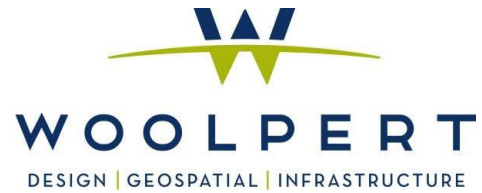


GROUND CONTROL SURVEY REPORT



UNITED STATES GEOLOGICAL SURVEY NM WHITE SANDS QLO LIDAR

12/14/2015





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DESIGN | GEOSPATIAL | INFRASTRUCTURE



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SECTION 1: SURVEY REPORT

INTRODUCTION

Report Date: 12/14/2015

Project Name: NM White Sands QL0 LiDAR
Client Information: USGS
Contract Number: G10PC00057
Requisition/Reference Number: G15PD00566
Date of Contract: 8/3/2015
Delivery Date: 1/31/2016

Prepared By: David Kuxhausen, PLS
Woolpert Project Number: 75721

This report contains a comprehensive outline of the LiDAR Ground Control Survey that supported NM White Sands QL0 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 43 square miles over the White Sands National Monument located in Otero County, NM.

PURPOSE

The purpose of this survey was to establish three-dimensional coordinates for 29 ground control points (GCPs) and a minimum of 34 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 September 16th 2015 and September 17th 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 95th percentile level, derived according to ASPRS Guidelines, Vertical Accuracy Reporting for LiDAR Data, i.e., based on the 95th percentile error for each required land cover class.

The Consolidated Vertical Accuracy (CVA): 26.9 cm at a 95th percentile level, derived according to ASPRS Guidelines, Vertical Accuracy Reporting for LiDAR Data, i.e., based on the 95th 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 2 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 29 LiDAR control points and 34 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 1002 and two (2) NGS marks named B 240 (PID# CX0118) and MOTEL 2 (PID# CX1482). 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 |
|-------------------|---------|------|-------------|
| 1002 | N/A | TSM | 3d |
| MOTEL 2 | CX1482 | NGS | VERTICALLY |
| B 240 | CX0118 | NGS | VERTICALLY |

Station 1002 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 two 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 B 240 and MOTEL 2 were also used as the primary geodetic control marks on this project.

DATUM REFERENCE AND FINAL COORDINATES

The spatial reference system for the NM White Sands QL0 LiDAR AOI is UTM, Zone 13N, WGS84 meters to 2 decimal places horizontal and NAVD88 meters vertical using the latest geoid model of 2012 (GEOID12B). 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 13-N

VERTICAL DATUM: NAVD88

ZONE: 13-North

GEOID MODEL: GEOID 12B

UNITS: Meters

LiDAR GROUND CONTROL

| Point | UTM Zone 13-North | | Elevation (m) | Description |
|-------|-------------------|-------------|---------------|---------------|
| | Northing (m) | Easting (m) | | |
| 1001A | 3639084.01 | 391763.42 | 1232.79 | LiDAR CONTROL |
| 1002A | 3639427.50 | 389874.91 | 1228.74 | LiDAR CONTROL |
| 1002B | 3639434.34 | 389876.31 | 1228.69 | LiDAR CONTROL |
| 1003 | 3638929.06 | 375679.08 | 1192.73 | LiDAR CONTROL |
| 1004 | 3631471.72 | 381915.37 | 1209.05 | LiDAR CONTROL |
| 1005 | 3637200.44 | 392108.07 | 1236.57 | LiDAR CONTROL |
| 1006 | 3638828.51 | 379162.24 | 1205.71 | LiDAR CONTROL |
| 1006A | 3638816.68 | 379165.19 | 1205.45 | LiDAR CONTROL |
| 1007 | 3639475.34 | 382481.22 | 1214.84 | LiDAR CONTROL |
| 1008 | 3639489.34 | 383746.44 | 1213.29 | LiDAR CONTROL |
| 1008A | 3639476.61 | 383746.15 | 1213.70 | LiDAR CONTROL |
| 1009 | 3639427.46 | 384839.22 | 1211.95 | LiDAR CONTROL |
| 1010 | 3639392.32 | 385951.81 | 1213.06 | LiDAR CONTROL |
| 1011 | 3639519.30 | 387646.74 | 1220.32 | LiDAR CONTROL |
| 1011A | 3639511.43 | 387644.83 | 1219.82 | LiDAR CONTROL |
| 1012 | 3639457.03 | 388708.32 | 1224.39 | LiDAR CONTROL |
| 1012A | 3639449.31 | 388707.59 | 1224.25 | LiDAR CONTROL |
| 1013 | 3639258.16 | 390589.43 | 1230.61 | LiDAR CONTROL |
| 1014 | 3639152.20 | 391497.90 | 1231.74 | LiDAR CONTROL |
| 1015 | 3638629.11 | 391728.40 | 1230.52 | LiDAR CONTROL |
| 1016 | 3638241.08 | 391700.02 | 1232.29 | LiDAR CONTROL |
| 1017 | 3637937.86 | 392021.18 | 1232.39 | LiDAR CONTROL |
| 1018 | 3637672.78 | 392156.47 | 1233.39 | LiDAR CONTROL |
| 1019 | 3638331.16 | 379351.65 | 1206.15 | LiDAR CONTROL |
| 1020 | 3636323.78 | 392109.44 | 1240.69 | LiDAR CONTROL |
| 1021 | 3631819.34 | 381005.61 | 1208.72 | LiDAR CONTROL |
| 1022 | 3632193.25 | 381115.45 | 1208.74 | LiDAR CONTROL |

| Point | UTM Zone 13-North | | Elevation (m) | Description |
|-------|-------------------|-------------|---------------|---------------|
| | Northing (m) | Easting (m) | | |
| 1023 | 3631523.54 | 381113.06 | 1208.92 | LiDAR CONTROL |
| 1024 | 3639225.95 | 385001.75 | 1211.83 | LiDAR CONTROL |

QUALITY CONTROL POINTS

| Point | UTM Zone 13-North | | Elevation (m) | Description |
|-------|-------------------|-------------|---------------|-------------|
| | Northing (m) | Easting (m) | | |
| 2001 | 3636630.035 | 392098.293 | 1239.944 | NVA |
| 2002 | 3634857.349 | 392084.42 | 1241.913 | NVA |
| 2003 | 3637845.771 | 392128.703 | 1232.178 | NVA |
| 2004 | 3638909.191 | 375778.041 | 1192.621 | NVA |
| 2005 | 3638856.083 | 377662.767 | 1202.867 | NVA |
| 2005A | 3638862.414 | 377662.551 | 1202.666 | NVA |
| 2006 | 3639378.296 | 382198.27 | 1211.725 | NVA |
| 2007 | 3639448.643 | 384194.163 | 1211.931 | NVA |
| 2008 | 3639379.215 | 385954.682 | 1212.709 | NVA |
| 2010 | 3639186.136 | 391561.825 | 1232.356 | NVA |
| 2011 | 3638758.301 | 391750.697 | 1230.658 | NVA |
| 2012 | 3638291.727 | 391661.213 | 1232.146 | NVA |
| 2013 | 3638100.353 | 391830.351 | 1232.724 | NVA |
| 2014 | 3637983.542 | 391830.084 | 1231.349 | NVA |
| 2015 | 3637983.842 | 391133.793 | 1234.937 | NVA |
| 2016 | 3638245.684 | 391088.223 | 1230.945 | NVA |
| 2017 | 3638396.787 | 379367.585 | 1205.356 | NVA |
| 2018 | 3637743.906 | 379859.727 | 1205.721 | NVA |
| 2019 | 3638298.943 | 387883.185 | 1219.272 | NVA |
| 2020 | 3637419.446 | 391597.159 | 1235.768 | NVA |
| 2021 | 3631442.343 | 381877.16 | 1208.953 | NVA |
| 2022 | 3639404.766 | 384841.649 | 1211.799 | NVA |
| 2023 | 3639288.898 | 385124.362 | 1211.812 | NVA |
| 2024 | 3639437.065 | 386704.201 | 1215.04 | NVA |
| 2024A | 3639447.135 | 386699.895 | 1215.78 | NVA |
| 2025 | 3639103.068 | 391744.583 | 1232.679 | NVA |
| 3001 | 3639155.697 | 391520.04 | 1231.56 | VVA |
| 3002 | 3637777.363 | 392053.449 | 1231.643 | VVA |

| Point | UTM Zone 13-North | | Elevation (m) | Description |
|-------|-------------------|-------------|---------------|-------------|
| | Northing (m) | Easting (m) | | |
| 3003 | 3637453.052 | 392131.112 | 1233.997 | VVA |
| 3004 | 3637736.653 | 379670.342 | 1205.681 | VVA |
| 3005 | 3634872.998 | 392089.324 | 1241.972 | VVA |
| 3006 | 3637995.697 | 391121.175 | 1234.013 | VVA |
| 3007 | 3638374.798 | 387730.061 | 1219.052 | VVA |
| 3008 | 3639397.632 | 385584.716 | 1212.482 | VVA |

CONTROL BASE STATIONS

| Point | UTM Zone 13-North | | Elevation (m) | Description |
|---------|-------------------|-------------|---------------|-------------|
| | Northing (m) | Easting (m) | | |
| 1002 | 3639073.72 | 380755.23 | 1224.01 | TSM |
| B 240 | 3629372.55 | 393574.86 | 1227.43 | NGS |
| MOTEL 2 | 3624172.52 | 388222.15 | 1221.43 | NGS |

COORDINATE SYSTEM: GEODETIC

HORIZONTAL DATUM: NAD83 (2011) Epoch 2010.00

VERTICAL DATUM: NAVD88

UNITS: Meters

DATE: 12/14/2015

LiDAR GROUND CONTROL

| Point | NAD83 (2011) Epoch 2010.00 | | Ellipsoid Ht. (m) | Description |
|-------|----------------------------|-------------------|-------------------|---------------|
| | N Latitude | W Longitude | | |
| 1001A | 32°53'04.45415" | -106°09'25.61930" | 1209.83 | LiDAR CONTROL |
| 1002A | 32°53'14.92808" | -106°10'38.43528" | 1205.71 | LiDAR CONTROL |
| 1002B | 32°53'15.15072" | -106°10'38.38440" | 1205.67 | LiDAR CONTROL |
| 1003 | 32°52'53.27154" | -106°19'44.43531" | 1169.35 | LiDAR CONTROL |
| 1004 | 32°48'53.64564" | -106°15'41.05922" | 1185.76 | LiDAR CONTROL |
| 1005 | 32°52'03.42190" | -106°09'11.56555" | 1213.60 | LiDAR CONTROL |
| 1006 | 32°52'51.41140" | -106°17'30.36999" | 1182.39 | LiDAR CONTROL |
| 1006A | 32°52'51.02844" | -106°17'30.25114" | 1182.13 | LiDAR CONTROL |
| 1007 | 32°53'13.71265" | -106°15'22.96431" | 1191.59 | LiDAR CONTROL |
| 1008 | 32°53'14.65350" | -106°14'34.28612" | 1190.08 | LiDAR CONTROL |
| 1008A | 32°53'14.24027" | -106°14'34.29142" | 1190.48 | LiDAR CONTROL |

| Point | NAD83 (2011) Epoch 2010.00 | | Ellipsoid Ht. (m) | Description |
|-------|----------------------------|-------------------|-------------------|---------------|
| | N Latitude | W Longitude | | |
| 1009 | 32°53'13.06055" | -106°13'52.20840" | 1188.76 | LiDAR CONTROL |
| 1010 | 32°53'12.33903" | -106°13'09.38084" | 1189.91 | LiDAR CONTROL |
| 1011 | 32°53'17.09284" | -106°12'04.21600" | 1197.22 | LiDAR CONTROL |
| 1011A | 32°53'16.83675" | -106°12'04.28630" | 1196.72 | LiDAR CONTROL |
| 1012 | 32°53'15.46199" | -106°11'23.33903" | 1201.32 | LiDAR CONTROL |
| 1012A | 32°53'15.21095" | -106°11'23.36367" | 1201.18 | LiDAR CONTROL |
| 1013 | 32°53'09.68813" | -106°10'10.86812" | 1207.61 | LiDAR CONTROL |
| 1014 | 32°53'06.57339" | -106°09'35.86529" | 1208.77 | LiDAR CONTROL |
| 1015 | 32°52'49.67237" | -106°09'26.77518" | 1207.56 | LiDAR CONTROL |
| 1016 | 32°52'37.06393" | -106°09'27.70310" | 1209.31 | LiDAR CONTROL |
| 1017 | 32°52'27.33330" | -106°09'15.21847" | 1209.42 | LiDAR CONTROL |
| 1018 | 32°52'18.77479" | -106°09'09.90181" | 1210.43 | LiDAR CONTROL |
| 1019 | 32°52'35.33979" | -106°17'22.84834" | 1182.83 | LiDAR CONTROL |
| 1020 | 32°51'34.95945" | -106°09'11.14427" | 1217.71 | LiDAR CONTROL |
| 1021 | 32°49'04.57793" | -106°16'16.19820" | 1185.42 | LiDAR CONTROL |
| 1022 | 32°49'16.76025" | -106°16'12.14769" | 1185.44 | LiDAR CONTROL |
| 1023 | 32°48'55.01618" | -106°16'11.93037" | 1185.62 | LiDAR CONTROL |
| 1024 | 32°53'06.57962" | -106°13'45.86415" | 1188.65 | LiDAR CONTROL |

