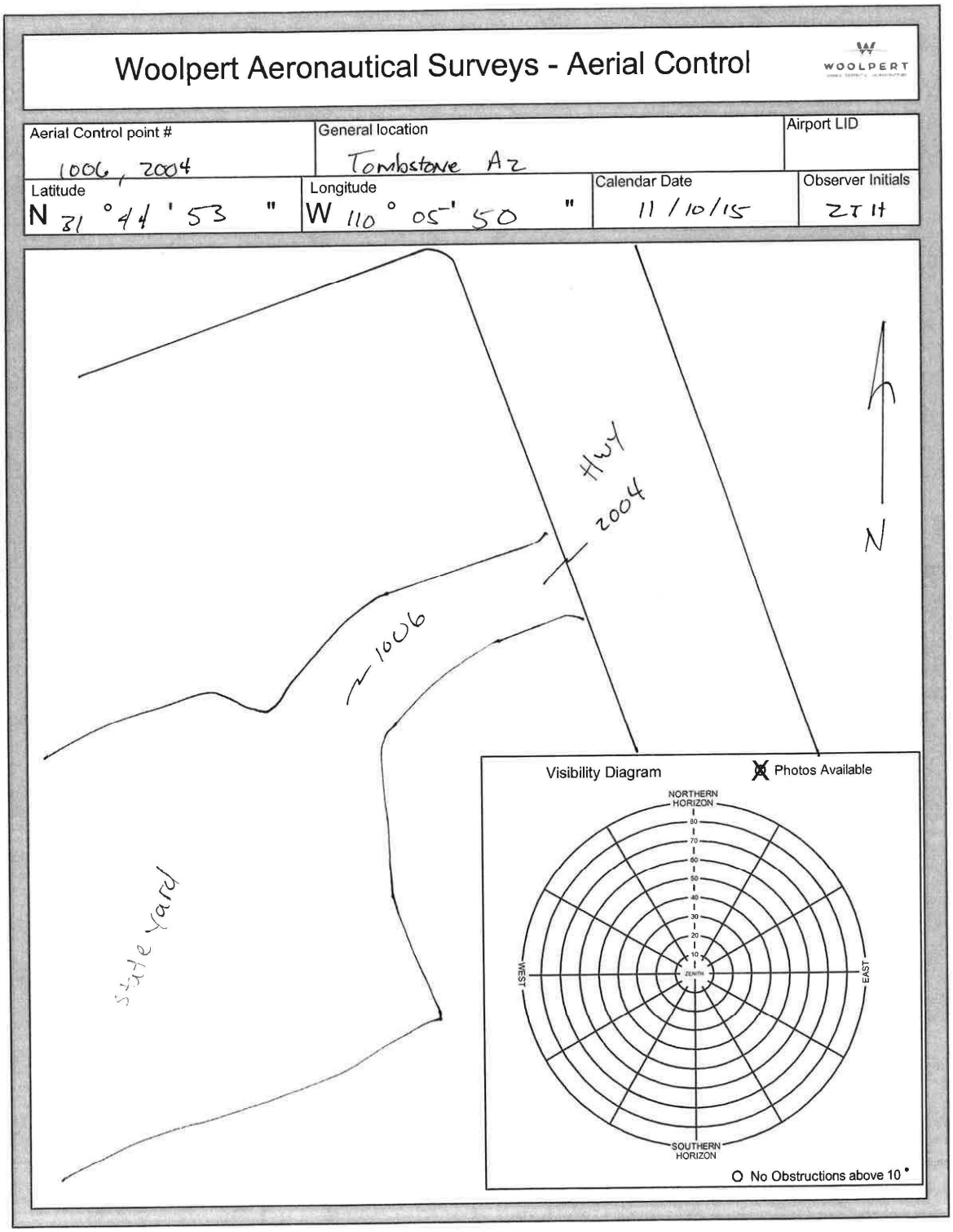




1006, 3E, 10NOV2015

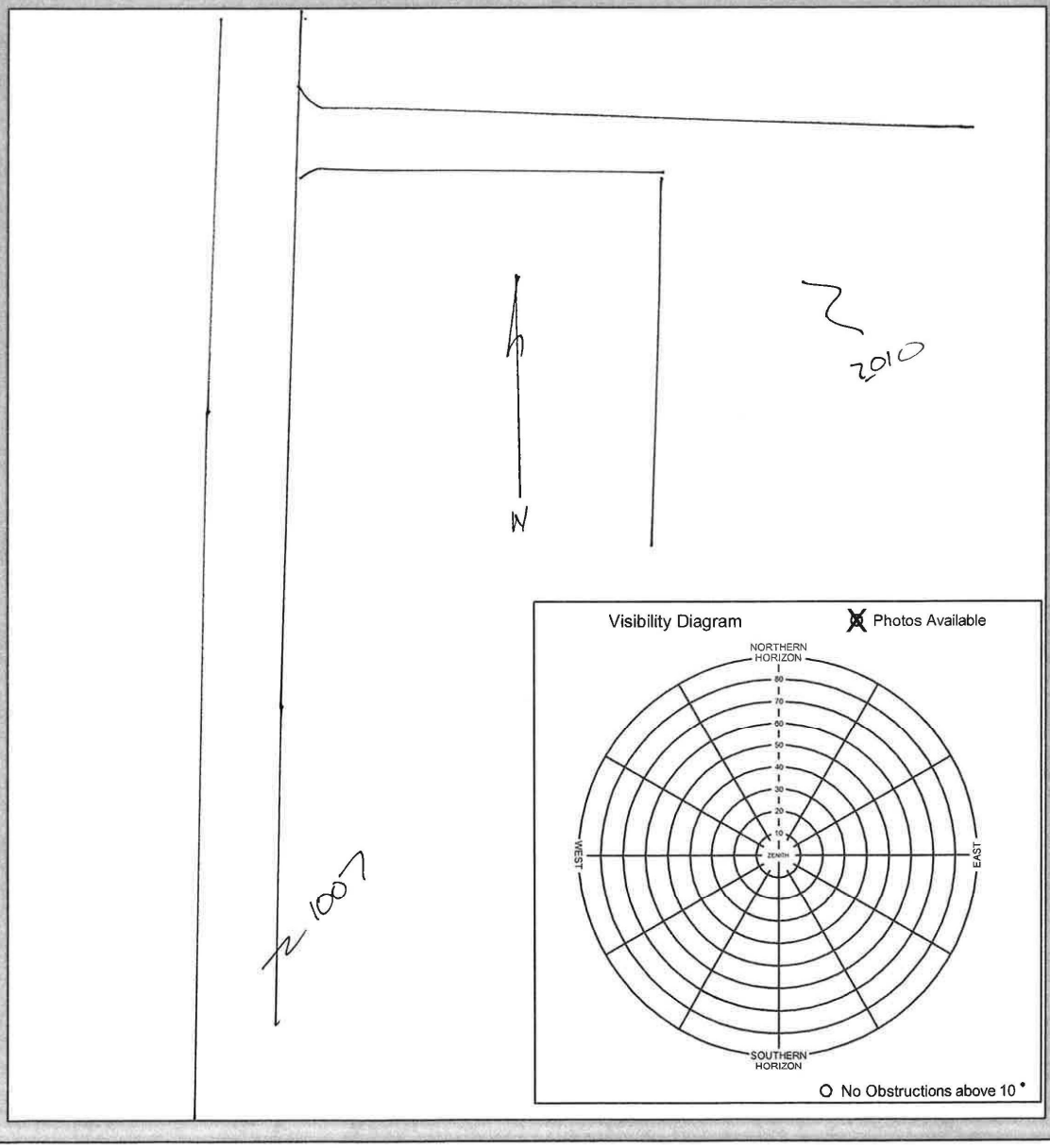

Woolpert Aeronautical Surveys - Aerial Control
WOOLPERT
Aerial Control point #
1006, 2004
General location
Tombstone Az
Airport LID
Latitude
N 31 ° 44 ' 53 "
Longitude
W 110 ° 05 ' 50 "
Calendar Date
11/10/15
Observer Initials
ZH
Hwy
2004
1006
N
side yard
Visibility Diagram
Photos Available
NORTHERN HORIZON
EAST
WEST
SOUTHERN HORIZON
ZENITH
No Obstructions above 10 °

1007, 3N, 10NOV2015

Woolpert Aeronautical Surveys - Aerial Control

Aerial Control point #	General location	Airport LID
2010 , 1007	Tombstone , Az	

Latitude	Longitude	Calendar Date	Observer Initials
N 31 ° 39 ' 44 "	W 110 ° 1 ' 51 "	11 / 9 /15	ZJH

