DPH-11 Report on Absolute Vertical Accuracy

The USGS Lidar Base Specification Version 1.3 states: "Absolute vertical accuracy of the lidar data and the derived DEM will be assessed and reported in accordance with the ASPRS (2014). Two broad land cover types shall be assessed: vegetated and nonvegetated. Three absolute accuracy values shall be assessed and reported: (1) NVA for the point data, (2) NVA for the DEM, and (3) VVA for the DEM. The minimum NVA and VVA requirements for all data, using the ASPRS methodology, are listed in Table 4. Both the NVA and VVA required values shall be met."

Table 4. Absolute vertical accuracy for light detection and ranging data and digital elevation models.

[QL, quality level, $RMSE_z$, root mean square error in the z direction; NVA, nonvegetated vertical accuracy; VVA, vegetated vertical accuracy; m, meter; ≤, less than or equal to]

Quality level	$RMSE_z$ (nonvegetated) (m)	NVA at the 95-percent confidence level (m)	VVA at the 95th percentile (m)
QL0	≤0.050	≤0.098	≤0.15
QL1	≤0.100	≤0.196	≤0.30
QL2	≤0.100	≤0.196	≤0.30
QL3	≤0.200	≤0.392	≤0.60

The purpose of this section is to report on the absolute vertical accuracy of the lidar data and DEMs generated from it by testing for NVA (Nonvegetated Vertical Accuracy) and VVA (Vegetated Vertical Accuracy) against surveyed ground check points.

DPH-11 Report on Absolute Vertical Accuracy - continued

Data Source - Y:\Mapping\Projects\65220171_USGS-TX_West_Texas\Production\Final_Client_Deliverables\Lot8_utm13\metadata\shapefiles\TX_WestTexas_Lot8_50NVA_39VVA_pts_u13.shp

Units: Meter (/Feet)

Vertical Accuracy Class tested: 10-cm

Check Points in defined project area (DPA):	89
Check Points with Lidar Coverage	89
Check Points with Lidar Coverage (NVA)	50
Check Points with Lidar Coverage (VVA)	39
Average Z Error (NVA)	-0.001/-0.002
Maximum Z Error (NVA)	0.105/0.343
Median Z Error (NVA)	0.002/0.005
Minimum Z Error (NVA)	-0.302/-0.990
Standard deviation of Vertical Error (NVA)	0.068/0.225
Skewness of Vertical Error (NVA)	-1.959
Kurtosis of Vertical Error (NVA)	6.650
Non-vegetated Vertical Accuracy (NVA) RMSE(z) [1]	0.068/0.222 PASS
Non-vegetated Vertical Accuracy (NVA) at the 95% Confidence Level +/- [1]	0.133/0.436 PASS
FGDC/NSSDA Vertical Accuracy at the 95% Confidence Level +/-	0.133/0.436
Non-vegetated Vertical Accuracy (NVA) RMSE(z) (DEM) [2]	0.066/0.218 PASS
Non-vegetated Vertical Accuracy (NVA) at the 95% Confidence Level (DEM) +/- [2]	0.130/0.426 PASS
Vegetated Vertical Accuracy (VVA) at the 95th Percentile (DEM) +/- [2]	0.210/0.688 PASS

This data set was tested to meet ASPRS Positional Accuracy Standard for Digital Geospatial Data (2014) for a 10-cm RMSEz Vertical Accuracy Class. Actual NVA accuracy was found to be RMSEz = 6.8cm, equating to +/- 13.3cm at the 95% confidence level. Actual VVA accuracy was found to be +/- 21.0cm at the 95th percentile.

[1] This value is calculated from TIN-based testing of the lidar point cloud data.

[2] This value is calculated from RAM-based grid testing of the lidar data. The grid cells are sized according to the Quality Level selected, and are defined in the USGS NGP Lidar Base Specification Version 1.3 (page 24, Table 6).

DPH-11 Report on Absolute Vertical Accuracy - continued

The purpose of this section is to report the results of measuring the lidar point cloud data against surveyed ground NVA (nonvegetated vertical accuracy) check points. All XY coordinates and Z values reported are in the selected data units.

NVA (lidar data)