QUALITY CONTROL POINTS

| Point | NAD83 (2011) Epoch 2010.00 | | Ellipsoid Ht. (m) | Description |
|-------|----------------------------|-------------------|-------------------|-------------|
| | N Latitude | W Longitude | | |
| 2001 | 32°51'44.89897" | -106°09'11.70191" | 1216.97 | NVA |
| 2002 | 32°50'47.33935" | -106°09'11.49089" | 1218.92 | NVA |
| 2003 | 32°52'24.38160" | -106°09'11.04293" | 1209.22 | NVA |
| 2004 | 32°52'52.66692" | -106°19'40.61817" | 1169.25 | NVA |
| 2005 | 32°52'51.70697" | -106°18'28.07663" | 1179.52 | NVA |
| 2005A | 32°52'51.91241" | -106°18'28.08796" | 1179.32 | NVA |
| 2006 | 32°53'10.45236" | -106°15'33.80746" | 1188.47 | NVA |
| 2007 | 32°53'13.50319" | -106°14'17.03943" | 1188.72 | NVA |
| 2008 | 32°53'11.91475" | -106°13'09.26453" | 1189.55 | NVA |
| 2010 | 32°53'07.69807" | -106°09'33.41987" | 1209.39 | NVA |
| 2011 | 32°52'53.87472" | -106°09'25.97159" | 1207.70 | NVA |
| 2012 | 32°52'38.69443" | -106°09'29.21775" | 1209.17 | NVA |

| Point | NAD83 (2011) Epoch 2010.00 | | Ellipsoid Ht. (m) | Description |
|-------|----------------------------|-------------------|-------------------|-------------|
| | N Latitude | W Longitude | | |
| 2013 | 32°52'32.54123" | -106°09'22.62923" | 1209.76 | NVA |
| 2014 | 32°52'28.74859" | -106°09'22.59027" | 1208.38 | NVA |
| 2015 | 32°52'28.50988" | -106°09'49.38026" | 1211.94 | NVA |
| 2016 | 32°52'36.99485" | -106°09'51.24471" | 1207.95 | NVA |
| 2017 | 32°52'37.47679" | -106°17'22.26623" | 1182.04 | NVA |
| 2018 | 32°52'16.47529" | -106°17'03.02577" | 1182.41 | NVA |
| 2019 | 32°52'37.55917" | -106°11'54.58424" | 1196.17 | NVA |
| 2020 | 32°52'10.35097" | -106°09'31.31384" | 1212.78 | NVA |
| 2021 | 32°48'52.67724" | -106°15'42.51481" | 1185.67 | NVA |
| 2022 | 32°53'12.32467" | -106°13'52.10482" | 1188.61 | NVA |
| 2023 | 32°53'08.66983" | -106°13'41.17429" | 1188.63 | NVA |
| 2024 | 32°53'14.07325" | -106°12'40.44894" | 1191.91 | NVA |
| 2024A | 32°53'14.39856" | -106°12'40.61909" | 1192.65 | NVA |
| 2025 | 32°53'05.06621" | -106°09'26.35235" | 1209.72 | NVA |
| 3001 | 32°53'06.69489" | -106°09'35.01488" | 1208.59 | VVA |
| 3002 | 32°52'22.13389" | -106°09'13.90955" | 1208.68 | VVA |
| 3003 | 32°52'11.63189" | -106°09'10.78520" | 1211.03 | VVA |
| 3004 | 32°52'16.16494" | -106°17'10.30835" | 1182.36 | VVA |
| 3005 | 32°50'47.84916" | -106°09'11.30885" | 1218.98 | VVA |
| 3006 | 32°52'28.89027" | -106°09'49.87079" | 1211.02 | VVA |
| 3007 | 32°52'39.96545" | -106°12'00.50898" | 1195.94 | VVA |
| 3008 | 32°53'12.37366" | -106°13'23.50884" | 1189.31 | VVA |

CONTROL BASE STATIONS

| Point | NAD83 (2011) Epoch 2010.00 | | Ellipsoid Ht. (m) | Description |
|---------|----------------------------|-------------------|----------------------|-------------|
| | N Latitude | W Longitude | | |
| 1002 | 32°53'00.00147" | -106°16'29.19191" | 1200.72 | TSM |
| B 240 | 32°47'49.78438" | -106°08'11.89507" | 1204.45 | NGS |
| MOTEL 2 | 32°44'59.03792" | -106°11'35.40767" | 1198.27 | 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.

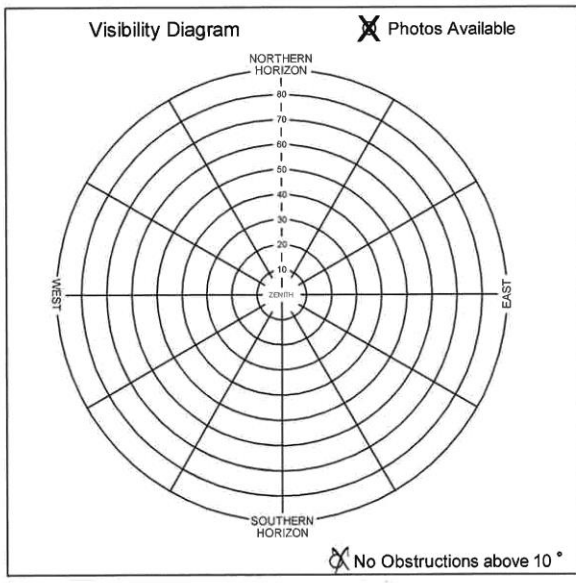
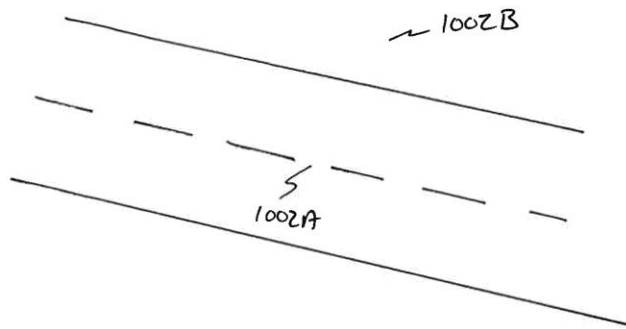


1002, 3S, 16SEP2015

White Sands LiDAR Survey - LiDAR Control



| | | |
|--|------------------------------------|--------------------------|
| LiDAR Control point # 1002A 1002 | General location White Sands AZ | Ground Class |
| Latitude N 32 ° 53 ' 14 " | Longitude W 106 ° 10 ' 38 " | Calendar Date 9/16/15 |
| | | Observer Initials ZJH |



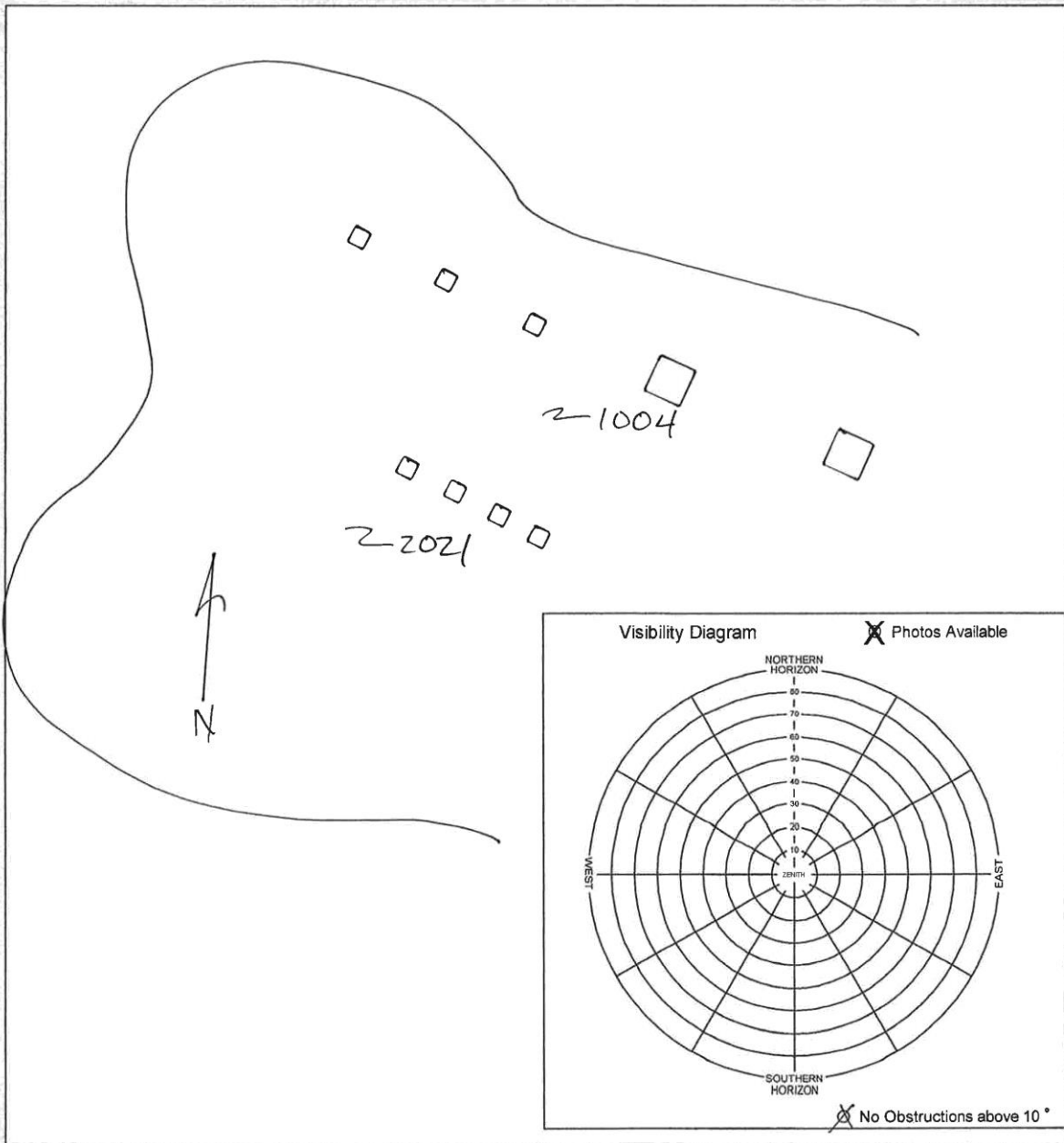


1004, 3W, 16SEP2015

White Sands LiDAR Survey - LiDAR Control



| | | | |
|-------------------------------------|------------------------------------|--------------------------|--------------------------|
| LIDAR Control point # 1004, 2021 | General location White Sands AZ | Ground Class | |
| Latitude N 32° 48' 52" | Longitude W 106° 15' 42" | Calendar Date 9/17/15 | Observer Initials ZJH |



