Date: 07/18/2018 **Product:** South Dakota Geiger Mode LiDAR

Overview:

Dewberry has completed the vertical accuracy assessment of the South Dakota Geiger Mode LiDAR. The data passes vertical accuracy for Non-Vegetated Accuracy (NVA), but fails for the vegetated vertical accuracy (VVA). We have reviewed the data and believe that there appears to be a bias in vegetated areas that is a result of the system not reaching the bare earth in areas of tall/short grass and cropland. This document provides an overview of the vertical accuracy assessment of the South Dakota Geiger Mode LiDAR data. Additionally, we have completed the vertical accuracy assessment of the Northeast Illinois Geiger Mode LiDAR dataset and have not observed these issues.

South Dakota Accuracy Assessment:

Dewberry performed the final accuracy assessment on the LiDAR surface. The NVA points meet the project requirements as shown in table 1. The vegetated vertical accuracy does not meet specifications. This report focuses on the VVA point analysis.

Land Cover Category	# of Points	NVA – Non-vegetated Vertical Accuracy ($RMSE_z$ x 1.9600) Spec=0.196 m	VVA – Vegetated Vertical Accuracy (95th Percentile) Spec=0.294 m
NVA	171	0.156	
VVA	130		0.447

There were a total of 130 points surveyed to test the vegetated vertical accuracy based on the ASPRS requirements. As per our standard survey procedures, half of these points (approximately 65) were surveyed a second time with at least 4 hours between the surveys.

During the review of the VVA points Dewberry made several observations that lead us to believe the issue related to the vegetated accuracy is a result of the inability of the Geiger mode lidar data to reliably measure bare earth elevations in tall/short grasslands and crops. The VVA points are biased in the positive direction suggesting that the majority of the checkpoints are below the LiDAR surface. Of the 130 VVA points only seven (7) of them had elevations that would put them above the LiDAR surface. The average difference for these seven points was 4.7 cm. There are currently 21 checkpoints below the LiDAR surface that have a difference exceeding 29.4 cm.

Using this information we also looked at the distribution of error throughout the SD project area and it appears that the errors are not isolated to any specific location within the project area.

Figure 1 provides an overview of the distribution of error of the VVA points where the red points show a difference exceeding 29.4 cm.

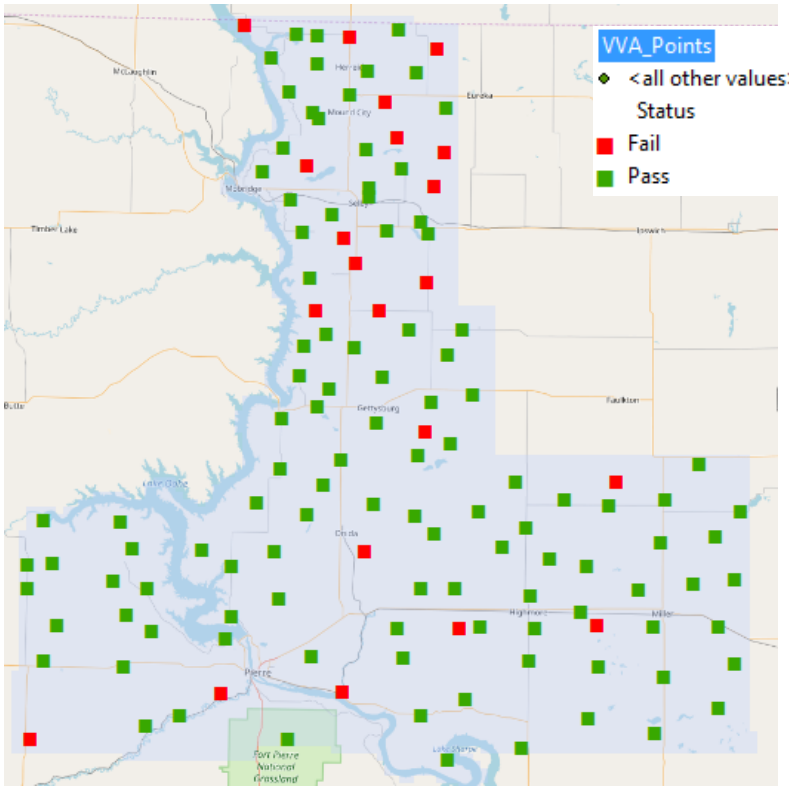
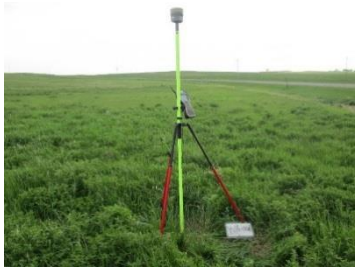


Figure 1 - Distribution of VVA Points. Points colored in Red deviate from the LiDAR surface by over 29.4 cm.

As part of this assessment we also reviewed the checkpoints to ensure that there were no obvious errors with the placement of the point or with the resulting coordinates. Table 2 provides and overview of the points along with information related to which ones were resurveyed and what the difference was between the surveys. Additionally the photo for each point is included for reference in the evaluation.