ID	X	Y	Coverage	Z	Z From Lidar	Z Error	Minimum Z	Median Z	Maximum Z	Intensity	Scan Angle Rank	Returns	Description	Comments
1018	634141.537	3444862.012	Yes	853.846	853.797	-0.049	853.782	853.797	853.806	5022	1501	1,1,1		
1036	600595.742	3450850.156	Yes	1024.275	1024.222	-0.053	1024.217	1024.227	1024.227	3906	-67	1,1,1		
1044	580088.551	3425234.701	Yes	1410.708	1410.677	-0.031	1410.662	1410.67	1410.691	3352	-1857	1,1,1		
1083	608903.821	3459940.154	Yes	936.126	936.149	0.023	936.132	936.151	936.152	7374	365	1,1,1		
1088	586365.642	3460431.369	Yes	1046.818	1046.826	0.008	1046.819	1046.82	1046.878	4517	-2365	1,1,1		
1092	610552.228	3409708.935	Yes	1187.823	1187.805	-0.018	1187.785	1187.803	1187.82	3353	-375	1,1,1		
1100	624572.188	3452505.972	Yes	874.132	874.129	-0.003	874.125	874.127	874.143	6803	-95	1,1,1		
1101	581345.965	3437167.374	Yes	1255.886	1255.96	0.074	1255.94	1255.979	1255.989	2582	2663	1,1,1		
1111	665191.938	3428054.696	Yes	905.672	905.631	-0.041	905.626	905.631	905.634	5651	1259	1,1,1		
1145	574666.775	3437544.935	Yes	1279.47	1279.463	-0.007	1279.452	1279.463	1279.497	2666	-2408	1,1,1		
1157	653914.554	3414361.584	Yes	1010.991	1010.956	-0.035	1010.948	1010.959	1010.961	6238	366	1,1,1		
1169	621198.64	3429504.109	Yes	965.064	965.139	0.075	965.096	965.139	965.139	7108	-2666	1,1,1		
1171	630861.685	3429001.211	Yes	906.407	906.432	0.025	906.419	906.428	906.447	3991	-90	1,1,1		
1175	577741.478	3469255.342	Yes	1091.759	1091.792	0.033	1091.777	1091.789	1091.8	7529	2470	1,1,1		
1176	611736.607	3447059.943	Yes	948.451	948.494	0.043	948.481	948.491	948.503	7496	2896	1,1,1		
1191	664091.954	3447464.213	Yes	844.311	844.221	-0.090	844.212	844.226	844.255	5527	-3281	1,1,1		
1200	610109.775	3423719.32	Yes	1063.086	1063.111	0.025	1063.098	1063.13	1063.139	4321	1035	1,1,1		
1207	581024.988	3415641.785	Yes	1530.531	1530.474	-0.057	1530.464	1530.478	1530.482	3209	813	1,1,1		
1212	601637.828	3464631.795	Yes	950.709	950.808	0.099	950.781	950.794	950.816	3770	1570	1,1,1		
1222	615100.062	3465347.4	Yes	886.607	886.616	0.009	886.612	886.613	886.626	7952	465	1,1,1		
1231	624903.865	3471433.73	Yes	848.852	848.903	0.051	848.896	848.91	848.922	6414	-2515	1,1,1		
1236	659577.812	3474095.739	Yes	784.419	784.434	0.015	784.426	784.436	784.436	8510	-338	1,1,1		
1237	579612.012	3406462.007	Yes	1674.76	1674.735	-0.025	1674.719	1674.748	1674.749	2886	-1553	1,1,1		
1241	577002.508	3430159.824	Yes	1336.814	1336.79	-0.024	1336.775	1336.788	1336.791	5896	-607	1,1,1		
1254	599315.656	3433288.247	Yes	1145.552	1145.631	0.079	1145.617	1145.629	1145.64	3233	-510	1,1,1		
1255	635920.4	3454356.936	Yes	818.83	818.812	-0.018	818.81	818.812	818.813	3478	2540	1,1,1		
1256	651359.255	3425488.898	Yes	950.494	950.568	0.074	950.56	950.575	950.587	5871	-293	1,1,1		
1259	646555.027	3472150.341	Yes	786.183	786.172	-0.011	786.171	786.173	786.175	11253	1831	1,1,1		
1262	615574.712	3419373.289	Yes	1082.803	1082.817	0.014	1082.815	1082.818	1082.828	4875	69	1,1,1		
1268	652757.558	3462906.156	Yes	796.393	796.362	-0.031	796.359	796.363	796.371	5630	-1586	1,1,1		