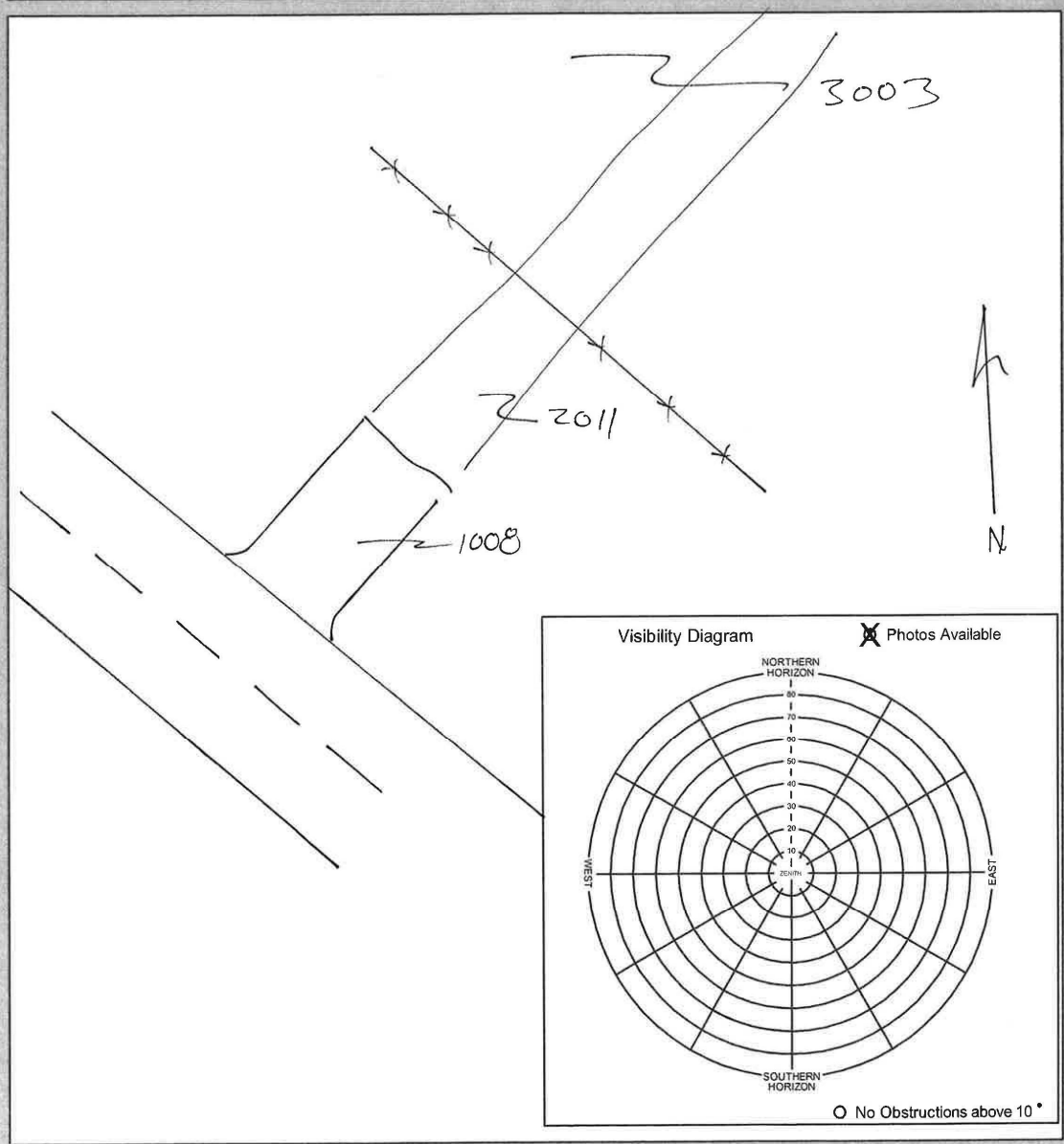


1008, 3N, 10NOV2015

Woolpert Aeronautical Surveys - Aerial Control

Aerial Control point #	General location	Airport LID
1008, 2011, 3003	Tombstone, AZ	

Latitude	Longitude	Calendar Date	Observer Initials
N 31 ° 40 ' 26 "	W 109 ° 59 ' 49 "	11/9/15	ZJH

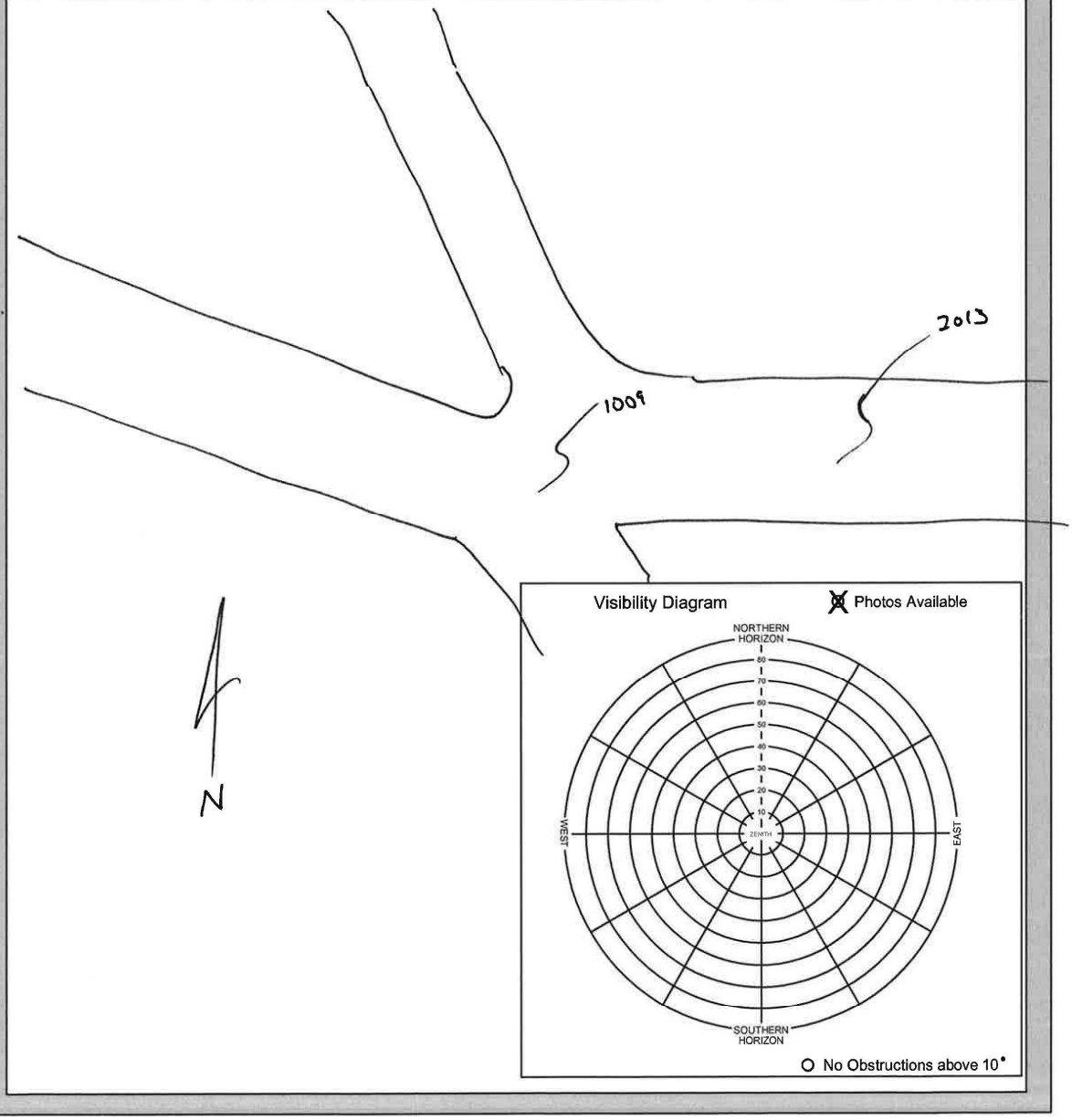


1009, 3E, 10NOV2015

Woolpert Aeronautical Surveys - Aerial Control

Aerial Control point #	General location	Airport LID
1009, 2013	Tombstone, AZ	

Latitude	Longitude	Calendar Date	Observer Initials
N 31 ° 43 ' 00 "	W 109 ° 58 ' 00 "	11 / 9 / 15	ZJH

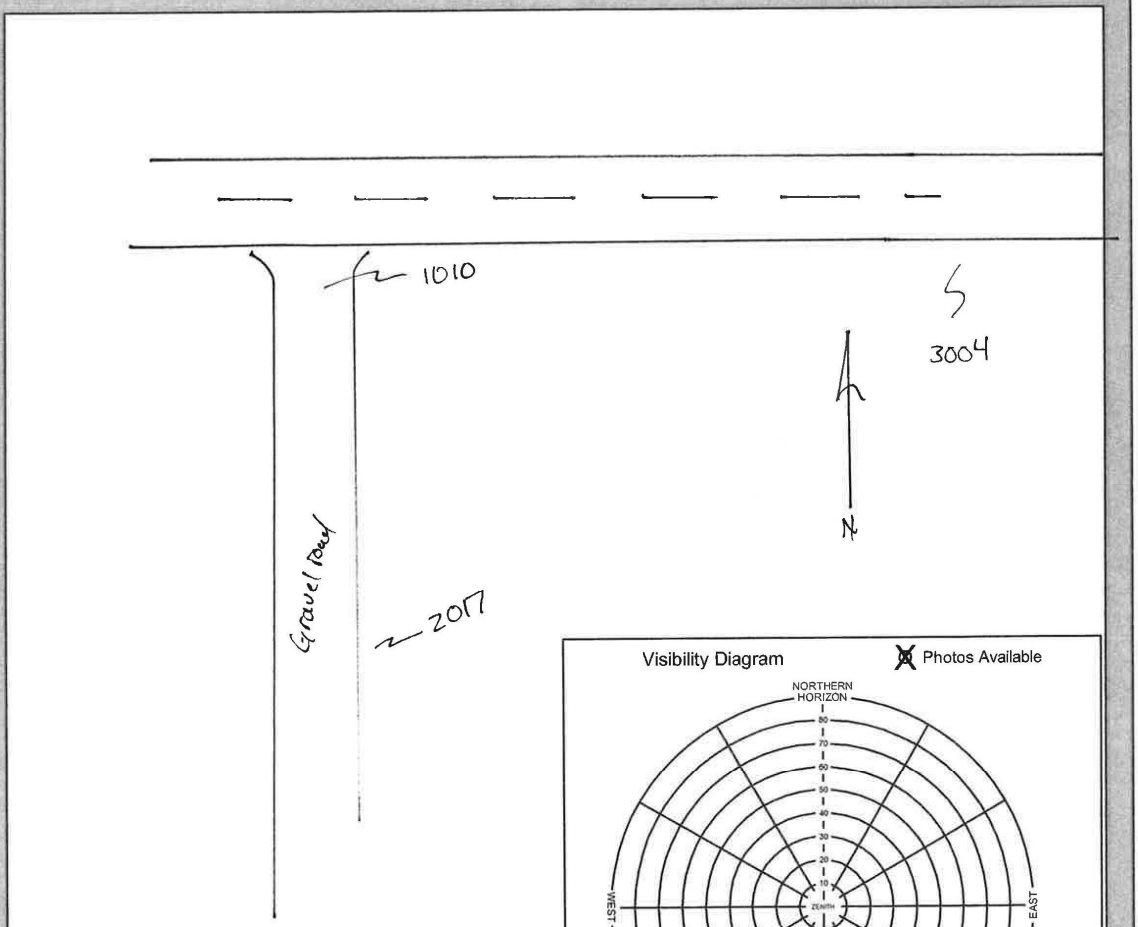


1010, 3N, 10NOV2015

Woolpert Aeronautical Surveys - Aerial Control

Aerial Control point #	General location	Airport LID
1010, 2017, 3004	Tombstone, Az	

Latitude	Longitude	Calendar Date	Observer Initials
N 31 ° 44 ' 19 "	W 109 ° 58 ' 53 "	11 / 9 / 15	ZJH