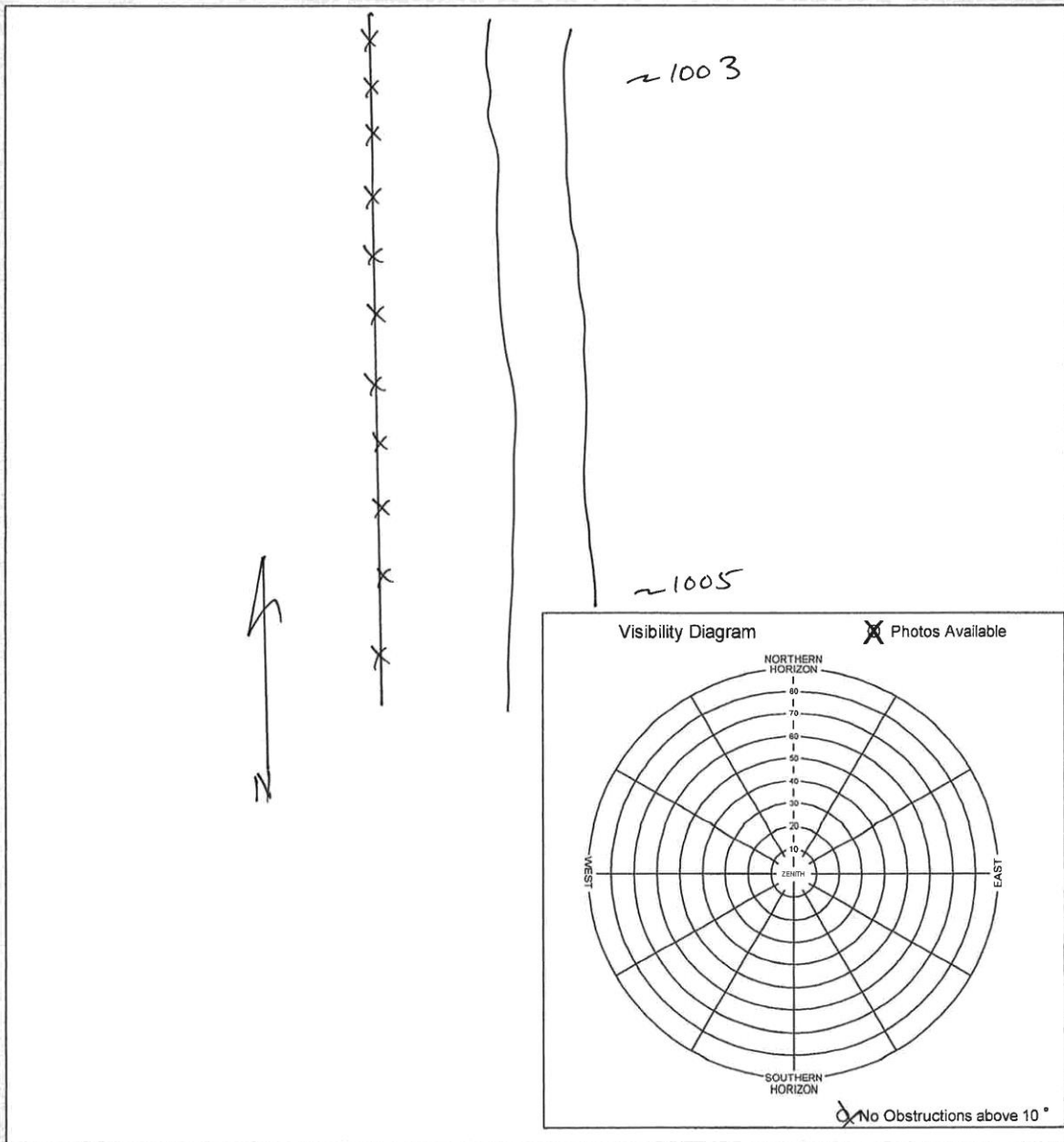


1005, 3W, 16SEP2015

White Sands LiDAR Survey - LiDAR Control



| | | | | |
|-------------------------------------|--|-------------------------------------|--------------------------|------------------------------|
| LiDAR Control point # 3003, 1005 | | General location White sands, AZ | | Ground Class |
| Latitude N 32 ° 52 ' 06 " | | Longitude W 106 ° 09 ' 11 " | | Calendar Date 9 / 16 / 17 |
| | | | Observer Initials ZJH | |



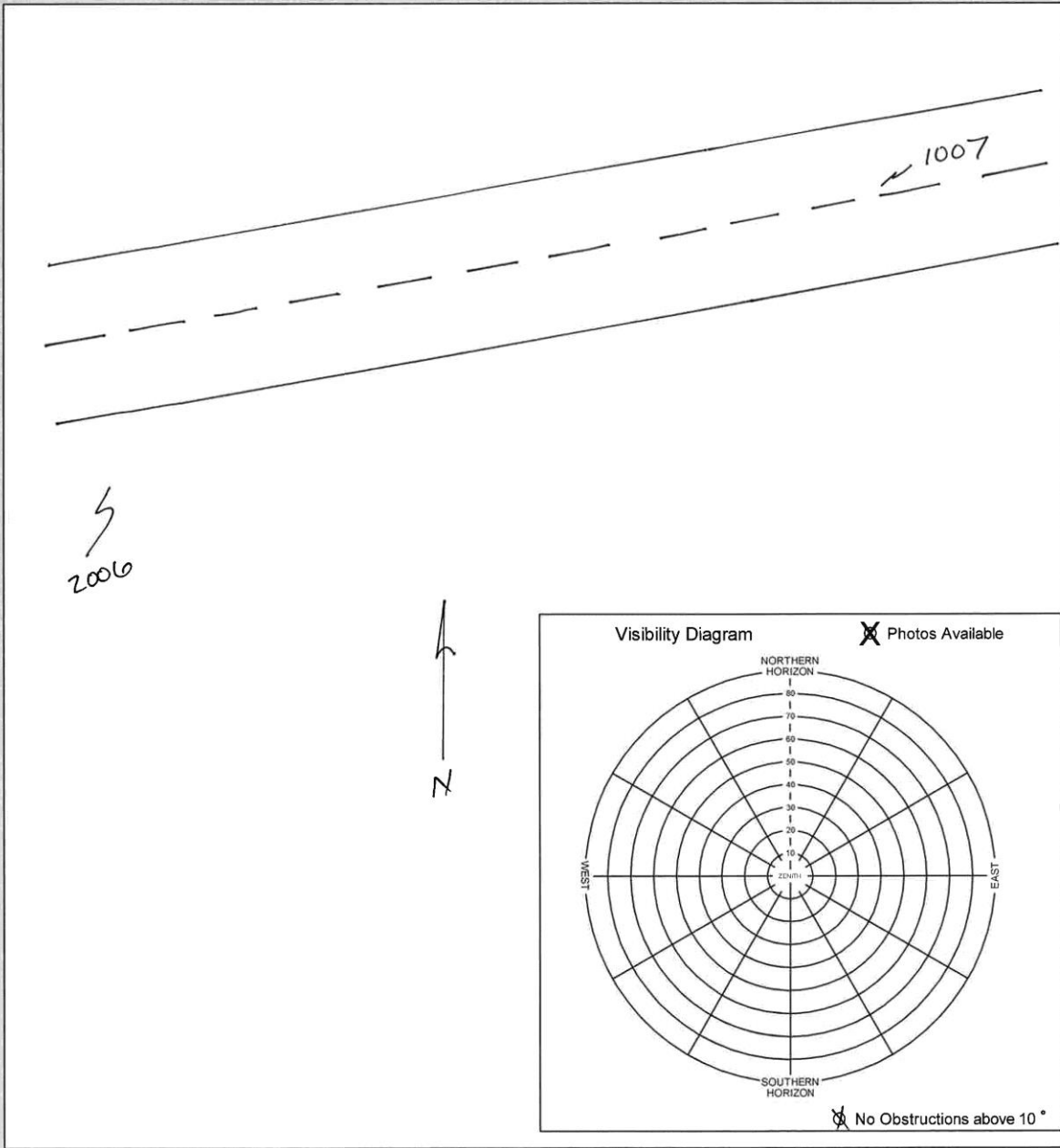


1007, 3S, 16SEP2015

White Sands LiDAR Survey - LiDAR Control



| | | | | | |
|--------------------------------------|--|---------------------------------|--|------------------------------|--|
| LiDAR Control point # 2006 , 1007 | | General location white sands | | Ground Class | |
| Latitude N ° ' " | | Longitude W ° ' " | | Calendar Date 9 / 16 / 15 | |
| | | | | Observer Initials ZJH | |



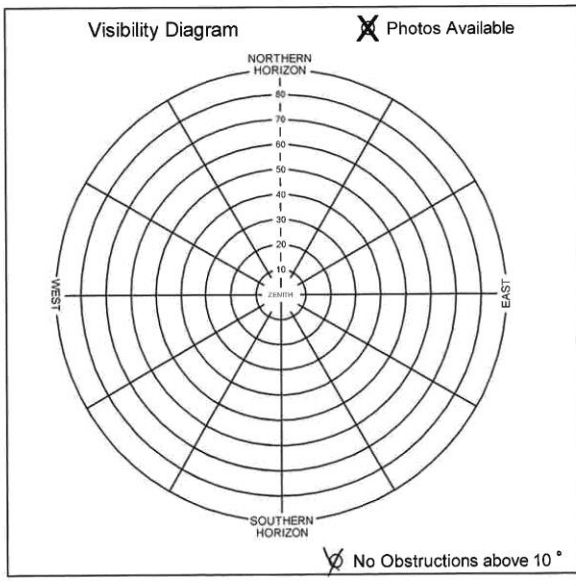
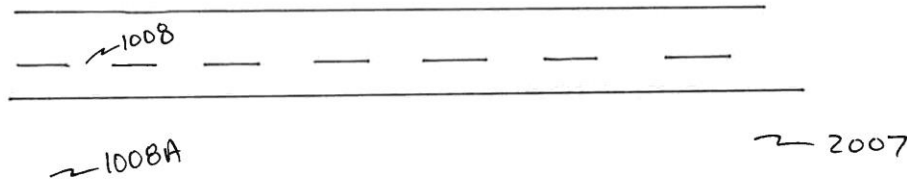


1008, 3S, 16SEP2015

White Sands LiDAR Survey - LiDAR Control



| | | | | | |
|-------------------------------------|--|---------------------------------|--|--------------------------|--|
| LiDAR Control point # 1008, 2007 | | General location White sands | | Ground Class | |
| Latitude N 32 ° 53 ' 13 " | | Longitude W 106 ° 14 ' 28 " | | Calendar Date 9/16/15 | |
| | | | | Observer Initials ZJH | |



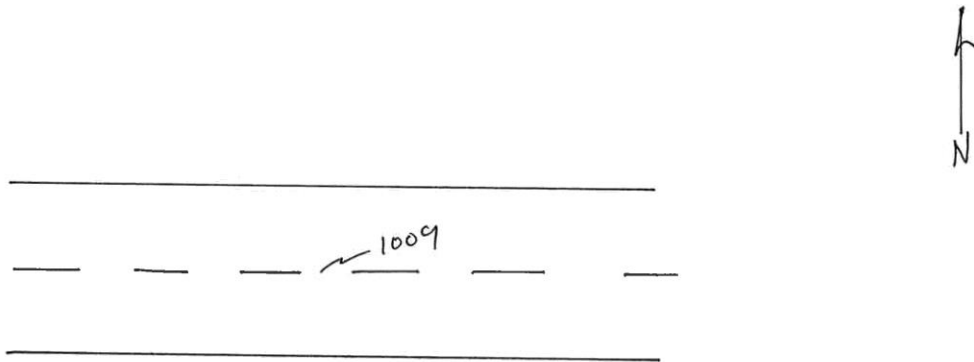


1009, 3S, 16SEP2015

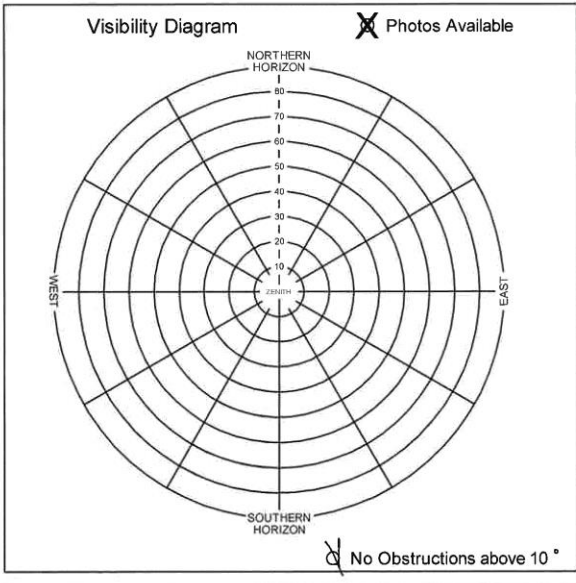
White Sands LiDAR Survey - LiDAR Control



| | | | | | |
|------------------------------------|--|---------------------------------|--|--------------------------|--|
| LiDAR Control point # 1009 2022 | | General location White Sands | | Ground Class | |
| Latitude N 32° 53' 12" | | Longitude W 106° 13' 52" | | Calendar Date 9/16/15 | |
| | | | | Observer Initials ZJH | |