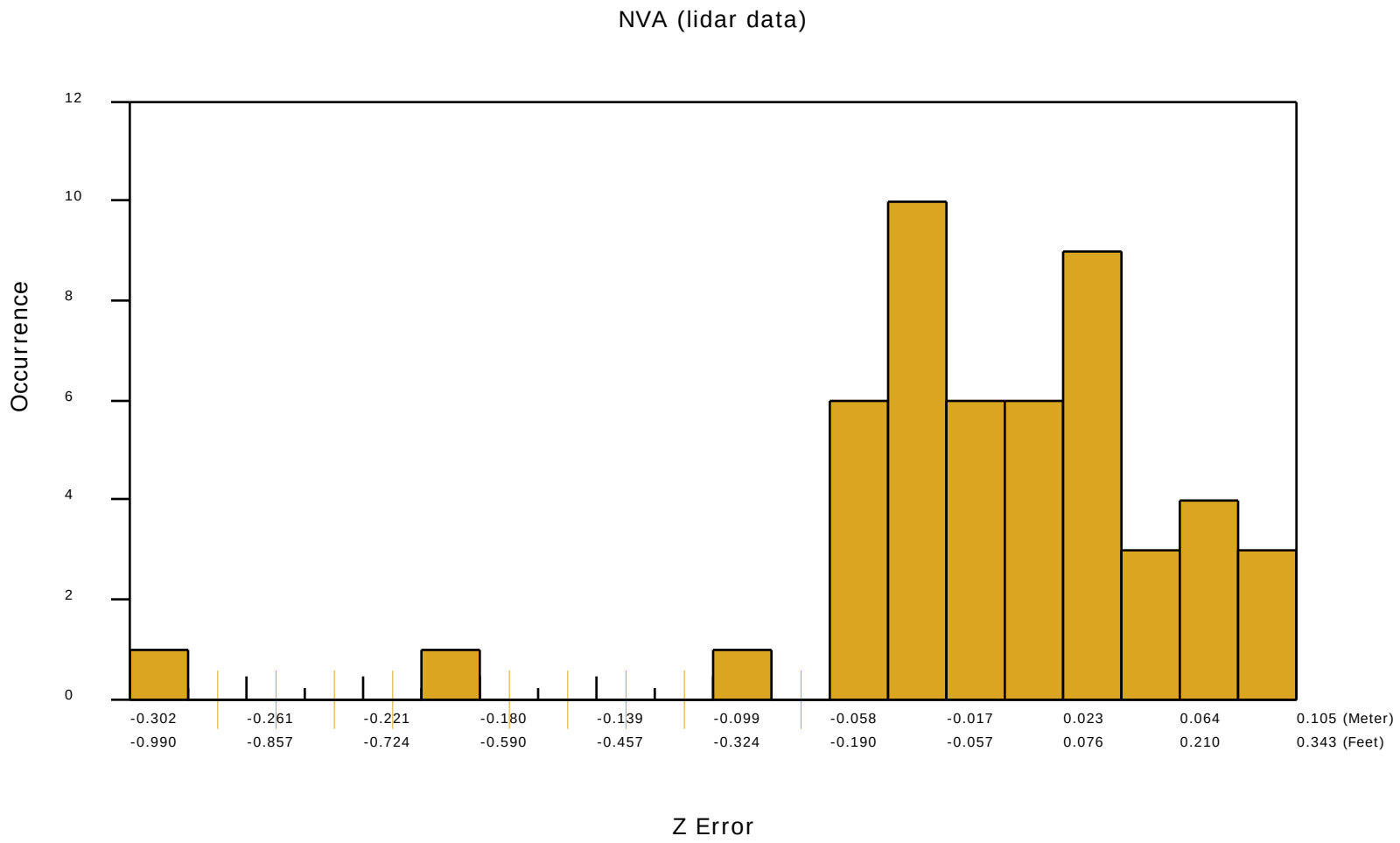
Check Points Vertical Accuracy - continued

ID	X	Y	Coverage	Z	Z From Lidar	Z Error	Minimum Z	Median Z	Maximum Z	Intensity	Scan Angle Rank	Returns	Description	Comments
1273	605976.438	3408528.225	Yes	1239.332	1239.374	0.042	1239.357	1239.379	1239.393	4153	2651	1,1,1		
1279	628447.462	3433093.765	Yes	910.58	910.638	0.058	910.624	910.651	910.658	5880	1366	1,1,1		
1291	630961.538	3445505.076	Yes	858.16	858.135	-0.025	858.131	858.142	858.143	5960	-1597	1,1,1		
1301	578719.024	3461572.953	Yes	1063.982	1064.015	0.033	1063.997	1064.042	1064.042	8146	-263	1,1,1		
1302	559391.813	3437519.932	Yes	1351.513	1351.321	-0.192	1351.309	1351.329	1351.333	6133	1636	1,1,1		
1303	644815.844	3432839.159	Yes	905.859	905.819	-0.040	905.816	905.827	905.828	10607	1480	1,1,1		
1320	613439.652	3431379.682	Yes	1013.822	1013.865	0.043	1013.844	1013.864	1013.869	3997	-7	1,1,1		
1322	565278.585	3459624.402	Yes	1189.525	1189.524	-0.001	1189.518	1189.525	1189.525	9103	954	1,1,1		
1326	652503.569	3412487.369	Yes	1034.57	1034.574	0.004	1034.564	1034.576	1034.579	7027	1461	1,1,1		
1326A	650997.377	3414068.289	Yes	1026.372	1026.334	-0.038	1026.315	1026.326	1026.364	9612	-3110	1,1,1		
1329	642057.585	3465422.824	Yes	791.874	791.87	-0.004	791.863	791.871	791.892	6466	1257	1,1,1		
1342	593589.183	3444596.292	Yes	1132.876	1132.934	0.058	1132.915	1132.92	1132.954	3532	1809	1,1,1		
1344	652611.113	3447148.027	Yes	844.882	844.877	-0.005	844.865	844.869	844.893	2443	-2250	1,1,1		
1349	636561.849	3471040.096	Yes	806.923	807.028	0.105	807.019	807.024	807.039	9017	-243	1,1,1		
881007	635926.366	3454387.838	Yes	817.984	817.958	-0.026	817.948	817.962	817.989	6039	2383	1,1,1		
921006	647626.157	3410399.023	Yes	1065.006	1065.018	0.012	1065.008	1065.018	1065.019	7507	2877	1,1,1		
921009	646692.151	3406730.585	Yes	1078.643	1078.612	-0.031	1078.607	1078.617	1078.618	10442	-3487	1,1,1		
941005	578696.682	3461555.277	Yes	1064.139	1064.169	0.030	1064.159	1064.161	1064.179	7115	-199	1,1,1		
941007	609531.796	3474473.05	Yes	903.9	903.995	0.095	903.994	903.994	903.996	4668	897	1,1,1		
991011	604162.811	3426364.502	Yes	1130.852	1130.55	-0.302	1130.539	1130.546	1130.568	4217	702	1,1,1		

DPH-11 Report on Absolute Vertical Accuracy - continued

The purpose of this section is to show a frequency distribution chart of the non-vegetated vertical accuracy (NVA) of the lidar point cloud data measured against surveyed ground check points.