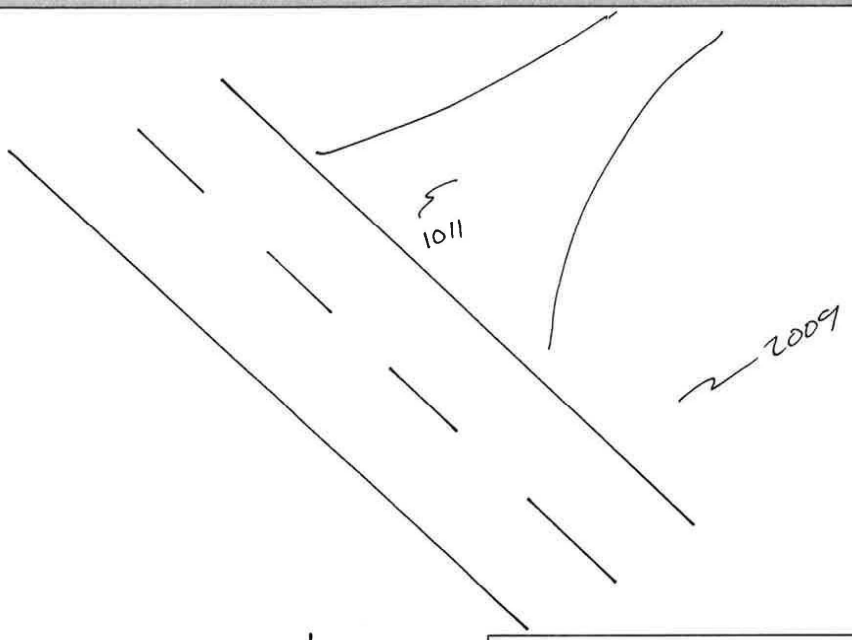


1011, 3N, 10NOV2015

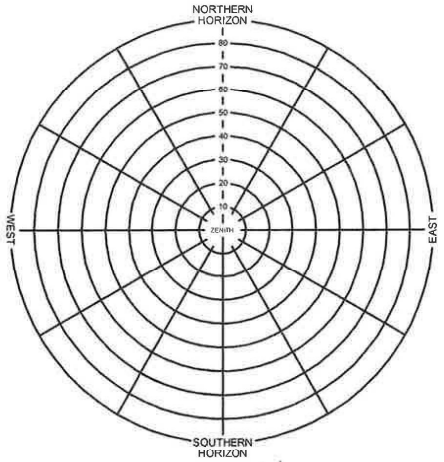
Woolpert Aeronautical Surveys - Aerial Control

Aerial Control point #	General location	Airport LID
1011 , 2009	Tombstone, AZ	

Latitude	Longitude	Calendar Date	Observer Initials
N 31 ° 41 ' 30 "	W 110 ° 2 ' 20 "	11/9/15	ZSH

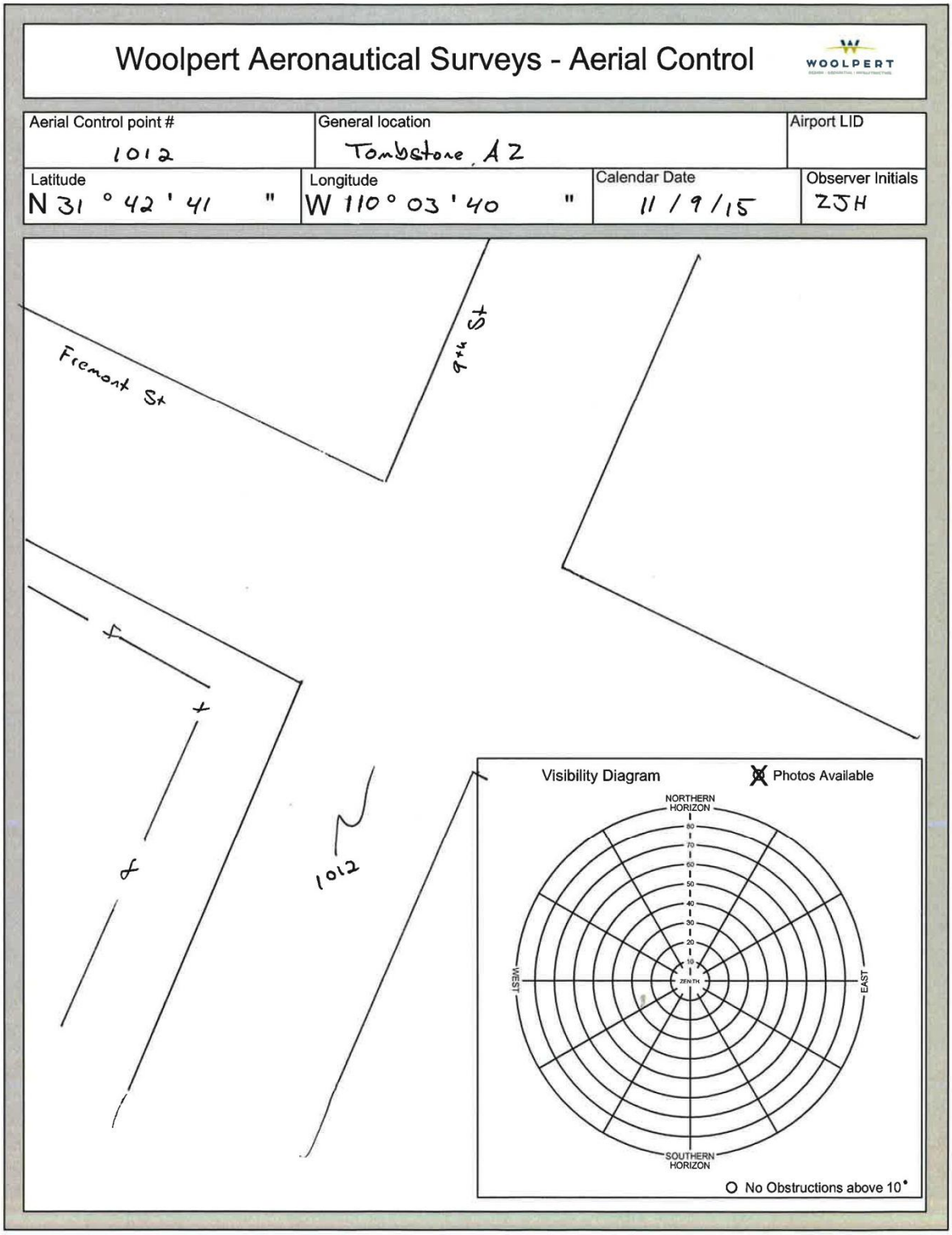


Visibility Diagram Photos Available



No Obstructions above 10 °

1012, 3E, 10NOV2015

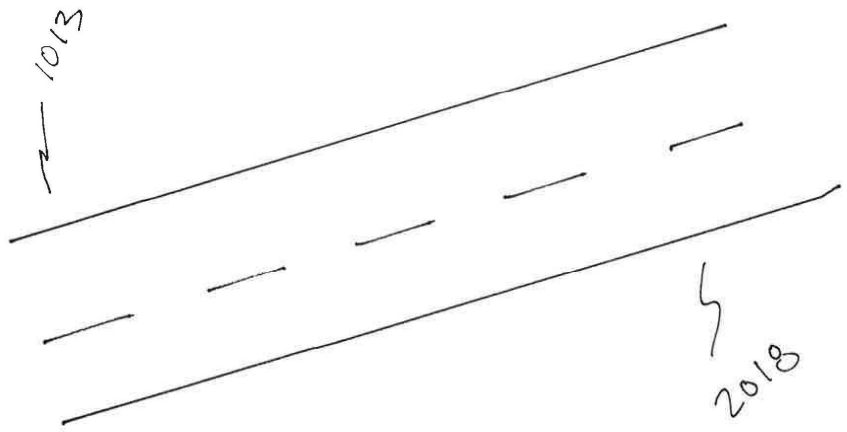

Woolpert Aeronautical Surveys - Aerial Control
WOOLPERT
Aerial Control point #
1012
General location
Tombstone, AZ
Airport LID
Latitude
N 31 ° 42 ' 41 "
Longitude
W 110 ° 03 ' 40 "
Calendar Date
11 / 9 / 15
Observer Initials
ZJH
Fremont St
9th St
1012
Visibility Diagram
Photos Available
NORTHERN HORIZON
SOUTHERN HORIZON
EAST
WEST
ZENITH
No Obstructions above 10°