2022



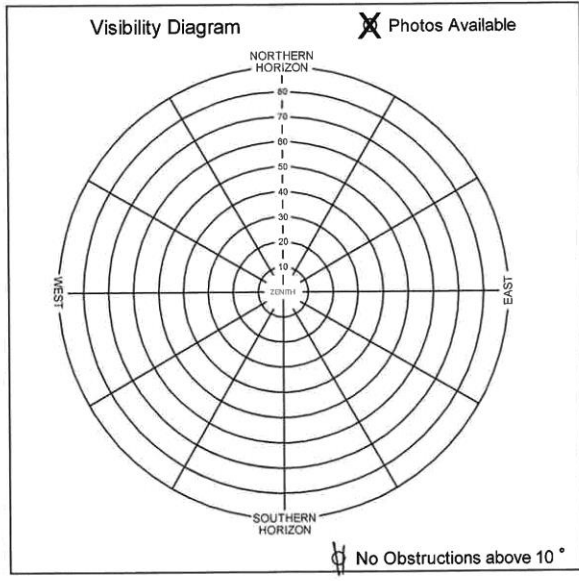
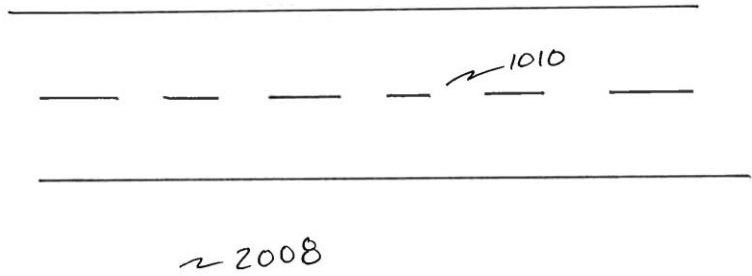


1010, 3S, 16SEP2015

White Sands LiDAR Survey - LiDAR Control



| | | | |
|---|--------------------------------|---------------------------------|--------------------------|
| LiDAR Control point # 1010 2008 | | General location White Sands | Ground Class |
| Latitude N 32 ° 53 ' 59 " | Longitude W 106 ° 13 ' 09 " | Calendar Date 9 / 16 / 15 | Observer Initials ZJH |



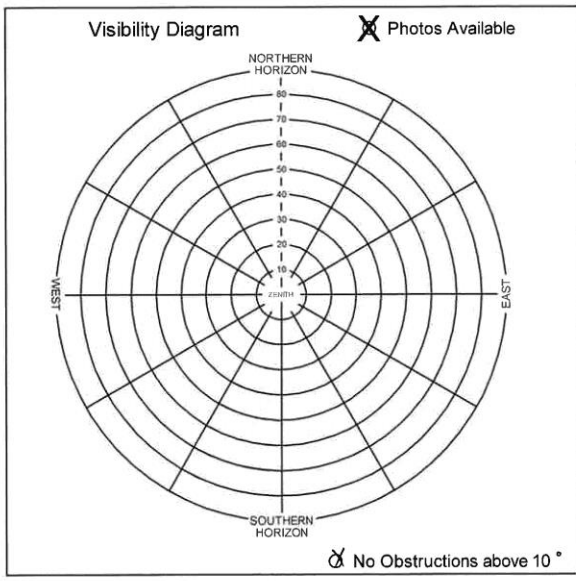
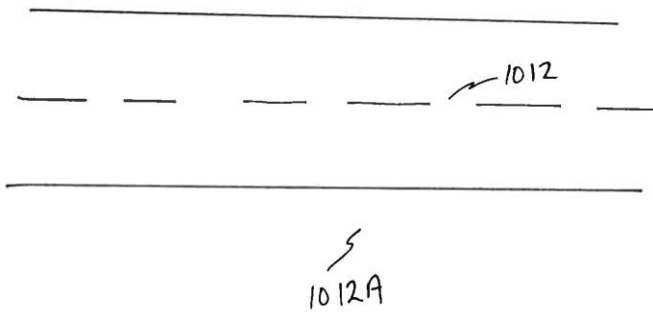


1012, 3S, 16SEP2015

White Sands LiDAR Survey - LiDAR Control



| | | | |
|-------------------------------|---------------------------------|------------------------------|--------------------------|
| LiDAR Control point # 1012 | General location White Sands | Ground Class | |
| Latitude N 32 ° 53 ' 15 " | Longitude W 106 ° 11 ' 23 " | Calendar Date 9 / 16 / 15 | Observer Initials ZJH |



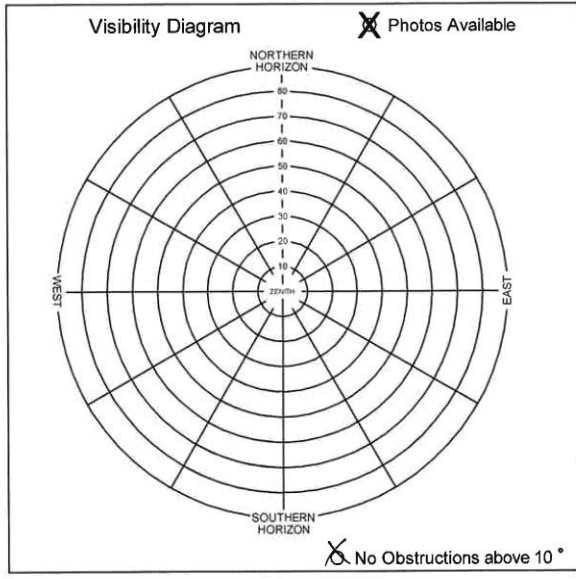
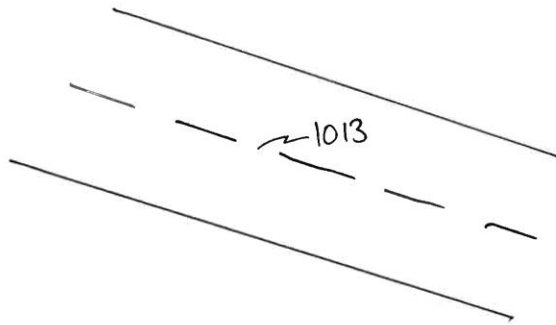


1013, 3S, 16SEP2015

White Sands LiDAR Survey - LiDAR Control



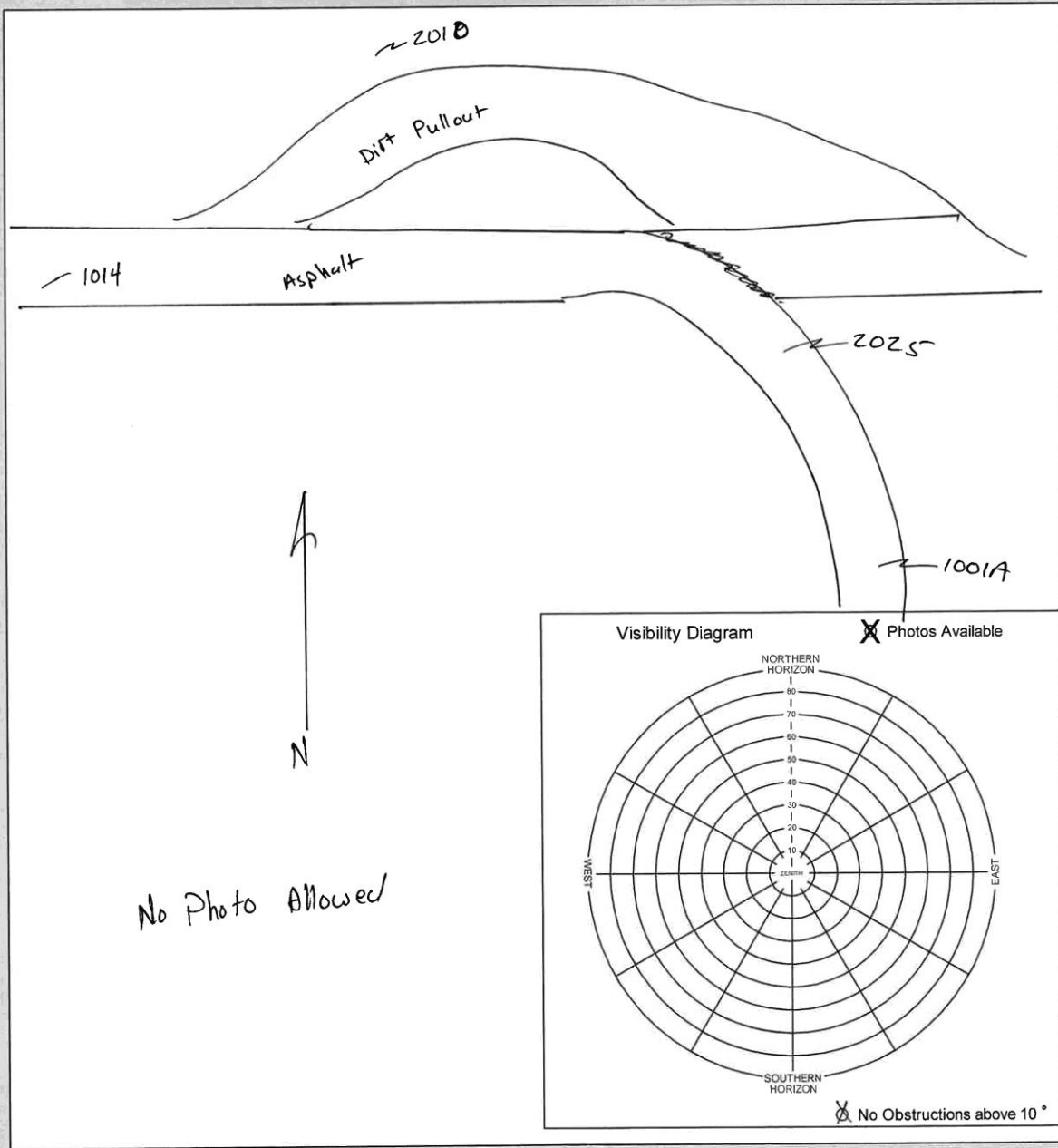
| | | | |
|-------------------------------|------------------------------------|------------------------------|--------------------------|
| LiDAR Control point # 1013 | General location White sands Az | Ground Class | |
| Latitude N 32 ° 53 ' 08 " | Longitude W 106 ° 10 ' 08 " | Calendar Date 9 / 16 / 15 | Observer Initials ZJH |



White Sands LiDAR Survey - LiDAR Control



| | | | | | |
|-------------------------|--|------------------|--|---------------|-------------------|
| LiDAR Control point # | | General location | | Ground Class | |
| 1014, 2010, 2025, 1001A | | White Sands | | | |
| Latitude | | Longitude | | Calendar Date | |
| N 106° 09' 05" | | W 106° 09' 31" | | / / | |
| | | | | | Observer Initials |
| | | | | | ZJH |