Data Source - Y:\Mapping\Projects\65220171_USGS-TX_West_Texas\Production\Final_Client_Deliverables\Lot8_utm13\point_cloud\tilecls



DPH-11 Report on Absolute Vertical Accuracy - continued

The purpose of this section is to report the results of measuring the DEM data against surveyed ground NVA (nonvegetated vertical accuracy) check points. All XY coordinates and Z values reported are in the selected data units.

NVA (DEM)

ID	X	Y	Coverage	Z	Z From Lidar	Z Error	Description	Comments
1018	634141.537	3444862.012	Yes	853.846	853.780	-0.066		
1036	600595.742	3450850.156	Yes	1024.275	1024.240	-0.035		
1044	580088.551	3425234.701	Yes	1410.708	1410.686	-0.022		
1083	608903.821	3459940.154	Yes	936.126	936.152	0.026		
1088	586365.642	3460431.369	Yes	1046.818	1046.825	0.007		
1092	610552.228	3409708.935	Yes	1187.823	1187.803	-0.020		
1100	624572.188	3452505.972	Yes	874.132	874.138	0.006		
1101	581345.965	3437167.374	Yes	1255.886	1255.975	0.089		
1111	665191.938	3428054.696	Yes	905.672	905.630	-0.042		
1145	574666.775	3437544.935	Yes	1279.47	1279.486	0.016		
1157	653914.554	3414361.584	Yes	1010.991	1010.957	-0.034		
1169	621198.64	3429504.109	Yes	965.064	965.099	0.035		
1171	630861.685	3429001.211	Yes	906.407	906.423	0.016		
1175	577741.478	3469255.342	Yes	1091.759	1091.799	0.040		
1176	611736.607	3447059.943	Yes	948.451	948.492	0.041		
1191	664091.954	3447464.213	Yes	844.311	844.242	-0.069		
1200	610109.775	3423719.32	Yes	1063.086	1063.121	0.035		
1207	581024.988	3415641.785	Yes	1530.531	1530.498	-0.033		
1212	601637.828	3464631.795	Yes	950.709	950.793	0.084		
1222	615100.062	3465347.4	Yes	886.607	886.618	0.011		
1231	624903.865	3471433.73	Yes	848.852	848.899	0.047		
1236	659577.812	3474095.739	Yes	784.419	784.430	0.011		
1237	579612.012	3406462.007	Yes	1674.76	1674.743	-0.017		
1241	577002.508	3430159.824	Yes	1336.814	1336.791	-0.023		
1254	599315.656	3433288.247	Yes	1145.552	1145.630	0.078		
1255	635920.4	3454356.936	Yes	818.83	818.803	-0.027		
1256	651359.255	3425488.898	Yes	950.494	950.579	0.085		
1259	646555.027	3472150.341	Yes	786.183	786.173	-0.010		
1262	615574.712	3419373.289	Yes	1082.803	1082.823	0.020		
1268	652757.558	3462906.156	Yes	796.393	796.366	-0.027		