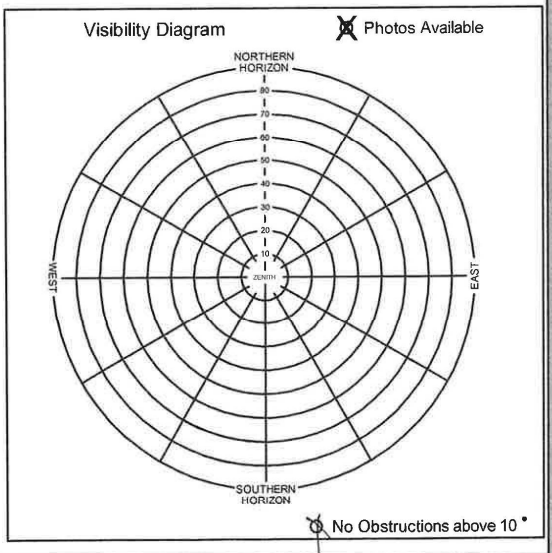
1013, 3E, 10NOV2015

Woolpert Aeronautical Surveys - Aerial Control

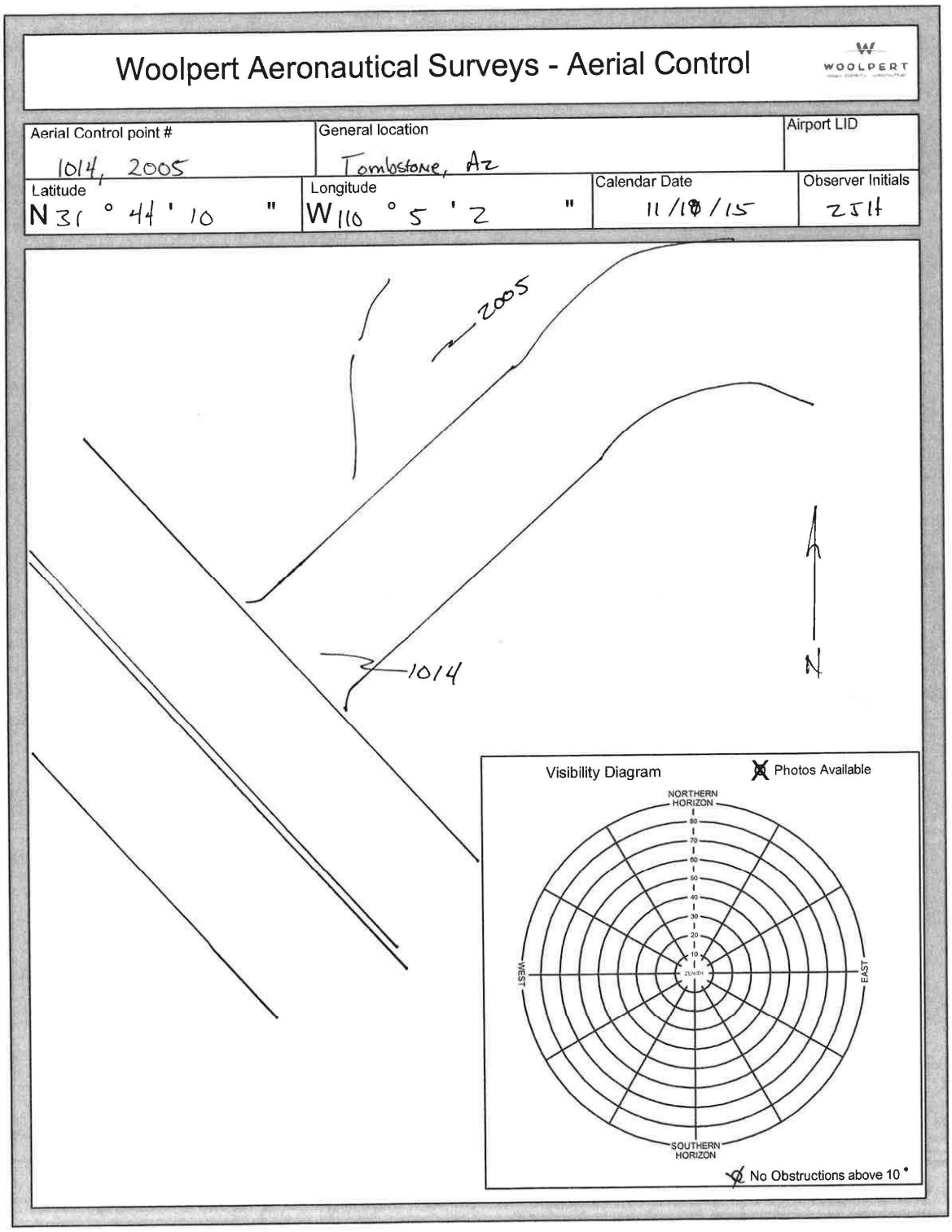
Aerial Control point #	General location	Airport LID
1013, 2018	Tombstone, AZ	

Latitude	Longitude	Calendar Date	Observer Initials
N 31 ° 44 ' 38 "	W 109 ° 56 ' 9 "	11/9/15	ZJH





1014, 3N, 10NOV2015

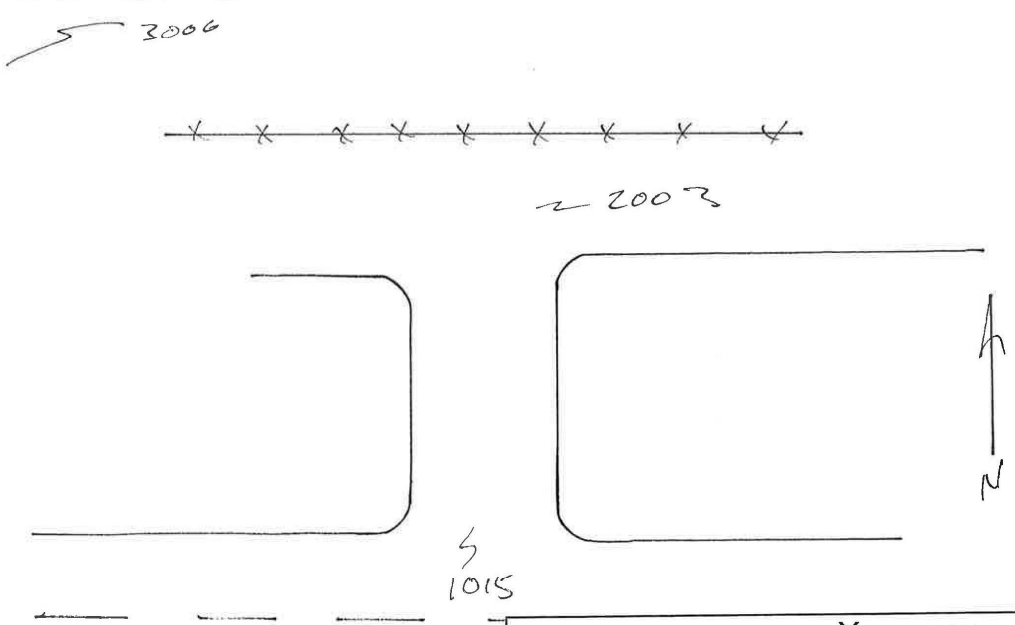

Woolpert Aeronautical Surveys - Aerial Control
WOOLPERT
Aerial Control point #
1014, 2005
General location
Tombstone, Az
Airport LID
Latitude
N 31 ° 44 ' 10 "
Longitude
W 110 ° 5 ' 2 "
Calendar Date
11/18/15
Observer Initials
ZSH
2005
1014
N
Visibility Diagram
Photos Available
NORTHERN HORIZON
EAST
SOUTHERN HORIZON
WEST
ZENITH
No Obstructions above 10 °

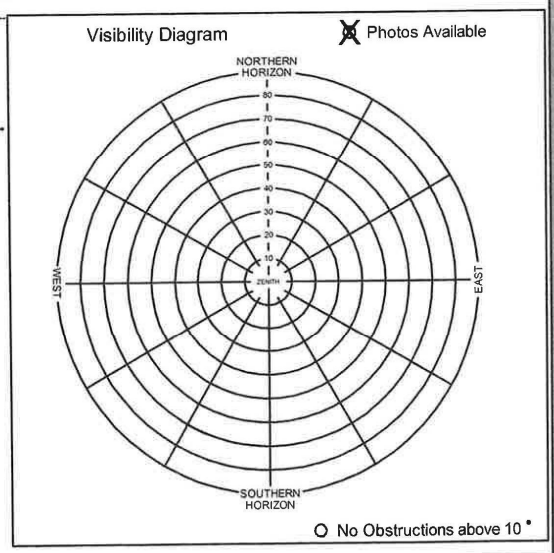
1015, 3E, 10NOV2015

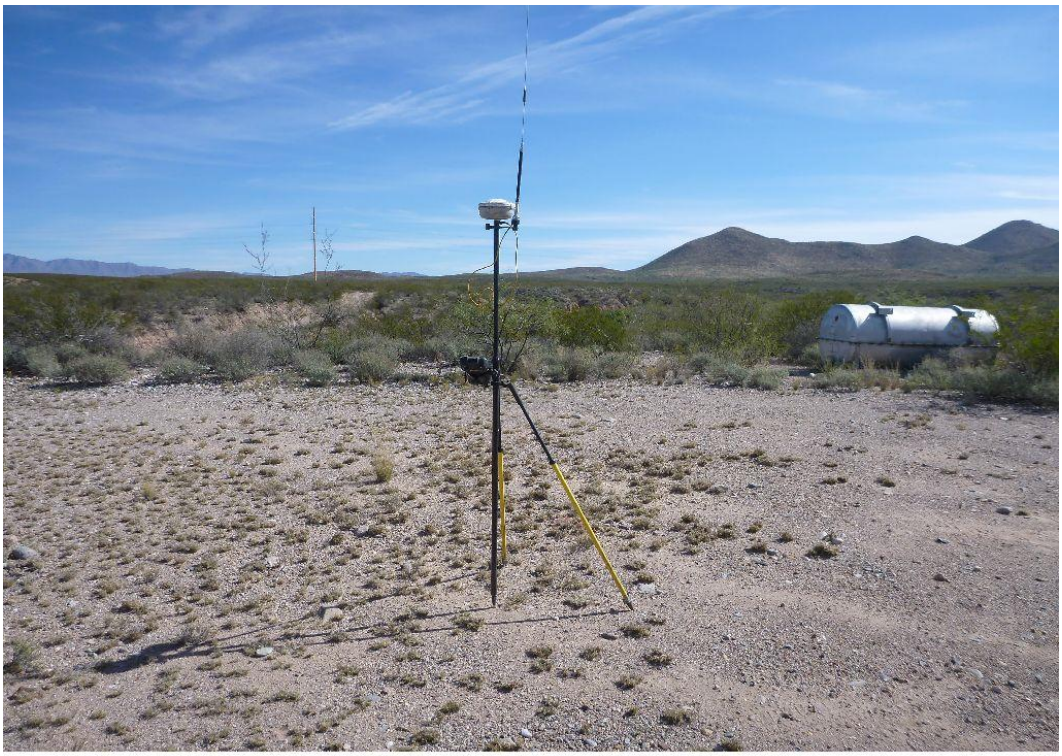
Woolpert Aeronautical Surveys - Aerial Control

Aerial Control point #	General location	Airport LID
3006, 2003, 1015	Tombstone, AZ	

Latitude	Longitude	Calendar Date	Observer Initials
N 31 ° 44 ' 43 "	W 110 ° 44 ' 42 "	11 /10 /15	ZJH