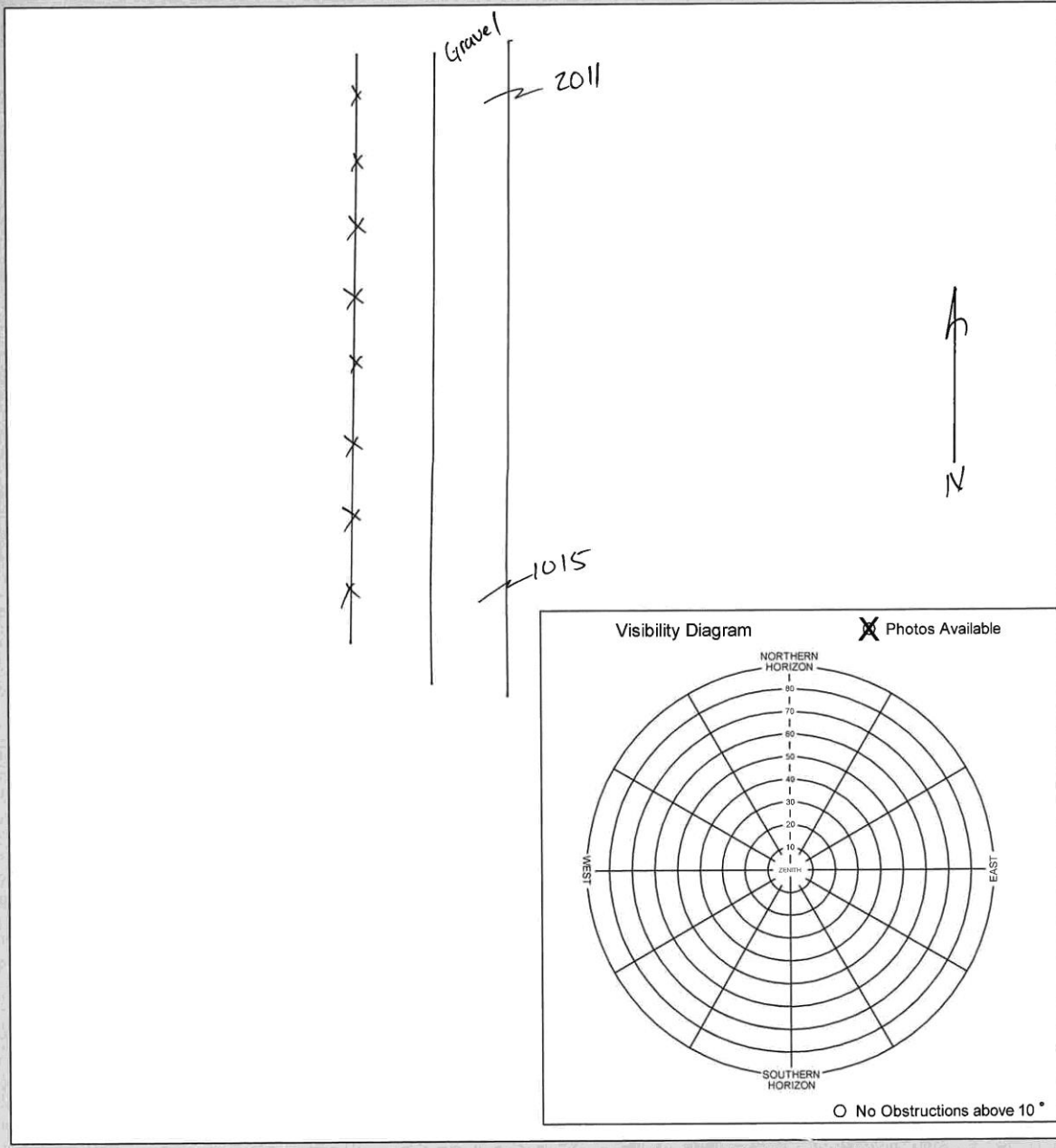


1015, 3W, 16SEP2015

White Sands LiDAR Survey - LiDAR Control



| | | | |
|-------------------------------------|---------------------------------|------------------------------|--------------------------|
| LiDAR Control point # 2011, 1015 | General location White Sands | Ground Class | |
| Latitude N 32 ° 52 ' 52 " | Longitude W 106 ° 09 ' 28 " | Calendar Date 9 / 16 / 15 | Observer Initials ZJH |



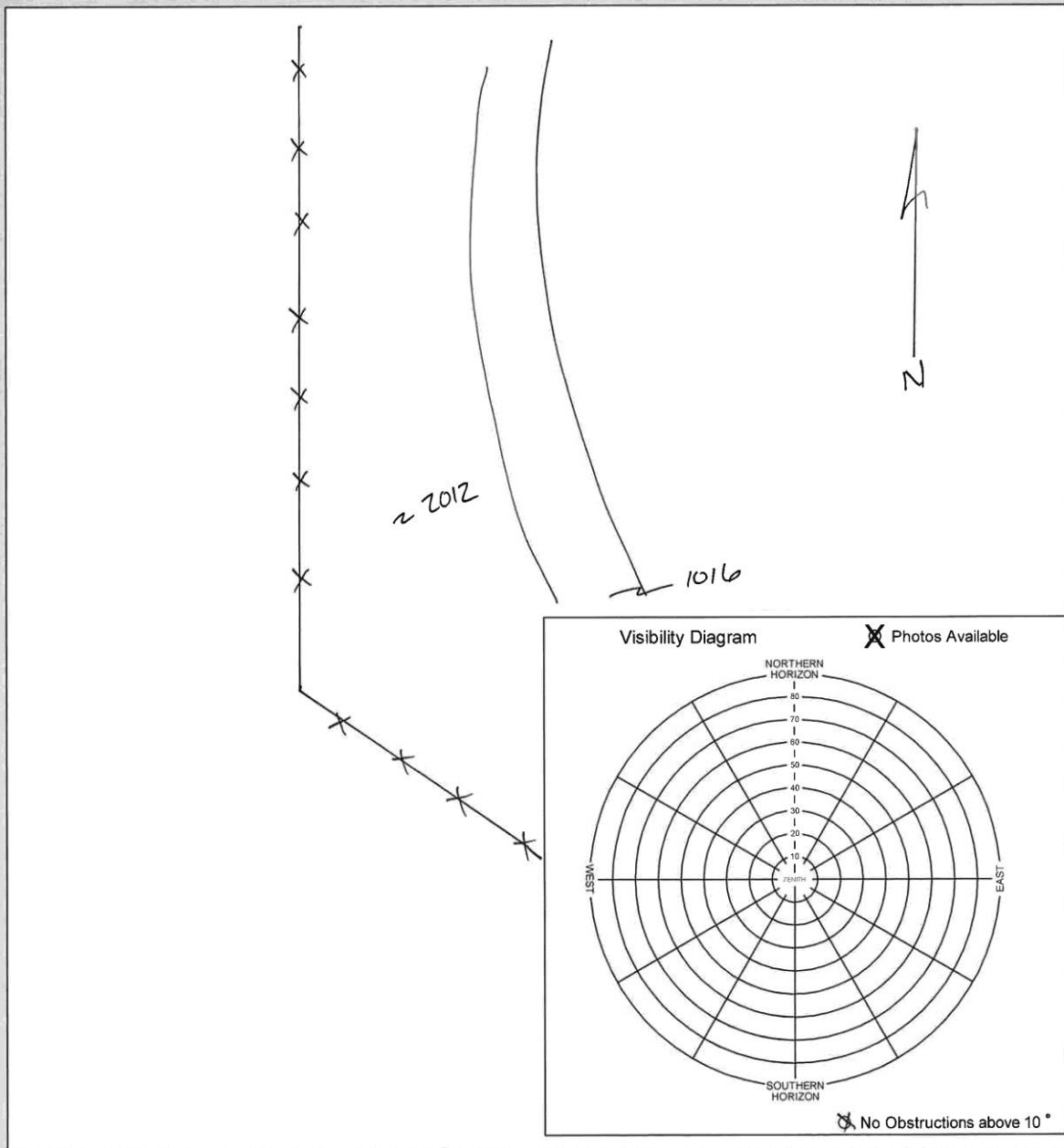


1016, 3W, 16SEP2015

White Sands LiDAR Survey - LiDAR Control



| | | | | | |
|-------------------------------------|--|------------------------------------|--|--------------------------|--|
| LiDAR Control point # 2012, 1016 | | General location White Sands Az | | Ground Class | |
| Latitude N 32° 52' 38" | | Longitude W 106° 09' 29" | | Calendar Date 9/16/15 | |
| | | | | Observer Initials ZJH | |



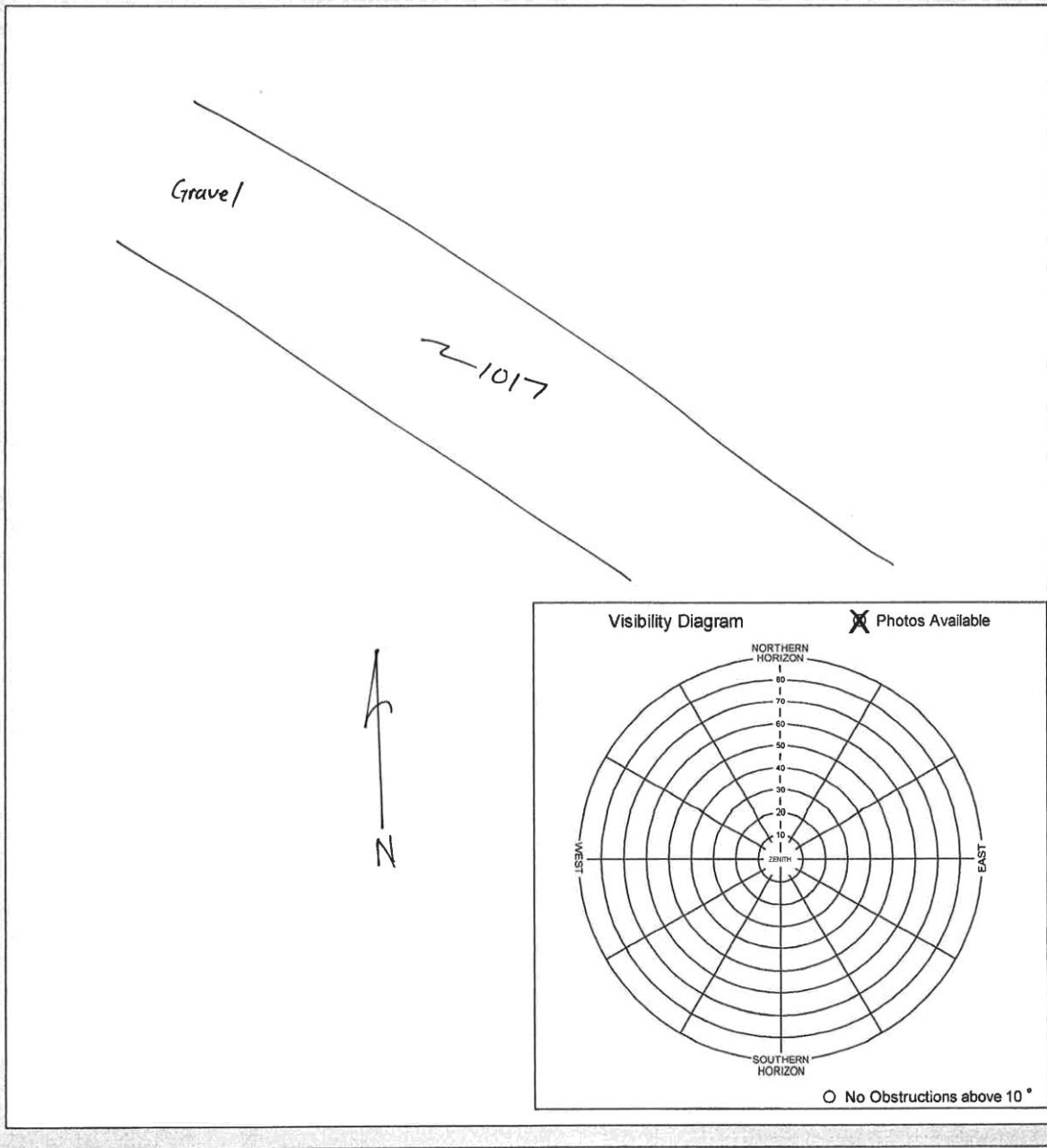


1017, 2, 16SEP2015

White Sands LiDAR Survey - LiDAR Control



| | | | |
|-------------------------------|---------------------------------|------------------------------|--------------------------|
| LIDAR Control point # 1017 | General location White sands | Ground Class | |
| Latitude N 32° 52' 27" | Longitude W 106° 09' 15" | Calendar Date 9 / 16 / 15 | Observer Initials ZJH |