Check Points Vertical Accuracy - continued

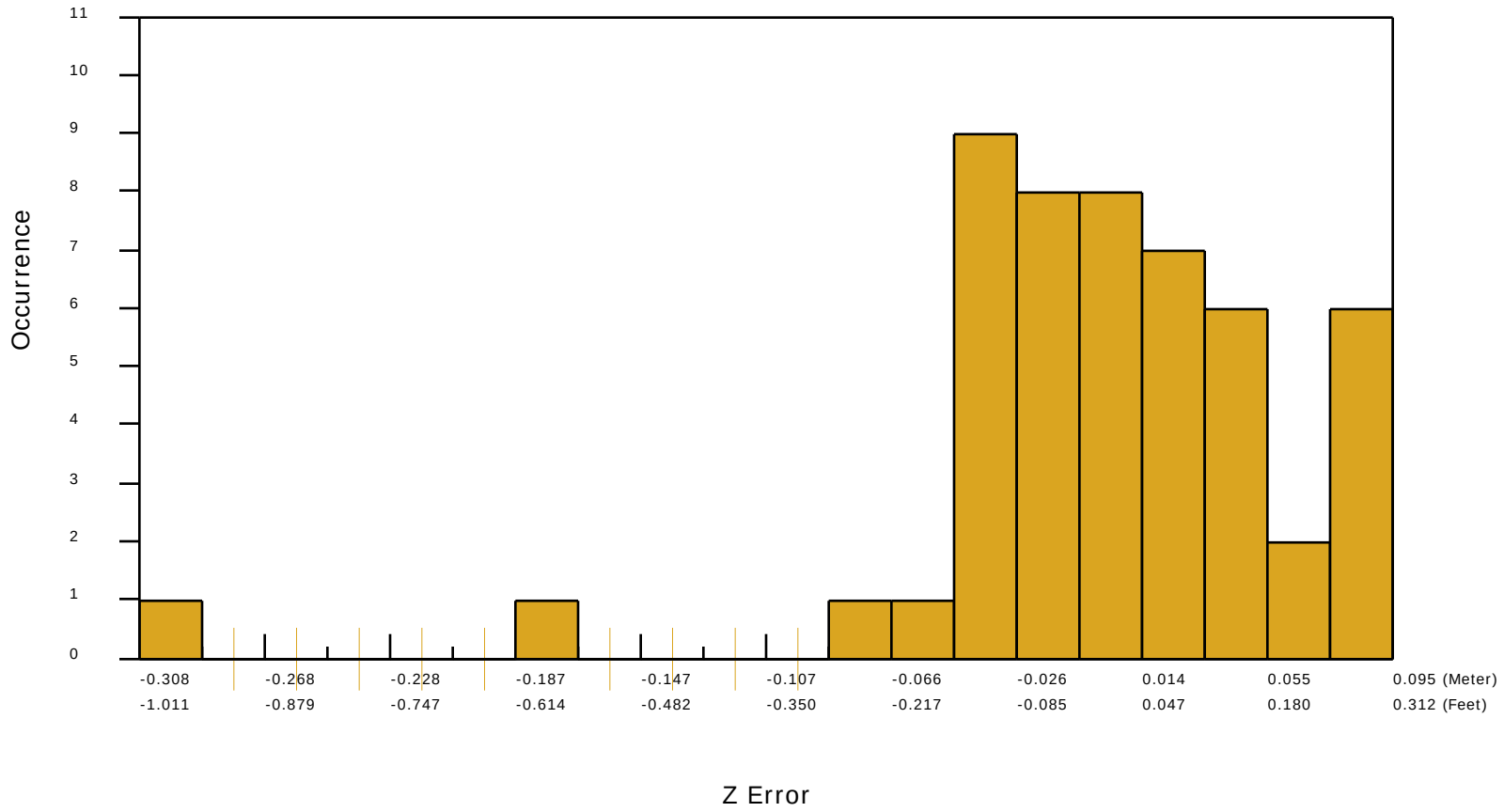
ID	X	Y	Coverage	Z	Z From Lidar	Z Error	Description	Comments
1273	605976.438	3408528.225	Yes	1239.332	1239.363	0.031		
1279	628447.462	3433093.765	Yes	910.58	910.637	0.057		
1291	630961.538	3445505.076	Yes	858.16	858.139	-0.021		
1301	578719.024	3461572.953	Yes	1063.982	1064.050	0.068		
1302	559391.813	3437519.932	Yes	1351.513	1351.326	-0.187		
1303	644815.844	3432839.159	Yes	905.859	905.824	-0.035		
1320	613439.652	3431379.682	Yes	1013.822	1013.858	0.036		
1322	565278.585	3459624.402	Yes	1189.525	1189.527	0.002		
1326	652503.569	3412487.369	Yes	1034.57	1034.570	0.000		
1326A	650997.377	3414068.289	Yes	1026.372	1026.328	-0.044		
1329	642057.585	3465422.824	Yes	791.874	791.879	0.005		
1342	593589.183	3444596.292	Yes	1132.876	1132.913	0.037		
1344	652611.113	3447148.027	Yes	844.882	844.863	-0.019		
1349	636561.849	3471040.096	Yes	806.923	807.013	0.090		
881007	635926.366	3454387.838	Yes	817.984	817.974	-0.010		
921006	647626.157	3410399.023	Yes	1065.006	1065.017	0.011		
921009	646692.151	3406730.585	Yes	1078.643	1078.613	-0.030		
941005	578696.682	3461555.277	Yes	1064.139	1064.165	0.026		
941007	609531.796	3474473.05	Yes	903.9	903.995	0.095		
991011	604162.811	3426364.502	Yes	1130.852	1130.544	-0.308		

DPH-11 Report on Absolute Vertical Accuracy - continued

The purpose of this section is to show a frequency distribution chart of the non-vegetated vertical accuracy (NVA) of the DEM data measured against surveyed ground check points.

Data Source - Y:\Mapping\Projects\65220171_USGS-TX_West_Texas\Production\Final_Client_Deliverables\Lot8_utm13\point_cloud\tilecls

NVA (DEM)



DPH-11 Report on Absolute Vertical Accuracy - continued

The purpose of this section is to report the results of measuring the DEM data against surveyed ground VVA (vegetated vertical accuracy) check points. All XY coordinates and Z values reported are in the selected data units.