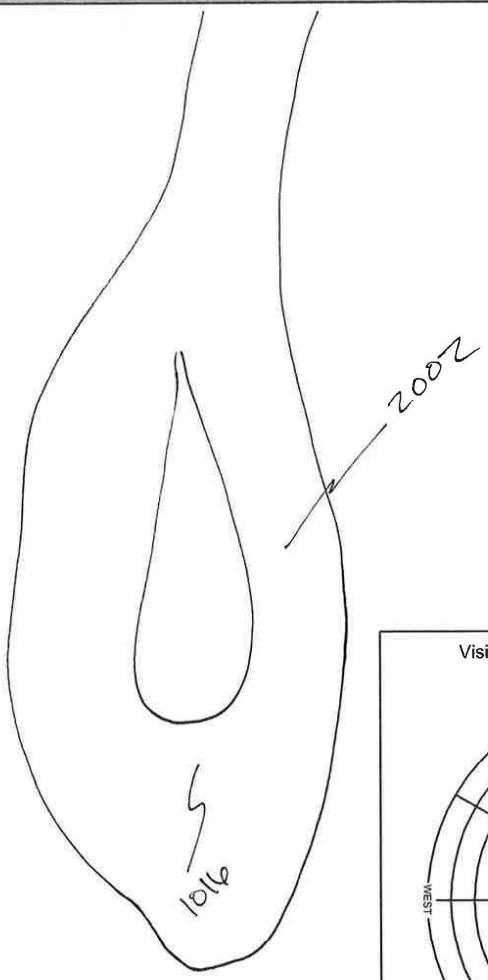


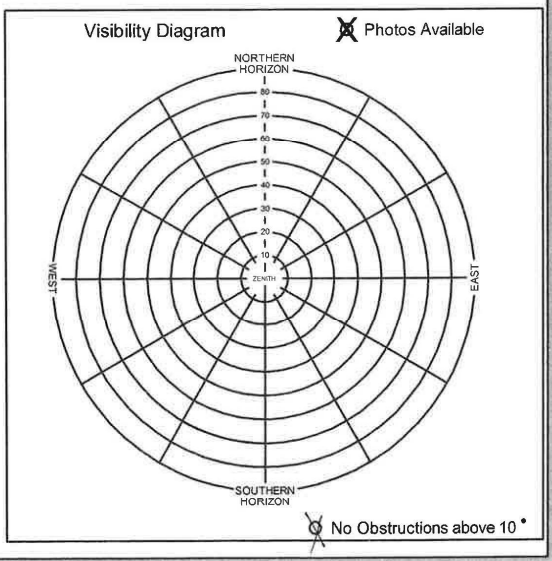
1016, 3E, 10NOV2015

Woolpert Aeronautical Surveys - Aerial Control

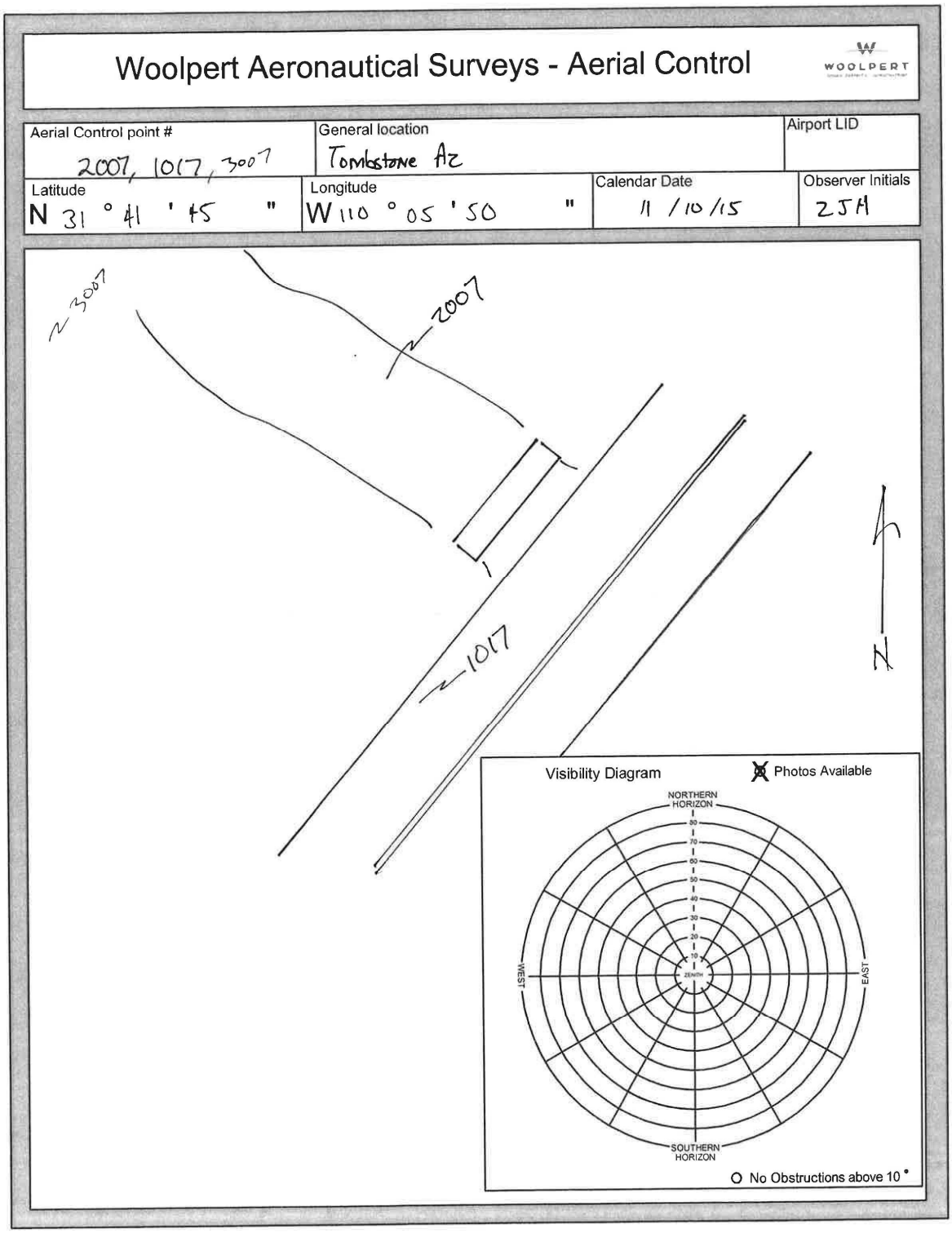
Aerial Control point #	General location	Airport LID
2002, 1016	Tombstone, Az	

Latitude	Longitude	Calendar Date	Observer Initials
N 31 ° 43 ' 46 "	W 110 ° 09 ' 12 "	11 / 10 / 15	ZJH

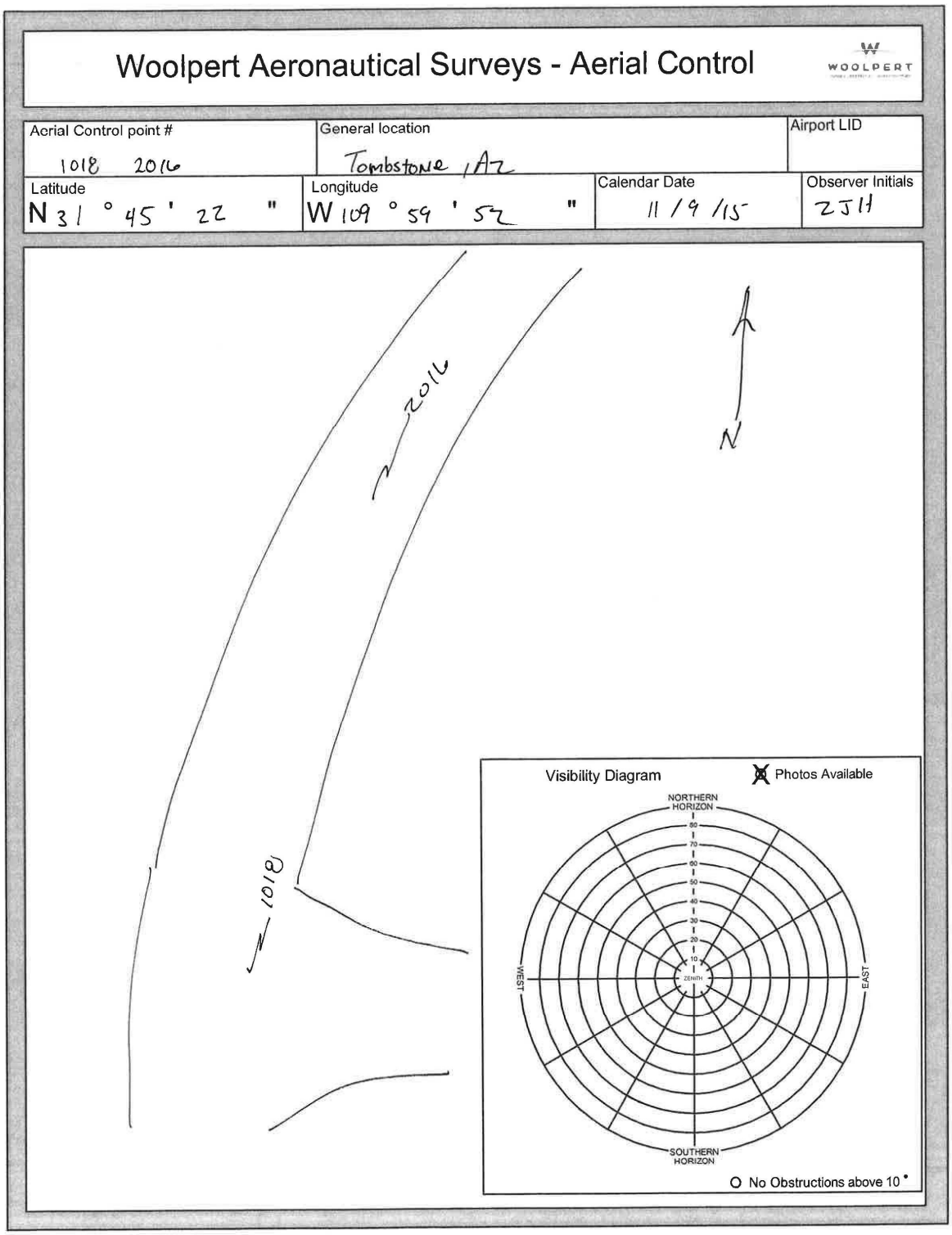




1017, 3N, 10NOV2015


Woolpert Aeronautical Surveys - Aerial Control
WOOLPERT
Aerial Control point #
2007, 1017, 3007
General location
Tombstone Az
Airport LID
Latitude
N 31 ° 41 ' 45 "
Longitude
W 110 ° 05 ' 50 "
Calendar Date
11 / 10 / 15
Observer Initials
ZJH
3007
2007
1017
N
Visibility Diagram
Photos Available
NORTHERN HORIZON
EAST
SOUTHERN HORIZON
WEST
ZENITH
No Obstructions above 10 °