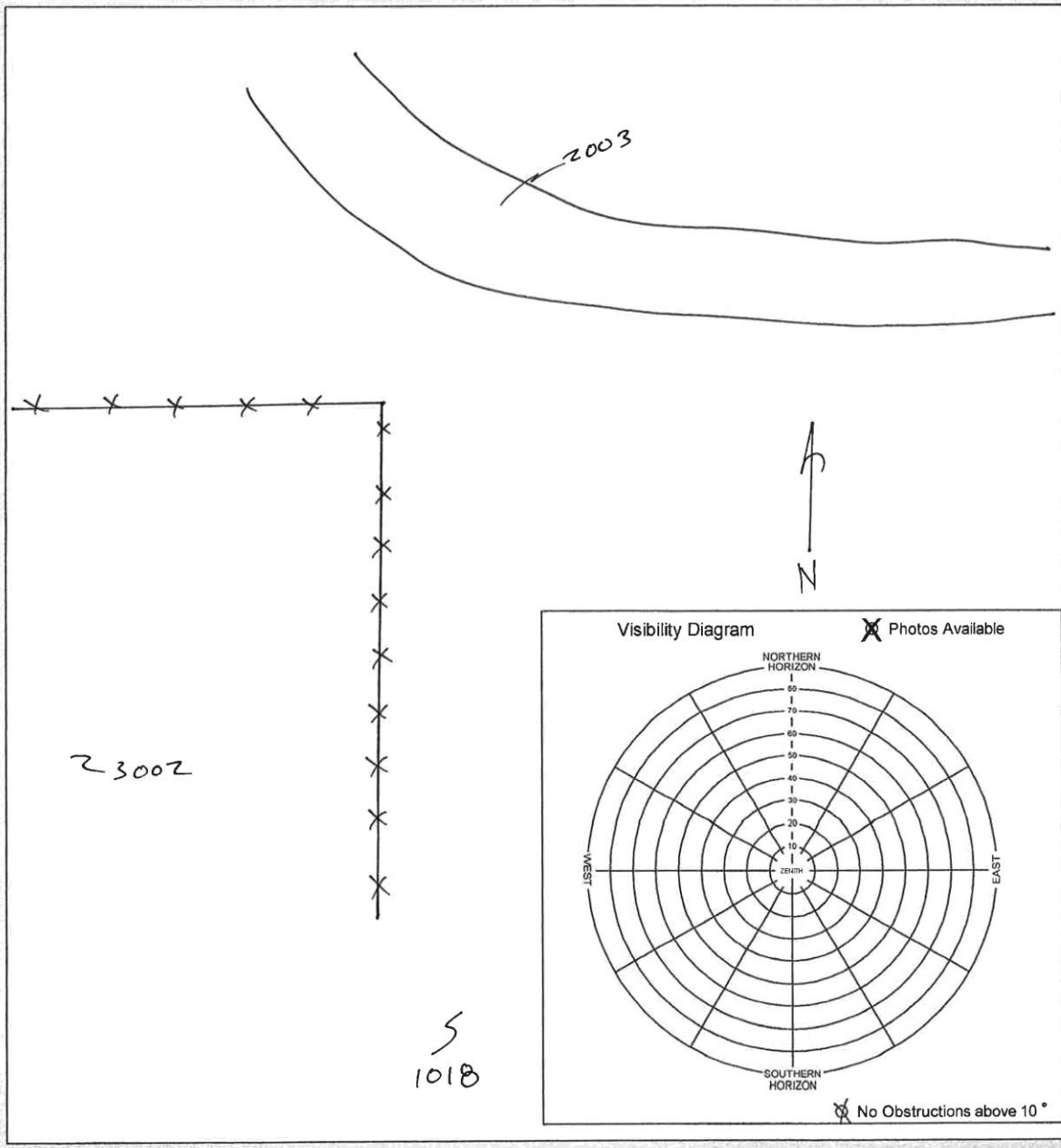


1018, 2, 16SEP2015

White Sands LiDAR Survey - LiDAR Control



| | | | | | |
|---|--|---------------------------------|--|------------------------------|--|
| LIDAR Control point # 2003 , 3002 , 1018 | | General location White Sands | | Ground Class | |
| Latitude N 32 ° 52 ' 27 " | | Longitude W 106 ° 09 ' 15 " | | Calendar Date 9 / 16 / 15 | |
| | | | | Observer Initials ZJH | |



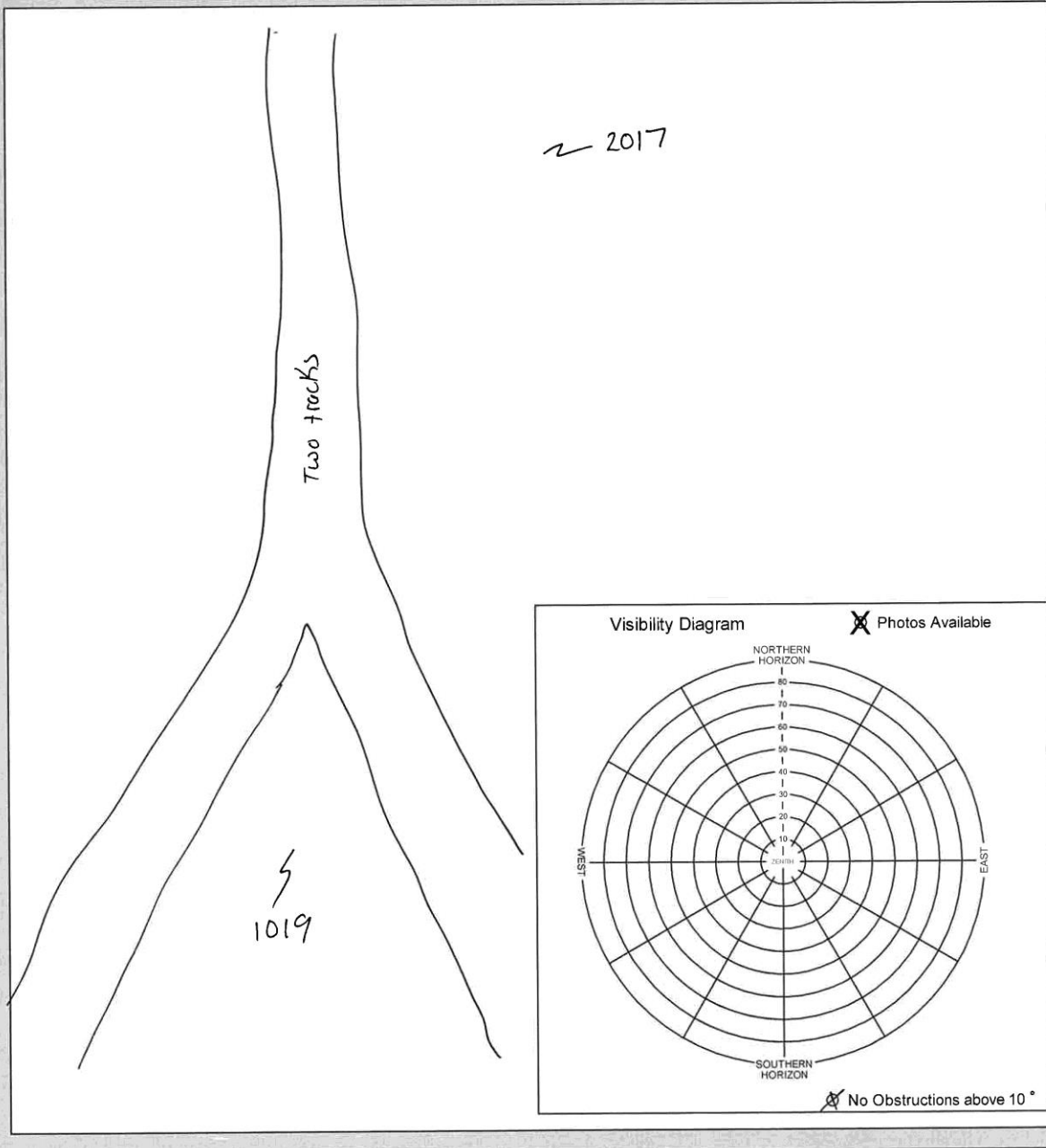


1019, 2, 16SEP2015

White Sands LiDAR Survey - LiDAR Control



| | | | |
|--------------------------------------|------------------------------------|------------------------------|--------------------------|
| LiDAR Control point # 2017 , 1019 | General location White sands AZ | Ground Class | |
| Latitude N 32 ° 52 ' 35 " | Longitude W 106 ° 17 ' 22 " | Calendar Date 9 / 16 / 15 | Observer Initials ZJH |



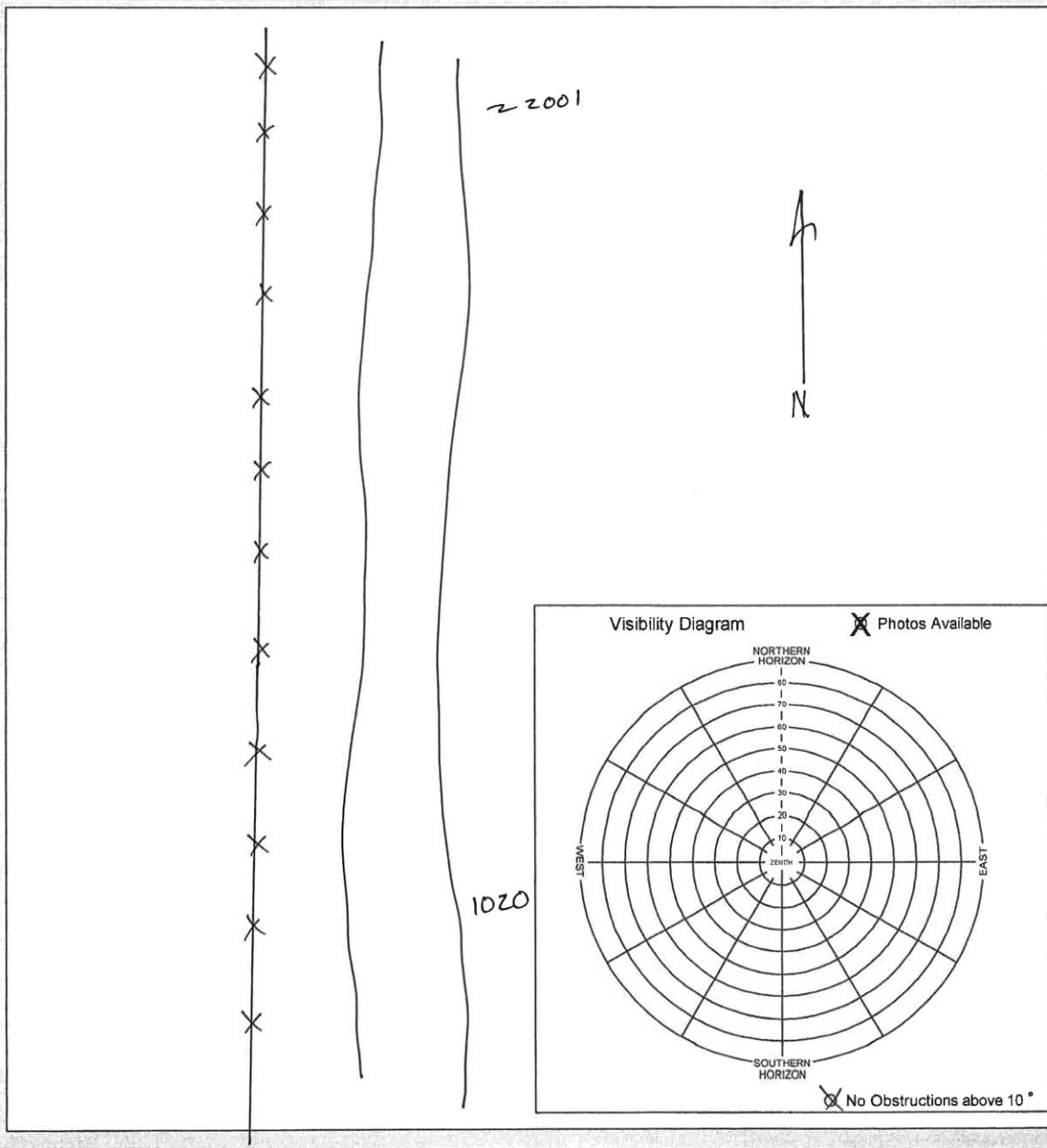


1020, 3W, 16SEP2015

White Sands LiDAR Survey - LiDAR Control



| | | | |
|-------------------------------------|-------------------------------------|--------------------------|--------------------------|
| LIDAR Control point # 2001, 1020 | General location White Sands, AZ | Ground Class | |
| Latitude N 32° 51' 39" | Longitude W 106° 09' 10" | Calendar Date 9/16/17 | Observer Initials ZJH |