VVA (DEM)

ID	X	Y	Coverage	Z	Z From Lidar	Z Error	Description	Comments
2017	634120.757	3444856.783	Yes	853.412	853.485	0.073		
2035	600583.799	3450830.414	Yes	1024.075	1024.131	0.056		
2042	580102.465	3425228.732	Yes	1409.769	1409.825	0.056		
2078	608889.132	3459923.287	Yes	936.254	936.346	0.092		
2083	586363.839	3460444.576	Yes	1046.6	1046.603	0.003		
2087	610548.799	3409693.54	Yes	1188.124	1188.224	0.100		
2095	624566.631	3452480.338	Yes	873.956	874.136	0.180		
2096	581445.544	3437233.373	Yes	1253.757	1253.891	0.134		
2106	665210.803	3428056.145	Yes	905.479	905.531	0.052		
2140	574688.447	3437545.519	Yes	1279.207	1279.391	0.184		
2151	653926.507	3414367.119	Yes	1010.881	1011.025	0.144		
2160	621167.048	3429520.161	Yes	964.524	964.723	0.199		
2161	630902.089	3428934.171	Yes	905.795	905.904	0.109		
2165A	577727.181	3469264.34	Yes	1091.892	1091.920	0.028		
2166	611758.997	3447048.616	Yes	947.751	947.764	0.013		
2180	664165.414	3447365.819	Yes	844.542	844.524	-0.018		
2189	610123.658	3423716.491	Yes	1062.373	1062.728	0.355		
2195	581031.933	3415804.854	Yes	1529.439	1529.448	0.009		
2200	601616.848	3464660.778	Yes	950.387	950.531	0.144		
2210	615159.546	3465290.873	Yes	886.363	886.428	0.065		
2219	624892.847	3471439.56	Yes	848.578	848.731	0.153		
2224	659621.759	3474213.866	Yes	783.704	783.693	-0.011		
2225	579631.044	3406720.632	Yes	1669.397	1669.549	0.152		
2236	565287.692	3459629.705	Yes	1188.924	1188.980	0.056		
881004	652765.434	3462889.023	Yes	795.963	796.165	0.202		
881006	642008.272	3465236.43	Yes	793.363	793.391	0.028		
911002	652507.868	3412478.415	Yes	1034.4	1034.532	0.132		
911004	644797.737	3432803.044	Yes	905.788	905.794	0.006		
911005	615570.277	3419384.772	Yes	1082.508	1082.537	0.029		
911007	613401.411	3431385.293	Yes	1013.566	1013.848	0.282		

Check Points Vertical Accuracy - continued

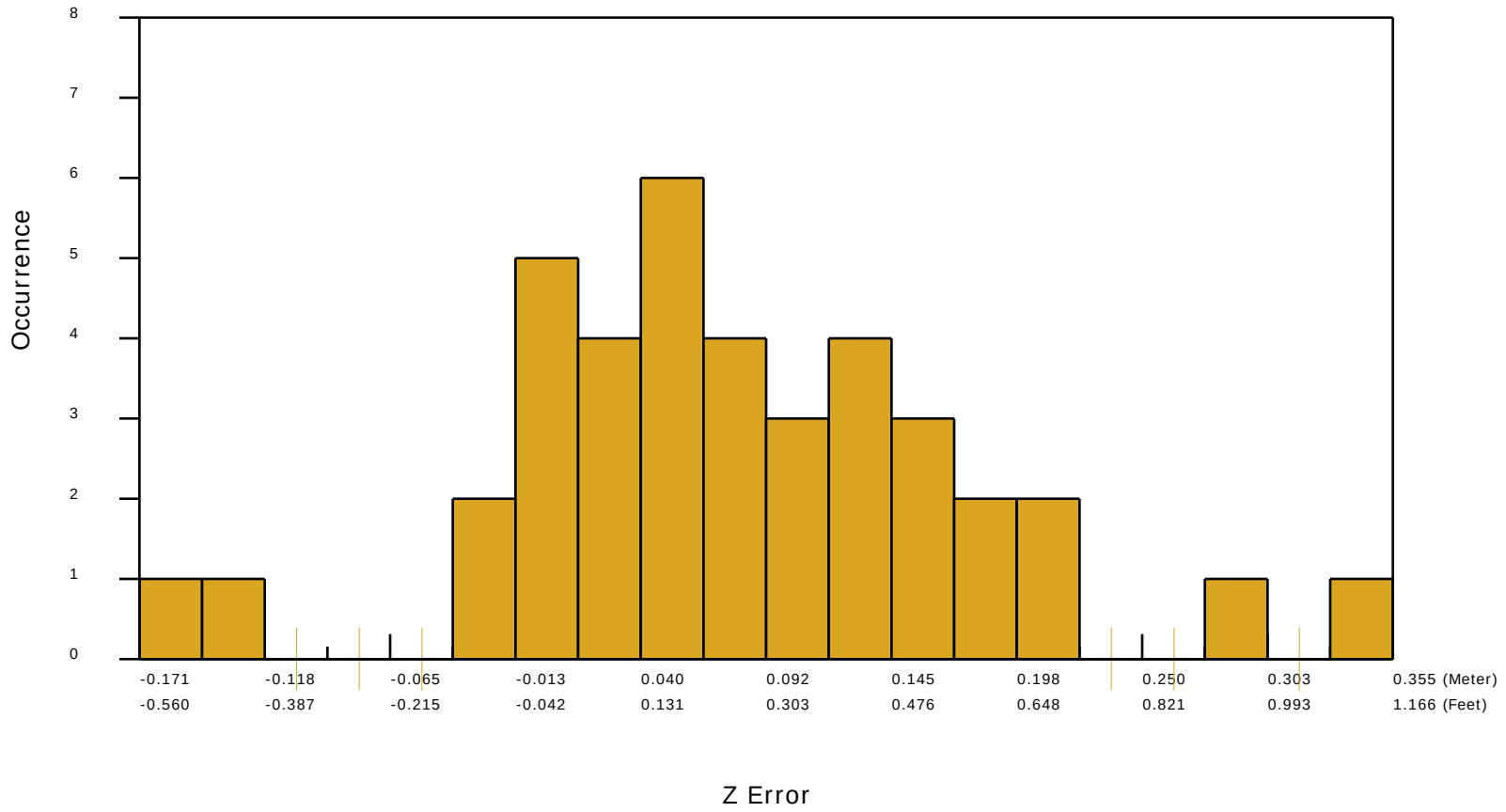
ID	X	Y	Coverage	Z	Z From Lidar	Z Error	Description	Comments
921005	650921.62	3414060.301	Yes	1025.864	1025.841	-0.023		
921008	647613.155	3410416.955	Yes	1066.041	1066.097	0.056		
921011	646545.737	3406695.61	Yes	1079.275	1079.372	0.097		
931003	559617.548	3437517.593	Yes	1355.565	1355.394	-0.171		
941004	578701.039	3461577.344	Yes	1064.291	1064.321	0.030		
941008	609553.175	3474483.616	Yes	904.105	904.173	0.068		
991001	577012.074	3430130.834	Yes	1337.295	1337.458	0.163		
991007	605980.281	3408538.291	Yes	1238.897	1238.966	0.069		
991010	604188.846	3426365.857	Yes	1130.173	1130.030	-0.143		