1018, 3E, 10NOV2015

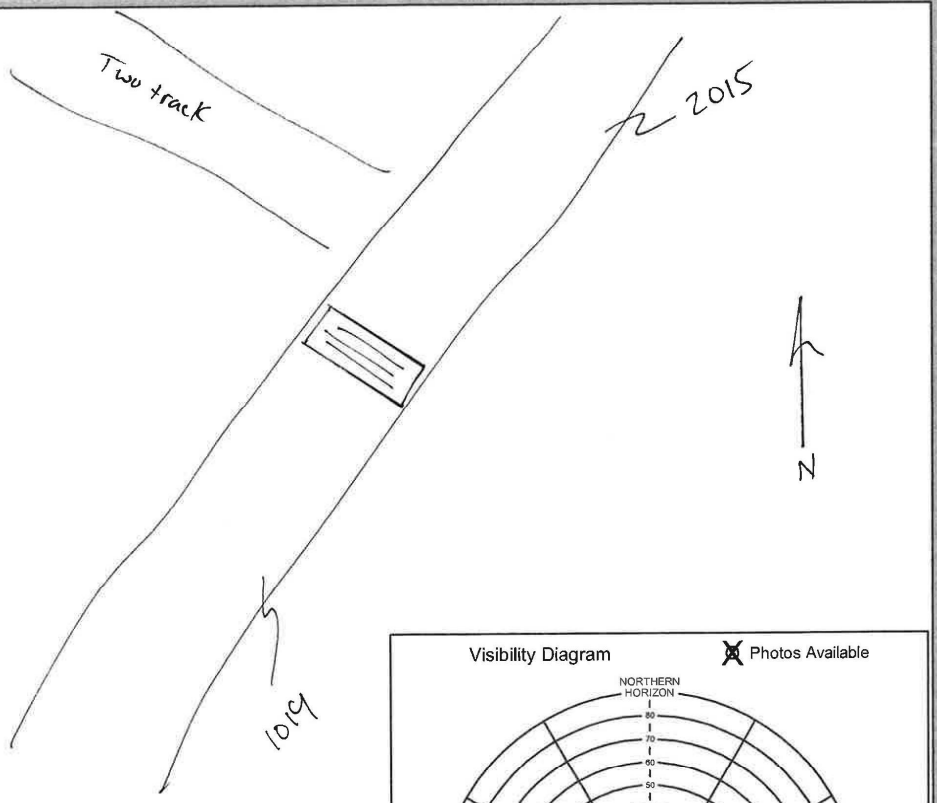

Woolpert Aeronautical Surveys - Aerial Control
WOOLPERT
Aerial Control point #
1018 2016
General location
Tombstone AZ
Airport LID
Latitude
N 31 ° 45 ' 22 "
Longitude
W 109 ° 59 ' 52 "
Calendar Date
11/9/15
Observer Initials
ZJH
2016
1018
N
Visibility Diagram
Photos Available
NORTHERN HORIZON
WEST
EAST
SOUTHERN HORIZON
ZENITH
No Obstructions above 10 °

1019, 3N, 10NOV2015

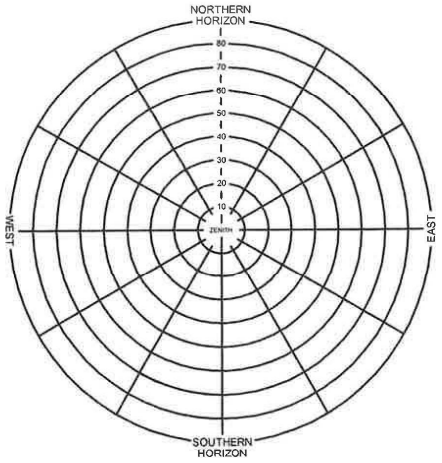
Woolpert Aeronautical Surveys - Aerial Control

Aerial Control point #	General location	Airport LID
1019, 2015	Tombstone, AZ	

Latitude	Longitude	Calendar Date	Observer Initials
N 31 ° 44 ' 41 "	W 110 ° 1 ' 4 "	11/9/15	ZJH



Visibility Diagram — Photos Available



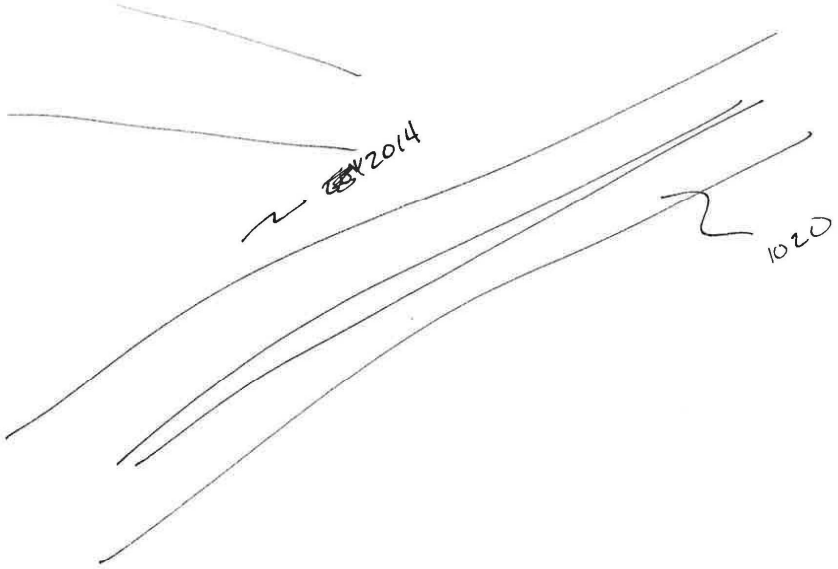
No Obstructions above 10 °

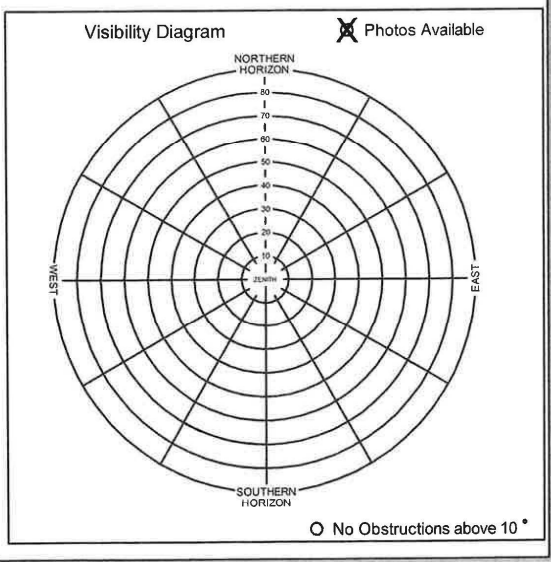
1020, 3E, 10NOV2015

Woolpert Aeronautical Surveys - Aerial Control

Aerial Control point #	General location	Airport LID
1020, 2014	Tombstone, Az	

Latitude	Longitude	Calendar Date	Observer Initials
N 31 ° 43 ' 30 "	W 110 ° 2 ' 8 "	11 / 9 / 15	ZJH