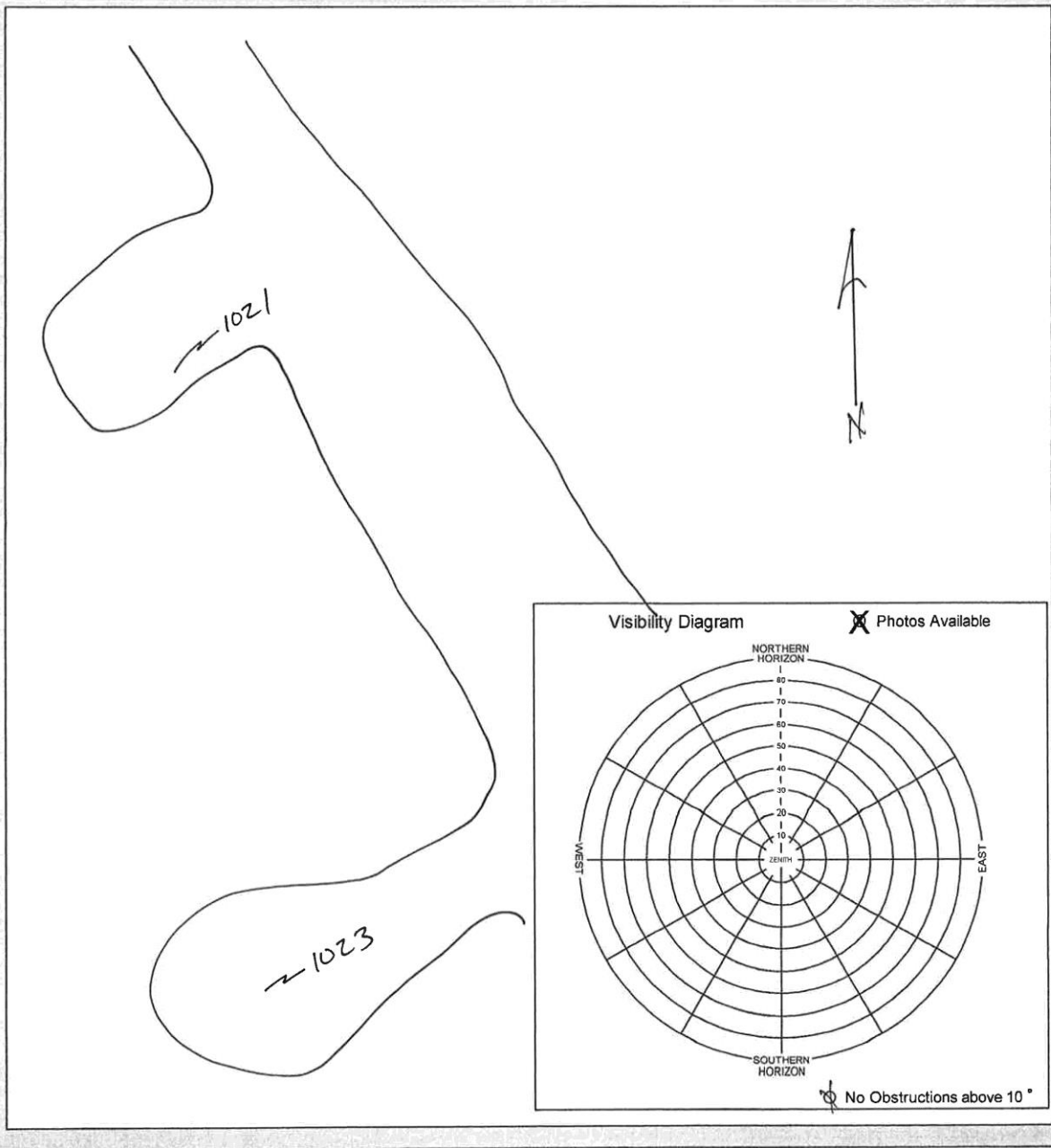


1021, 3E, 16SEP2015

White Sands LiDAR Survey - LiDAR Control



| | | | |
|-------------------------------------|------------------------------------|----------------------|--------------------------|
| LIDAR Control point # 1021, 1023 | General location White Sands AZ | Ground Class | |
| Latitude N 32 ° 48 ' 59 " | Longitude W 106 ° 16 ' 16 " | Calendar Date / / | Observer Initials ZJH |



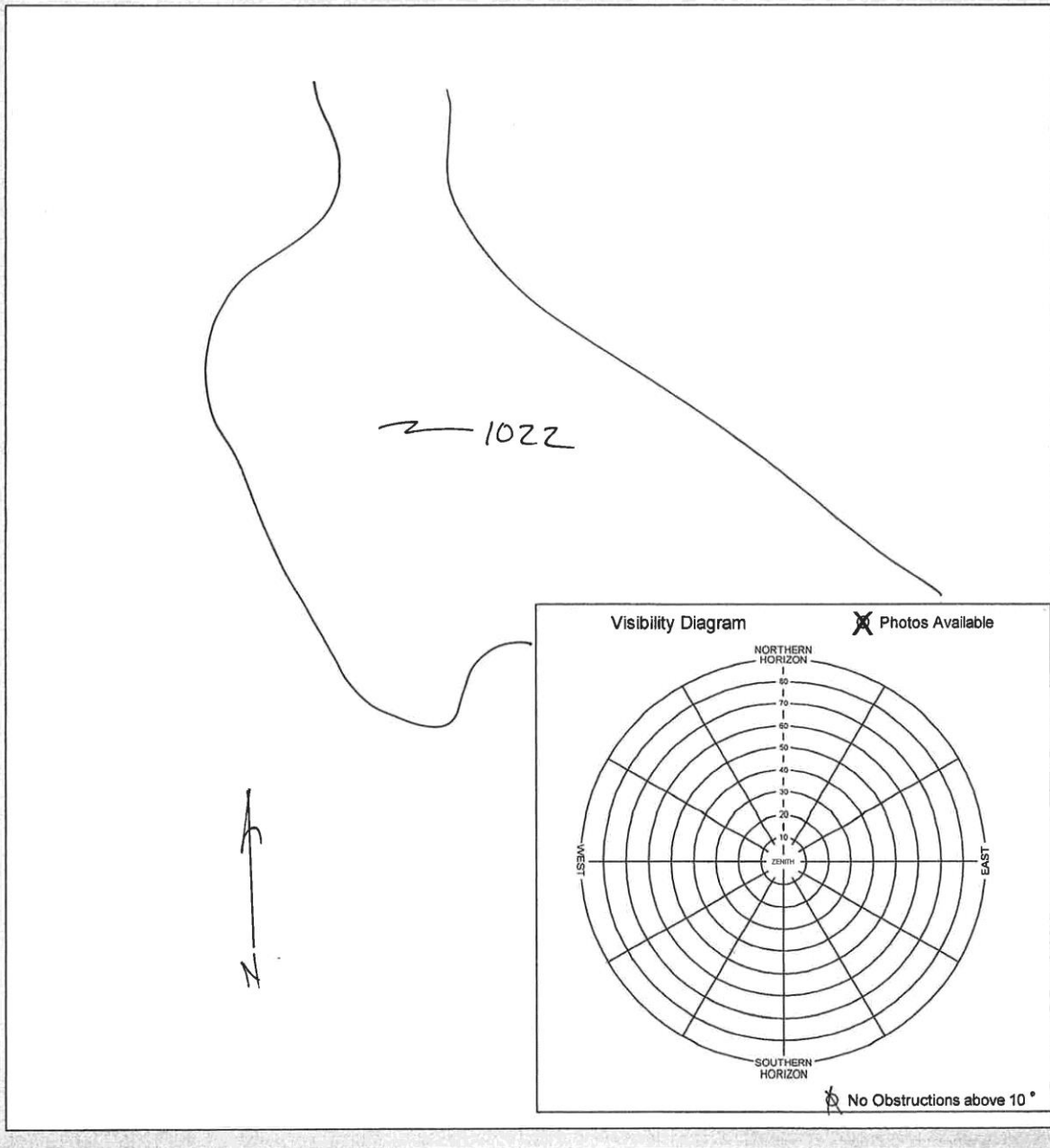


1022, 3N, 16SEP2015

White Sands LiDAR Survey - LiDAR Control



| | | | |
|-------------------------------|------------------------------------|--------------------------|--------------------------|
| LIDAR Control point # 1022 | General location White Sands AZ | Ground Class | |
| Latitude N 32 ° 49 ' 16 " | Longitude W 106 ° 16 ' 11 " | Calendar Date 9/17/15 | Observer Initials ZJH |



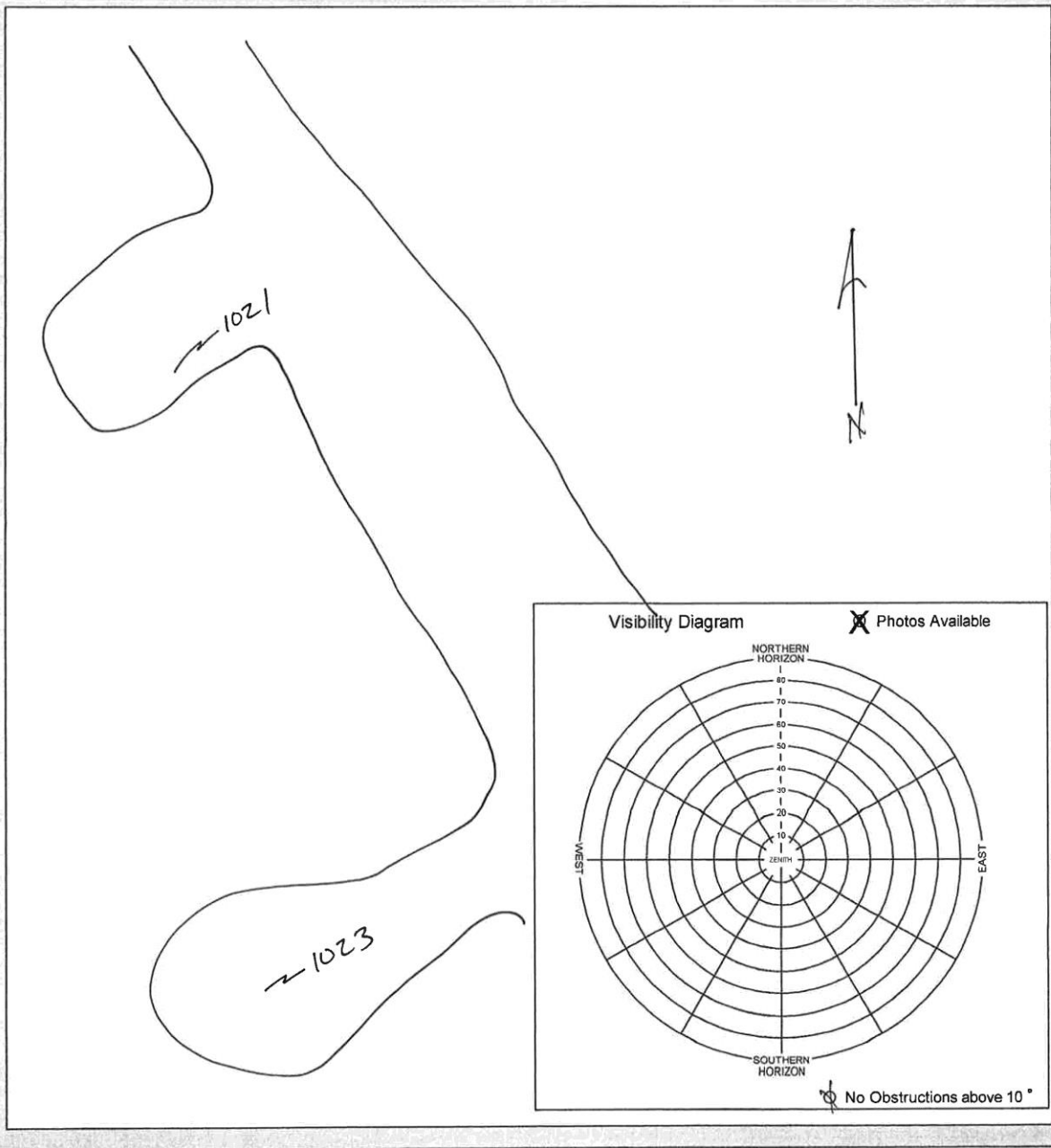


1023, 3N, 16SEP2015

White Sands LiDAR Survey - LiDAR Control



| | | |
|-------------------------------------|------------------------------------|--------------------------|
| LIDAR Control point # 1021, 1023 | General location White Sands AZ | Ground Class |
| Latitude N 32 ° 48 ' 59 " | Longitude W 106 ° 16 ' 16 " | Calendar Date / / |
| | | Observer Initials ZJH |