DPH-11 Report on Absolute Vertical Accuracy - continued

The purpose of this section is to show a frequency distribution chart of the vegetated vertical accuracy (VVA) of the DEM data measured against surveyed ground check points.

Data Source - Y:\Mapping\Projects\65220171_USGS-TX_West_Texas\Production\Final_Client_Deliverables\Lot8_utm13\point_cloud\tilecls

VVA (DEM)

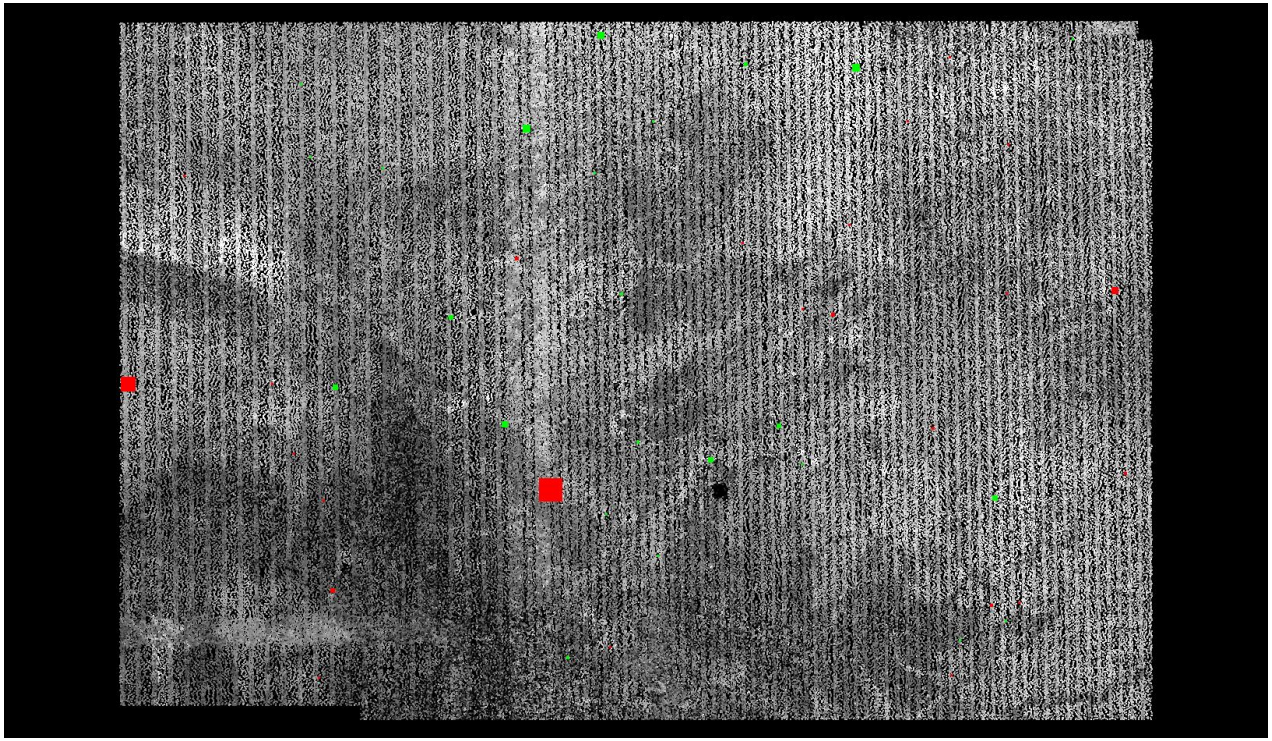


DPH-11 Report on Absolute Vertical Accuracy - continued

The purpose of this section is to show a graphic of lidar data points colored by intensity with NVA check points rendered "thematically" showing the green and red squares sized by Z error.