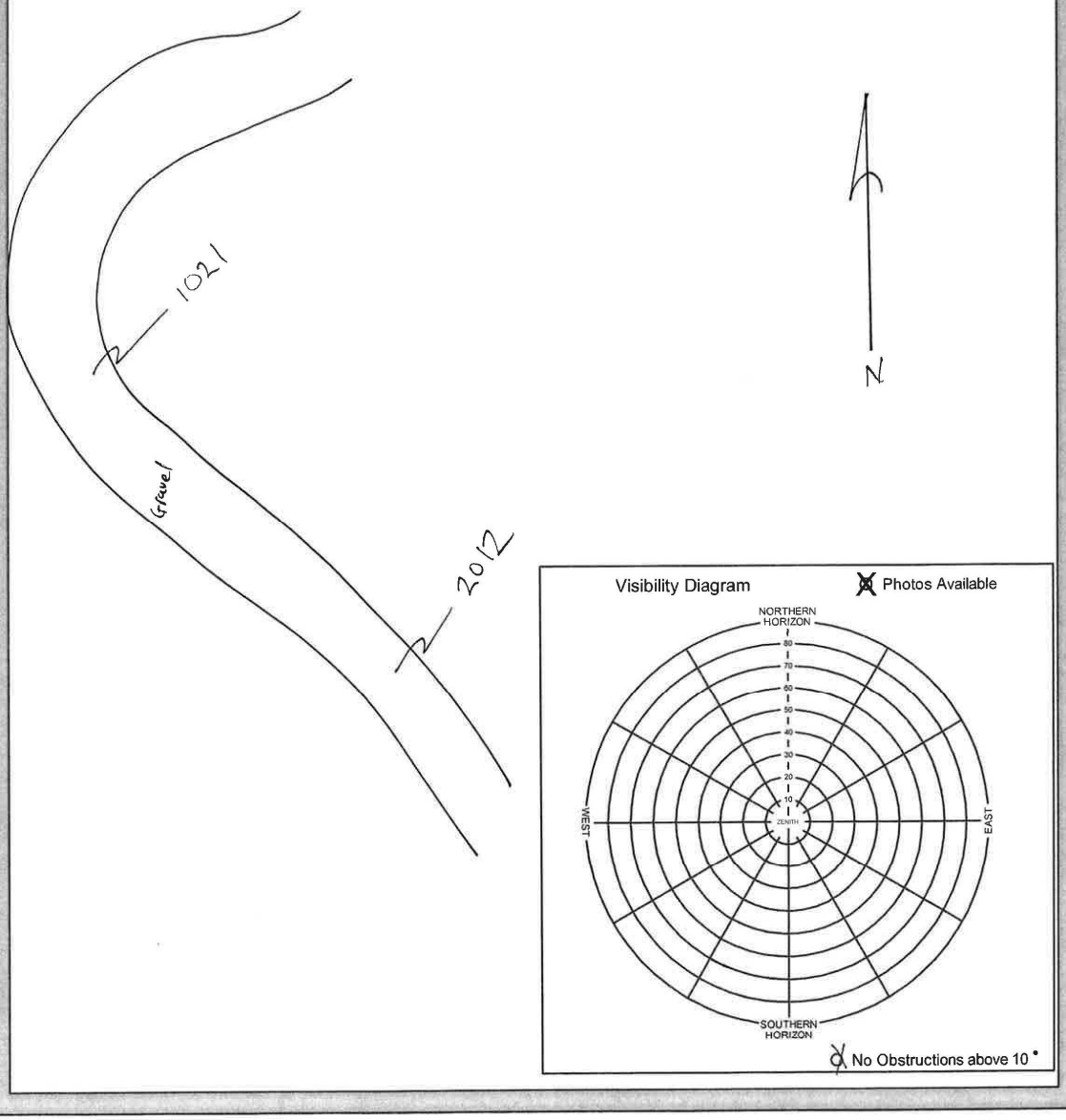




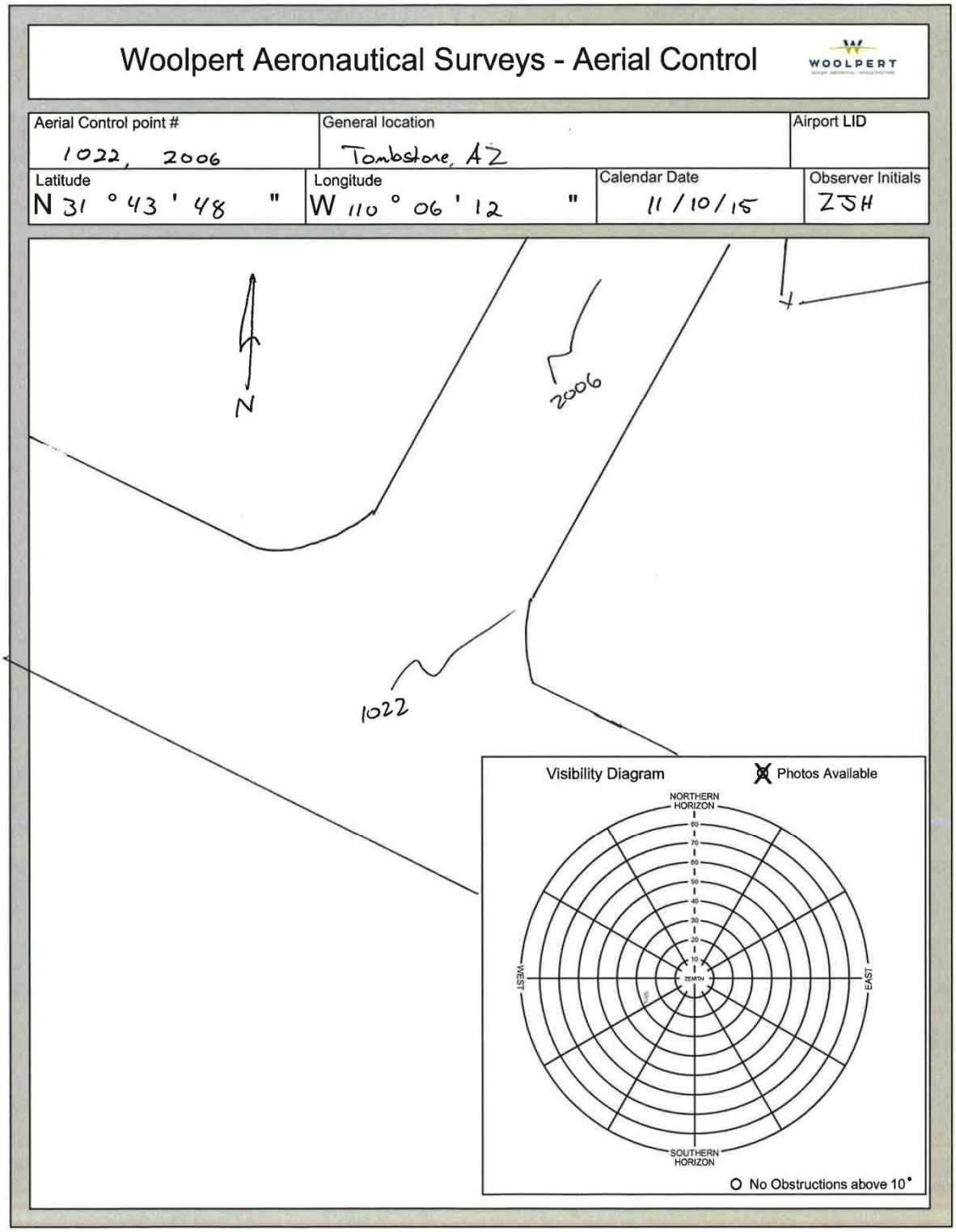
1021, 3N, 10NOV2015

Woolpert Aeronautical Surveys - Aerial Control

Aerial Control point #	General location		Airport LID
1021, 2012	Tombstone, AZ		
Latitude	**Longitude**	**Calendar Date**	**Observer Initials**
N 31 ° 42 ' 52 "	W 109 ° 59 ' 43 "	11/9/15	ZJH



1022, 3N, 10NOV2015


Woolpert Aeronautical Surveys - Aerial Control
WOOLPERT
Aerial Control point #
1022, 2006
General location
Tombstone, AZ
Airport LID
Latitude
N 31 ° 43 ' 48 "
Longitude
W 110 ° 06 ' 12 "
Calendar Date
11/10/15
Observer Initials
ZJH
N
2006
1022
Visibility Diagram
Photos Available
NORTHERN HORIZON
60
70
80
50
40
30
20
10
ZENITH
WEST
EAST
SOUTHERN HORIZON
No Obstructions above 10°

SECTION 5: EXISTING NGS DATA SHEETS

This section contains the published National Geodetic Survey (NGS) Data Sheets used in the final control network for this project.

THE NGS DATA SHEET

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

```
DN3616  HT_MOD      -  This is a Height Modernization Survey Station.
DN3616  DESIGNATION -  AIRPORT
DN3616  PID         -  DN3616
DN3616  STATE/COUNTY-  AZ/COCHISE
DN3616  COUNTRY     -  US
DN3616  USGS QUAD   -  TOMBSTONE (1978)
DN3616
DN3616                       *CURRENT SURVEY CONTROL
DN3616  ______________________________________________________________________
DN3616* NAD 83(2011) POSITION- 31 40 21.97138(N) 110 01 54.07632(W)       ADJUSTED
DN3616* NAD 83(2011) ELLIP HT-  1421.296 (meters)        (06/27/12)   ADJUSTED
DN3616* NAD 83(2011) EPOCH   -  2010.00
DN3616* NAVD 88 ORTHO HEIGHT -  1448.85  (meters)     4753.4   (feet) GPS OBS
DN3616  ______________________________________________________________________
DN3616  NAVD 88 orthometric height was determined with geoid model    GEOID09
DN3616  GEOID HEIGHT    -        -27.538 (meters)                     GEOID09
DN3616  GEOID HEIGHT    -        -27.539 (meters)                     GEOID12B
DN3616  NAD 83(2011) X  - -1,861,500.917 (meters)                     COMP
DN3616  NAD 83(2011) Y  - -5,105,644.124 (meters)                     COMP
DN3616  NAD 83(2011) Z  -  3,330,351.906 (meters)                     COMP
DN3616  LAPLACE CORR    -          1.20  (seconds)                    DEFLEC12B
DN3616
DN3616  Network accuracy estimates per FGDC Geospatial Positioning Accuracy
DN3616  Standards:
DN3616         FGDC (95% conf, cm)     Standard deviation (cm)     CorrNE
DN3616            Horiz  Ellip           SD_N   SD_E   SD_h      (unitless)
DN3616  ------------------------------------------------------------------
DN3616  NETWORK    0.69   2.12           0.30   0.26   1.08     -0.08645368
DN3616  ------------------------------------------------------------------
DN3616  Click here for local accuracies and other accuracy information.
DN3616
DN3616
DN3616.The horizontal coordinates were established by GPS observations
DN3616.and adjusted by the National Geodetic Survey in June 2012.
DN3616
DN3616.NAD 83(2011) refers to NAD 83 coordinates where the reference
DN3616.frame has been affixed to the stable North American tectonic plate. See
DN3616.NA2011 for more information.
DN3616
DN3616.The horizontal coordinates are valid at the epoch date displayed above
DN3616.which is a decimal equivalence of Year/Month/Day.
DN3616
DN3616.The orthometric height was determined by GPS observations and a
DN3616.high-resolution geoid model using precise GPS observation and
DN3616.processing techniques.
DN3616
DN3616.Significant digits in the geoid height do not necessarily reflect accuracy.
DN3616.GEOID12B height accuracy estimate available here.
DN3616
DN3616.The X, Y, and Z were computed from the position and the ellipsoidal ht.
DN3616
DN3616.The Laplace correction was computed from DEFLEC12B derived deflections.
DN3616
DN3616.The ellipsoidal height was determined by GPS observations
DN3616.and is referenced to NAD 83.
DN3616
```

```
 DN3616. The following values were computed from the NAD 83(2011) position.
 DN3616
 DN3616;                    North         East     Units Scale Factor Converg.
 DN3616;SPC AZ E     -    74,593.992   226,158.387   MT  0.99990202   +0 04 15.1
 DN3616;SPC AZ E     -   244,730.94    741,989.46   iFT  0.99990202   +0 04 15.1
 DN3616;UTM  12      - 3,504,572.907   591,787.571   MT  0.99970391   +0 30 30.5
 DN3616
 DN3616!             -  Elev Factor  x  Scale Factor =   Combined Factor
 DN3616!SPC AZ E     -   0.99977687  x   0.99990202  =   0.99967892
 DN3616!UTM  12      -   0.99977687  x   0.99970391  =   0.99948085
 DN3616
 DN3616                          SUPERSEDED SURVEY CONTROL
 DN3616
 DN3616  NAD 83(2007)-  31 40 21.97077(N)    110 01 54.07656(W) AD(2007.00) B
 DN3616  ELLIP H (09/06/11) 1421.303  (m)                      GP(2007.00) 4 2
 DN3616
 DN3616.Superseded values are not recommended for survey control.
 DN3616
 DN3616.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
 DN3616.See file dsdata.txt to determine how the superseded data were derived.
 DN3616
 DN3616_U.S. NATIONAL GRID SPATIAL ADDRESS: 12RWA9178704572(NAD 83)
 DN3616
 DN3616_MARKER: DD = SURVEY DISK
 DN3616_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
 DN3616_STAMPING: AIRPORT LS 30365
 DN3616_MARK LOGO: AZ-003
 DN3616_PROJECTION: FLUSH
 DN3616_MAGNETIC: N = NO MAGNETIC MATERIAL
 DN3616_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO
 DN3616+STABILITY: SURFACE MOTION
 DN3616_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
 DN3616+SATELLITE: SATELLITE OBSERVATIONS - 2006
 DN3616
 DN3616  HISTORY     - Date     Condition        Report By
 DN3616  HISTORY     - 2006     MONUMENTED       AZ-003
 DN3616
 DN3616                          STATION DESCRIPTION
 DN3616
 DN3616'DESCRIBED BY COCHISE COUNTY ARIZONA 2006 (DLS)
 DN3616'THE STATION IS LOCATED ABOUT 9.5 MI (15.3 KM) EAST-SOUTHEAST OF
 DN3616'FAIRBANK, 9.0 MI (14.5 KM) NORTHEAST OF LEWIS SPRINGS AND 3.5 MI (5.6
 DN3616'KM) SOUTHEAST OF TOMBSTONE.
 DN3616'
 DN3616'TO REACH FROM THE INTERSECTION OF HIGHWAY 80 AND DAVIS ROAD, TRAVEL
 DN3616'EASTERLY ON DAVIS ROAD FOR APPROXIMATELY 130 FT (40 M) TO THE STATION.
 DN3616'STATION IS LOCATED IMMEDIATELY SOUTH OF DAVIS ROAD AT PULLOUT.  POINT
 DN3616'IS A 3 INCH (8 CM) COCHISE COUNTY HIGHWAY AND FLOODPLAIN DEPARTMENT
 DN3616'BRASS CAP.

**********************************************************************
 CG1200  HT_MOD      -  This is a Height Modernization Survey Station.
 CG1200  DESIGNATION -  WALNUT
 CG1200  PID         -  CG1200
 CG1200  STATE/COUNTY-  AZ/COCHISE
 CG1200  COUNTRY     -  US
 CG1200  USGS QUAD   -  FAIRBANK (1952)
 CG1200
 CG1200                         *CURRENT SURVEY CONTROL
 CG1200  ______________________________________________________________________
 CG1200* NAD 83(2011) POSITION- 31 44 40.71868(N) 110 08 34.09833(W)   ADJUSTED
 CG1200* NAD 83(2011) ELLIP HT-  1241.696 (meters)        (06/27/12)   ADJUSTED
 CG1200* NAD 83(2011) EPOCH   -  2010.00
 CG1200* NAVD 88 ORTHO HEIGHT -  1269.47  (meters)     4164.9   (feet) GPS OBS
 CG1200  ______________________________________________________________________
 CG1200  NAVD 88 orthometric height was determined with geoid model    GEOID09
 CG1200  GEOID HEIGHT    -        -27.753 (meters)                     GEOID09
 CG1200  GEOID HEIGHT    -        -27.769 (meters)                     GEOID12B
 CG1200  NAD 83(2011) X  - -1,869,903.723 (meters)                     COMP
 CG1200  NAD 83(2011) Y  - -5,097,947.532 (meters)                     COMP
 CG1200  NAD 83(2011) Z  -  3,337,038.866 (meters)                     COMP
```

```
CG1200  LAPLACE CORR    -          2.69  (seconds)                    DEFLEC12B
CG1200
CG1200  Network accuracy estimates per FGDC Geospatial Positioning Accuracy
CG1200  Standards:
CG1200         FGDC (95% conf, cm)     Standard deviation (cm)     CorrNE
CG1200            Horiz  Ellip           SD_N   SD_E   SD_h      (unitless)
CG1200  ------------------------------------------------------------------
CG1200  NETWORK    1.18   2.92           0.52   0.43   1.49     -0.16581488
CG1200  ------------------------------------------------------------------
CG1200  Click here for local accuracies and other accuracy information.
CG1200
CG1200
CG1200.The horizontal coordinates were established by GPS observations
CG1200.and adjusted by the National Geodetic Survey in June 2012.
CG1200
CG1200.NAD 83(2011) refers to NAD 83 coordinates where the reference
CG1200.frame has been affixed to the stable North American tectonic plate. See
CG1200.NA2011 for more information.
CG1200
CG1200.The horizontal coordinates are valid at the epoch date displayed above
CG1200.which is a decimal equivalence of Year/Month/Day.
CG1200
CG1200.The orthometric height was determined by GPS observations and a
CG1200.high-resolution geoid model using precise GPS observation and
CG1200.processing techniques.
CG1200
CG1200.Significant digits in the geoid height do not necessarily reflect accuracy.
CG1200.GEOID12B height accuracy estimate available here.
CG1200
CG1200.The X, Y, and Z were computed from the position and the ellipsoidal ht.
CG1200
CG1200.The Laplace correction was computed from DEFLEC12B derived deflections.
CG1200
CG1200.The ellipsoidal height was determined by GPS observations
CG1200.and is referenced to NAD 83.
CG1200
CG1200. The following values were computed from the NAD 83(2011) position.
CG1200
CG1200;                    North         East     Units Scale Factor Converg.
CG1200;SPC AZ E     -    82,555.068   215,620.756   MT  0.99990006   +0 00 45.2
CG1200;SPC AZ E     -   270,849.96    707,417.18   iFT  0.99990006   +0 00 45.2
CG1200;UTM  12      - 3,512,451.547   581,191.595   MT  0.99968130   +0 27 03.7
CG1200
CG1200!             -  Elev Factor  x  Scale Factor =   Combined Factor
CG1200!SPC AZ E     -   0.99980506  x   0.99990006  =   0.99970514
CG1200!UTM  12      -   0.99980506  x   0.99968130  =   0.99948643
CG1200
CG1200|-----------------------------------------------------------------------|
CG1200| PID    Reference Object                     Distance      Geod. Az   |
CG1200|                                                           dddmmss.s  |
CG1200| CS6173 WALNUT RM 1                          12.892 METERS 08640      |
CG1200| CS6174 WALNUT RM 2                          12.851 METERS 27034      |
CG1200|-----------------------------------------------------------------------|
CG1200
CG1200                          SUPERSEDED SURVEY CONTROL
CG1200
CG1200  NAD 83(2007)-  31 44 40.71811(N)    110 08 34.09871(W) AD(2007.00) 0
CG1200  ELLIP H (02/10/07) 1241.701  (m)                       GP(2007.00)
CG1200  NAD 83(1992)-  31 44 40.71785(N)    110 08 34.09842(W) AD(       ) B
CG1200  ELLIP H (08/22/05) 1241.712  (m)                       GP(       ) 4 2
CG1200  NAD 83(1992)-  31 44 40.72015(N)    110 08 34.09725(W) AD(       ) 2
CG1200  NAD 83(1986)-  31 44 40.71381(N)    110 08 34.09334(W) AD(       ) 2
CG1200  NAVD 88 (08/22/05) 1269.49   (m)  GEOID03 model used   GPS OBS
CG1200  NGVD 29 (06/28/91) 1268.62   (m)         4162.1    (f) LEVELING    3
CG1200
CG1200.Superseded values are not recommended for survey control.
CG1200
CG1200.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
CG1200.See file dsdata.txt to determine how the superseded data were derived.
CG1200
CG1200_U.S. NATIONAL GRID SPATIAL ADDRESS: 12RWA8119112451(NAD 83)
```