1024, 3W, 16SEP2015

White Sands LiDAR Survey - LiDAR Control



| | | | | | |
|------------------------------------|--|---------------------------------|--|------------------------------|--|
| LiDAR Control point # 2023 4000 | | General location White Sands | | Ground Class | |
| Latitude N 32° 53' 07" | | Longitude W 106° 13' 41" | | Calendar Date 9 / 16 / 15 | |
| | | | | Observer Initials ZJH | |

~ 2023

↖ 4000

Visibility Diagram Photos Available

 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.

```
CX0118 DESIGNATION - B 240
CX0118 PID - CX0118
CX0118 STATE/COUNTY- NM/OTERO
CX0118 COUNTRY - US
CX0118 USGS QUAD - GARTON LAKE (1982)
CX0118
CX0118 *CURRENT SURVEY CONTROL
CX0118
CX0118* NAD 83(1986) POSITION- 32 47 49.8 (N) 106 08 11.9 (W) HD_HELD2
CX0118* NAVD 88 ORTHO HEIGHT - 1227.426 (meters) 4026.98 (feet) ADJUSTED
CX0118
CX0118 GEOID HEIGHT - -22.98 (meters) GEOID12B
CX0118 DYNAMIC HEIGHT - 1225.641 (meters) 4021.12 (feet) COMP
CX0118 MODELED GRAVITY - 979,142.0 (mgal) NAVD 88
CX0118
CX0118 VERT ORDER - SECOND CLASS 0
CX0118
CX0118.The horizontal coordinates were established by autonomous hand held GPS
CX0118.observations and have an estimated accuracy of +/- 10 meters.
CX0118.
CX0118.The orthometric height was determined by differential leveling and
CX0118.adjusted by the NATIONAL GEODETIC SURVEY
CX0118.in June 1991.
CX0118
CX0118.The dynamic height is computed by dividing the NAVD 88
CX0118.geopotential number by the normal gravity value computed on the
CX0118.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
CX0118.degrees latitude (g = 980.6199 gals.).
CX0118
CX0118.The modeled gravity was interpolated from observed gravity values.
CX0118
CX0118; North East Units Estimated Accuracy
CX0118;SPC NM C - 199,265. 510,617. MT (+/- 10 meters HH2 GPS)
CX0118
CX0118 SUPERSEDED SURVEY CONTROL
CX0118
CX0118 NGVD 29 (??/??/92) 1226.841 (m) 4025.06 (f) ADJ UNCH 2 0
CX0118
CX0118.Superseded values are not recommended for survey control.
CX0118
CX0118.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
CX0118.See file dsdata.txt to determine how the superseded data were derived.
CX0118
CX0118 U.S. NATIONAL GRID SPATIAL ADDRESS: 13SCS9357429373(NAD 83)
CX0118
CX0118_MARKER: DB = BENCH MARK DISK
CX0118_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
CX0118_SP_SET: SET IN TOP OF CONCRETE MONUMENT
CX0118_STAMPING: B 240 1952
CX0118_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO
CX0118+STABILITY: SURFACE MOTION
CX0118_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
CX0118+SATELLITE: SATELLITE OBSERVATIONS - April 02, 2005
CX0118
CX0118 HISTORY - Date Condition Report By
CX0118 HISTORY - 1952 MONUMENTED CGS
```

CX0118 HISTORY - 1986 GOOD DMA
 CX0118 HISTORY - 20040211 GOOD ORBITE
 CX0118 HISTORY - 20050402 GOOD USPSQD
 CX0118
 CX0118 STATION DESCRIPTION
 CX0118
 CX0118'DESCRIBED BY COAST AND GEODETIC SURVEY 1952
 CX0118'12.9 MI SW FROM ALAMOGORDO.
 CX0118'12.9 MILES SOUTHWEST ALONG US HIGHWAY 70 FROM THE POST OFFICE AT
 CX0118'ALAMOGORDO, 1.0 MILE SOUTH OF BENCH MARK D 221, 98 FEET NORTHWEST OF
 CX0118'THE CENTER LINE OF THE HIGHWAY, 38 FEET NORTHEAST OF THE CENTER OF THE
 CX0118'WIRE GATE, 2 FEET SOUTHEAST OF A FENCE, 3 FEET SOUTHWEST OF A WITNESS
 CX0118'POST, SET IN THE TOP OF A CONCRETE POST WHICH PROJECTS 0.8 FOOT ABOVE
 CX0118'THE GROUND.
 CX0118
 CX0118 STATION RECOVERY (1986)
 CX0118
 CX0118'RECOVERY NOTE BY DEFENSE MAP AGENCY 1986 (PET)
 CX0118'RECOVERED IN GOOD CONDITION.
 CX0118
 CX0118 STATION RECOVERY (2004)
 CX0118
 CX0118'RECOVERY NOTE BY ORBITECH INC 2004 (SHG)
 CX0118'RECOVERED IN GOOD CONDITION.
 CX0118
 CX0118 STATION RECOVERY (2005)
 CX0118
 CX0118'RECOVERY NOTE BY US POWER SQUADRON 2005 (FM)
 CX0118'RECOVERED IN GOOD CONDITION.

CX1482 DESIGNATION - MOTEL 2
 CX1482 PID - CX1482
 CX1482 STATE/COUNTY- NM/OTERO
 CX1482 COUNTRY - US
 CX1482 USGS QUAD - FOSTER LAKE (1982)
 CX1482
 CX1482 *CURRENT SURVEY CONTROL
 CX1482
 CX1482* NAD 83(1992) POSITION- 32 44 59.03914(N) 106 11 35.40678(W) NO CHECK
 CX1482* NAVD 88 ORTHO HEIGHT - 1221.43 (+/-2cm) 4007.3 (feet) VERTCON
 CX1482
 CX1482 GEOID HEIGHT - -23.163 (meters) GEOID12B
 CX1482 LAPLACE CORR - 3.50 (seconds) DEFLEC12B
 CX1482 HORZ ORDER - SECOND
 CX1482 VERT ORDER - THIRD ? (See Below)
 CX1482
 CX1482.The horizontal coordinates were established by classical geodetic methods
 CX1482.and adjusted by the National Geodetic Survey in December 1993.
 CX1482.
 CX1482.No horizontal observational check was made to the station.
 CX1482.
 CX1482.The NAVD 88 height was computed by applying the VERTCON shift value to
 CX1482.the NGVD 29 height (displayed under SUPERSEDED SURVEY CONTROL.)
 CX1482
 CX1482.Significant digits in the geoid height do not necessarily reflect accuracy.
 CX1482.GEOID12B height accuracy estimate available [here](#).
 CX1482
 CX1482.The vertical order pertains to the NGVD 29 superseded value.
 CX1482
 CX1482.The Laplace correction was computed from DEFLEC12B derived deflections.
 CX1482
 CX1482. The following values were computed from the NAD 83(1992) position.
 CX1482
 CX1482;

| | North | East | Units | Scale | Factor | Converg. |
|-----------------|-----------------|--------------|-------|------------|--------|----------|
| CX1482;SPC NM C | - 194,000.588 | 505,325.493 | MT | 0.99990035 | +0 01 | 50.7 |
| CX1482;SPC NM C | - 636,483.60 | 1,657,888.72 | sFT | 0.99990035 | +0 01 | 50.7 |
| CX1482;UTM 13 | - 3,624,172.563 | 388,222.175 | MT | 0.99975406 | -0 38 | 43.9 |

 CX1482

| | Elev Factor | x | Scale Factor | = | Combined Factor |
|-----------------|--------------|---|--------------|---|-----------------|
| CX1482!SPC NM C | - 0.99981190 | x | 0.99990035 | = | 0.99971227 |
| CX1482!UTM 13 | - 0.99981190 | x | 0.99975406 | = | 0.99956601 |


```

CX1482
CX1482:          Primary Azimuth Mark          Grid Az
CX1482:SPC NM C    - MOTEL AZ MK RESET          027 57 26.4
CX1482:UTM 13     - MOTEL AZ MK RESET          028 38 01.0
CX1482
CX1482|-----|
CX1482| PID      Reference Object          Distance      Geod. Az |
CX1482|          |                          |              | dddmmss.s |
CX1482| CX1986 MOTEL AZ MK RESET          APPROX. 1.4 KM 0275917.1 |
CX1482| CC6967 MOTEL 2 RM 3              9.129 METERS 13419 |
CX1482| CC6968 MOTEL 2 RM 4              7.995 METERS 20723 |
CX1482| CX0108 MOTEL                      27.346 METERS 30329 |
CX1482|-----|
CX1482
CX1482          SUPERSEDED SURVEY CONTROL
CX1482
CX1482 NAD 83(1986)- 32 44 59.04654(N) 106 11 35.40776(W) AD( ) 2
CX1482 NAD 27      - 32 44 58.73126(N) 106 11 33.43197(W) AD( ) 2
CX1482 NGVD 29 (07/19/86) 1220.86 (m) 4005.4 (f) LEVELING 3
CX1482
CX1482.Superseded values are not recommended for survey control.
CX1482
CX1482.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
CX1482.See file dsdata.txt to determine how the superseded data were derived.
CX1482
CX1482 U.S. NATIONAL GRID SPATIAL ADDRESS: 13SCS8822224172(NAD 83)
CX1482
CX1482 MARKER: DS = TRIANGULATION STATION DISK
CX1482 SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
CX1482 SP_SET: TOP OF SQUARE CONCRETE MONUMENT
CX1482 MAGNETIC: R = STEEL ROD IMBEDDED IN MONUMENT
CX1482
CX1482 HISTORY      - Date      Condition      Report By
CX1482 HISTORY      - 1980      MONUMENTED      NGS
CX1482
CX1482          STATION DESCRIPTION
CX1482
CX1482'DESCRIBED BY NATIONAL GEODETIC SURVEY 1980 (CLN)
CX1482'STATION IS LOCATED ABOUT 18 MILES SOUTHWEST OF ALAMOGORDO, ALONG THE
CX1482'SOUTH SIDE OF U.S. HIGHWAY 70 AND 82 AND ON FEDERAL LAND.
CX1482'
CX1482'STATION IS REACHED FROM THE JUNCTION OF U.S. HIGHWAY 54, 70 AND 82 AT
CX1482'SOUTH EDGE OF ALAMOGORDO. GO SOUTH, SOUTHWESTERLY ON
CX1482'U.S. HIGHWAY 70 AND 82 FOR 13.6 MILES TO THE WHITE SANDS NATIONAL
CX1482'MONUMENT ON THE RIGHT, CONTINUE AHEAD ON HIGHWAY FOR 1.45 MILES TO A
CX1482'CONCRETE CULVERT UNDER HIGHWAY AND AZIMUTH MARK IN TOP OF HEADWALL ON
CX1482'RIGHT, CONTINUE AHEAD ON HIGHWAY FOR 0.9 MILE TO STATION ON LEFT.
CX1482'
CX1482'STATION IS A STANDARD DISK, STAMPED---MOTEL 2 1980--- SET IN THE TOP
CX1482'OF A ROUND CONCRETE MONUMENT PROJECTING ABOUT 3 INCHES, 85 FEET
CX1482'SOUTHEAST OF PRESENT HIGHWAY RIGHT-OF-WAY FENCE, 3 FEET SOUTHWEST OF
CX1482'A METAL WITNESS POST, 10 FEET SOUTHEAST OF A TRACK ROAD.
CX1482'
CX1482'REFERENCE MARK 3 IS A STANDARD DISK, STAMPED---MOTEL 2 NO 3 1980---
CX1482'SET IN THE TOP OF A ROUND CONCRETE MONUMENT PROJECTING ABOUT 6
CX1482'INCHES, 18 FEET SOUTHEAST OF THE TRACK ROAD.
CX1482'
CX1482'REFERENCE MARK 4 IS A STANDARD DISK, STAMPED---MOTEL 2 NO 4 1980---
CX1482'SET IN THE TOP OF A ROUND CONCRETE MONUMENT PROJECTING ABOUT 2 INCHES,
CX1482'85 FEET SOUTHEAST OF PRESENT HIGHWAY RIGHT-OF-WAY FENCE, 18 FEET
CX1482'SOUTHEAST OF THE TRACK ROAD.

```

SECTION 6: GPS CONTROL DIAGRAM

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