Data Source - Y:\Mapping\Projects\65220171_USGS-TX_West_Texas\Production\Final_Client_Deliverables\Lot8_utm13\point_cloud\tilecls

Result Path - Y:\Mapping\Projects\65220171_USGS-TX_West_Texas\Admin\QA_QC\Lot8\DPH_11\ColorByIntensity_CheckPoints_NVA.jpg



Green represents where the lidar surface is above the check point (positive elevation error).

Red represents where the lidar surface is below the check point (negative elevation error).

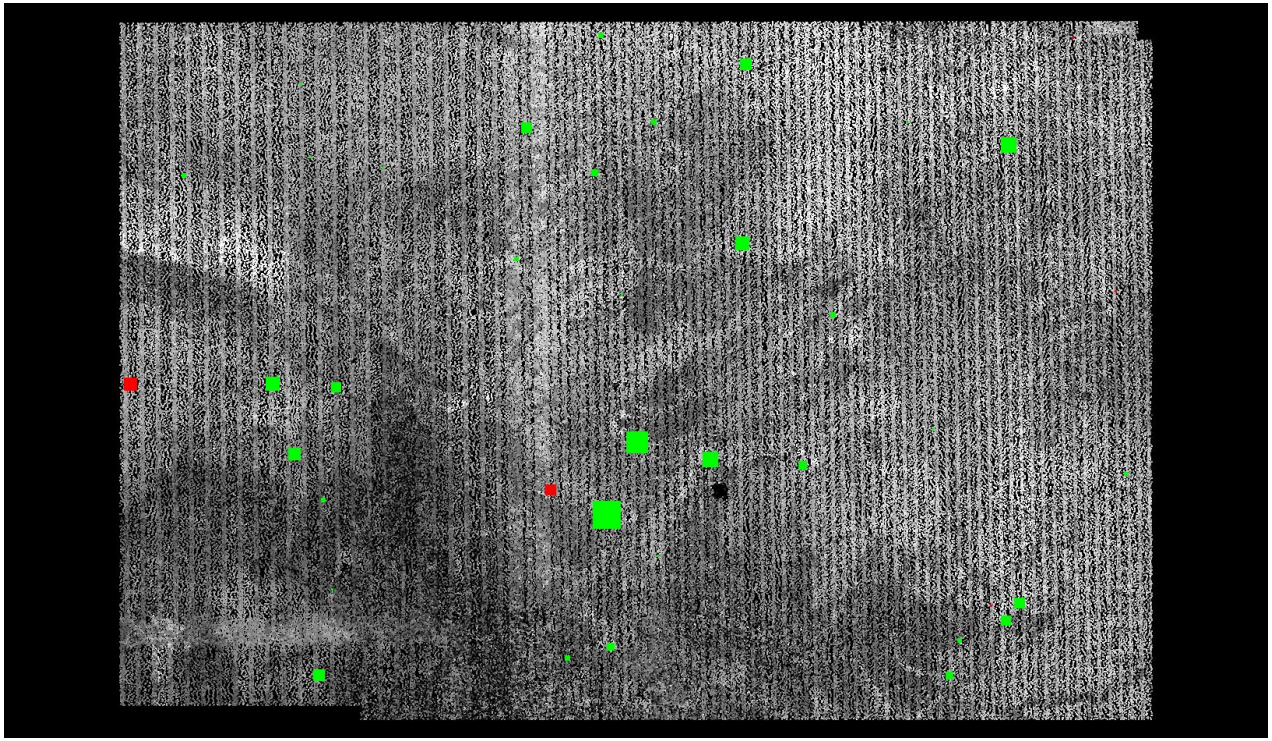
The size of the square symbol represents the absolute value magnitude of error.

DPH-11 Report on Absolute Vertical Accuracy - continued

The purpose of this section is to show a graphic of lidar data points colored by intensity with VVA check points rendered "thematically" showing the green and red squares sized by Z error.

Data Source - Y:\Mapping\Projects\65220171_USGS-TX_West_Texas\Production\Final_Client_Deliverables\Lot8_utm13\point_cloud\tilecls

Result Path - Y:\Mapping\Projects\65220171_USGS-TX_West_Texas\Admin\QA_QC\Lot8\DPH_11\ColorByIntensity_CheckPoints_VVA.jpg



Green represents where a DEM of the lidar surface is above the check point (positive elevation error).

Red represents where a DEM of the lidar surface is below the check point (negative elevation error).

The size of the square symbol represents the absolute value magnitude of error.