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CG1200
CG1200_MARKER: DD = SURVEY DISK
CG1200_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
CG1200_STAMPING: WALNUT 1987
CG1200_MARK LOGO: AZDT
CG1200_MAGNETIC: O = OTHER; SEE DESCRIPTION
CG1200_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO
CG1200+STABILITY: SURFACE MOTION
CG1200_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
CG1200+SATELLITE: SATELLITE OBSERVATIONS - May 04, 2007
CG1200
CG1200  HISTORY     - Date     Condition        Report By
CG1200  HISTORY     - 1986     MONUMENTED       AZDT
CG1200  HISTORY     - 20040429 GOOD             AZDT
CG1200  HISTORY     - 20070504 GOOD             GEOCAC
CG1200
CG1200                          STATION DESCRIPTION
CG1200
CG1200'DESCRIBED BY ARIZONA DEPARTMENT OF TRANSPORTATION 1986 (ART)
CG1200'THE STATION IS LOCATED 5 MILES NORTHWEST OF TOMBSTONE ALONG THE
CG1200'NORTHWEST SIDE OF U.S. HIGHWAY 80.
CG1200'
CG1200'THE STATION MARK IS AN AZDT DISK STAMPED---WALNUT 1986---.  IT IS SET
CG1200'IN TOP OF A 10 INCH CONCRETE MONUMENT 5 FEET NORTH OF A WITNESS POST.
CG1200'IT IS ON TOP OF A SMALL HILL ABOUT 100 FEET NORTHWEST OF THE HIGHWAY.
CG1200'
CG1200'REFERENCE MARK 1 IS AN AZDT DISK STAMPED---WALNUT RM 1 1986---.  IT IS
CG1200'SET IN TOP OF A 10 INCH CONCRETE MONUMENT.
CG1200'
CG1200'REFERENCE MARK 2 IS AN AZDT DISK STAMPED---WALNUT RM 2 1986---.  IT IS
CG1200'SET IN TOP OF A 10 INCH CONCRETE MONUMENT.
CG1200'
CG1200'TO REACH THE STATION FROM TOMBSTONE TRAVEL NORTH ALONG U.S. HIGHWAY 80
CG1200'AND STATE ROUTE 82 FOR ABOUT 3 MILES TO THEIR JUNCTION.  TRAVEL WEST
CG1200'ALONG SR 82 FOR 2.95 MILES TO THE END OF TRUCK TRAVEL AT MILE POST
CG1200'64.8.  PACK NORTH TO THE TOP OF A SMALL HILL AND STATION.
CG1200
CG1200                          STATION RECOVERY (2004)
CG1200
CG1200'RECOVERY NOTE BY ARIZONA DEPARTMENT OF TRANSPORTATION 2004
CG1200'RECOVERED AS DESCRIBED
CG1200
CG1200                          STATION RECOVERY (2007)
CG1200
CG1200'RECOVERY NOTE BY GEOCACHING 2007 (JM)
CG1200'RECOVERED STATION MARK, REFERENCE MARK 1 AND REFERENCE MARK 2 IN GOOD
CG1200'CONDITION AS DESCRIBED WITH THE FOLLOWING UPDATE TO THE DESCRIPTION
CG1200'THE STATION MARK IS 5 FEET NORTHWEST OF A WITNESS POST.
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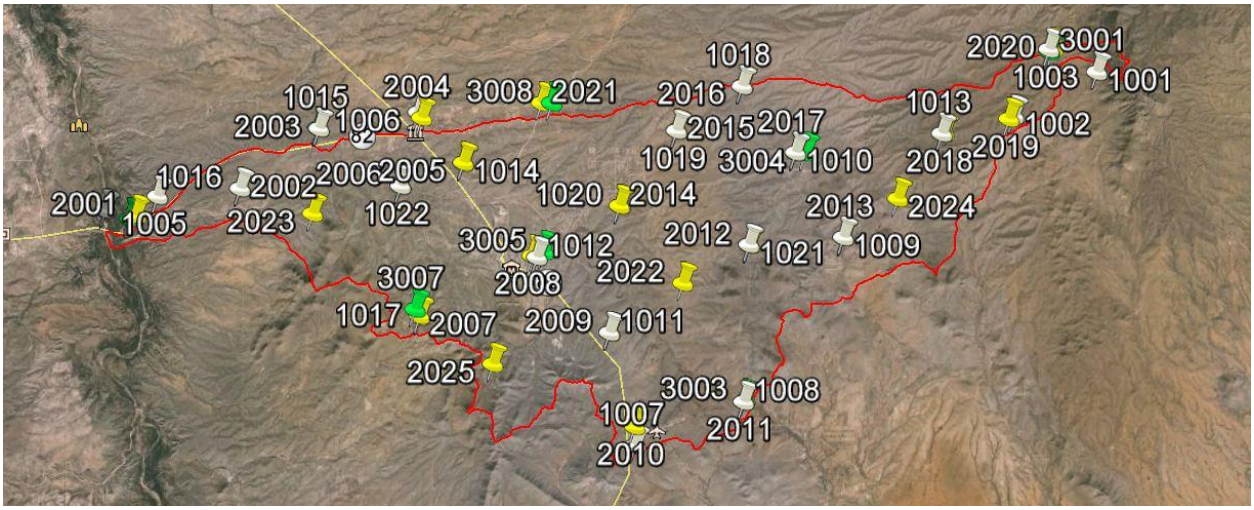
SECTION 6: GPS CONTROL DIAGRAM

This section contains a graphical representation of the new and existing control stations used for the project.



N

Not to Scale