Table 02 - VVA Checkpoints in excess of 0.294 m from survey. All units in meters

Name	X	Y	
VVA-006	483397.166	4926521.161	
SurveyZ	**LiDARZ**	**Delta**	
568.235	568.630	0.395	
Date Collected	**Recheck**	**Recheck Delta**	
5/16/2016	Yes	-0.008	

Name	X	Y
VVA-010	331303.013	4895961.422
SurveyZ	**LiDARZ**	**Delta**
636.315	636.776	0.461
Date Collected	**Recheck**	**Recheck Delta**
5/17/2016	Yes	0.011

Name	X	Y
VVA-013	382542.599	4908238.728
SurveyZ	**LiDARZ**	**Delta**
538.080	538.383	0.303
Date Collected	**Recheck**	**Recheck Delta**
5/18/2016	No	

Name	X	Y
VVA-014	414969.354	4908370.176
SurveyZ	**LiDARZ**	**Delta**
438.491	438.804	0.313
Date Collected	**Recheck**	**Recheck Delta**
5/18/2016	Yes	0.011

Name	X	Y
VVA-026	446468.203	4925736.743
SurveyZ	**LiDARZ**	**Delta**
581.371	581.677	0.306
Date Collected	**Recheck**	**Recheck Delta**
5/17/2016	No	

Name	X	Y
VVA-053	420760.779	4946072.986
SurveyZ	**LiDARZ**	**Delta**
546.571	546.968	0.397
Date Collected	**Recheck**	**Recheck Delta**
5/18/2016	No	

Name	X	Y
VVA-072	488436.383	4964976.998
SurveyZ	**LiDARZ**	**Delta**
513.017	513.337	0.320
Date Collected	**Recheck**	**Recheck Delta**
5/20/2016	Yes	0.003

Name	X	Y
VVA-080	437164.701	4978333.947
SurveyZ	**LiDARZ**	**Delta**
597.258	597.720	0.462
Date Collected	**Recheck**	**Recheck Delta**
5/21/2016	Yes	-0.006

Name	X	Y
VVA-093	425026.879	5010801.706
SurveyZ	**LiDARZ**	**Delta**
633.768	634.187	0.419
Date Collected	**Recheck**	**Recheck Delta**
5/23/2106	Yes	-0.031

Name	X	Y
VVA-094	408033.493	5011013.969
SurveyZ	**LiDARZ**	**Delta**
561.691	562.067	0.376
Date Collected	**Recheck**	**Recheck Delta**
5/19/2016	Yes	0.004

Name	X	Y
VVA-096	418728.007	5023833.954
SurveyZ	**LiDARZ**	**Delta**
611.587	612.017	0.430
Date Collected	**Recheck**	**Recheck Delta**
5/23/2016	Yes	-0.003

Name	X	Y
VVA-097	437656.140	5018669.004
SurveyZ	**LiDARZ**	**Delta**
589.006	589.515	0.509
Date Collected	**Recheck**	**Recheck Delta**
5/20/2016	Yes	-0.002

Name	X	Y
VVA-100	415573.031	5030223.868
SurveyZ	**LiDARZ**	**Delta**
598.452	598.781	0.329
Date Collected	**Recheck**	**Recheck Delta**
5/19/2016	No	

Name	X	Y
VVA-106	439548.126	5044342.632
SurveyZ	**LiDARZ**	**Delta**
628.798	629.317	0.519
Date Collected	**Recheck**	**Recheck Delta**
5/21/2016	Yes	-0.004

Name	X	Y
VVA-109	405365.642	5049720.603
SurveyZ	**LiDARZ**	**Delta**
534.494	535.303	0.809
Date Collected	**Recheck**	**Recheck Delta**
5/21/2016	Yes	-0.024

Name	X	Y
VVA-114	429509.591	5057301.730
SurveyZ	**LiDARZ**	**Delta**
529.925	530.241	0.316
Date Collected	**Recheck**	**Recheck Delta**
5/24/2016	No	

Name	X	Y
VVA-115	442469.893	5053413.792
SurveyZ	**LiDARZ**	**Delta**
535.340	535.888	0.548
Date Collected	**Recheck**	**Recheck Delta**
5/21/2016	No	

Name	X	Y
VVA-117	426569.506	5067037.319
SurveyZ	**LiDARZ**	**Delta**
537.878	538.279	0.401
Date Collected	**Recheck**	**Recheck Delta**
5/24/2016	Yes	-0.018

Name	X	Y
VVA-124	440521.762	5081371.465
SurveyZ	**LiDARZ**	**Delta**
554.494	554.857	0.363
Date Collected	**Recheck**	**Recheck Delta**
5/23/2016	Yes	0.004

Name	X	Y
VVA-126	417109.437	5084199.890
SurveyZ	**LiDARZ**	**Delta**
534.243	534.599	0.356
Date Collected	**Recheck**	**Recheck Delta**
5/23/2016	No	

Name	X	Y
VVA-130	388974.545	5087595.417
SurveyZ	**LiDARZ**	**Delta**
494.647	495.317	0.670
Date Collected	**Recheck**	**Recheck Delta**
5/23/2016	Yes	-0.009

In order to evaluate the dataset more completely we also went through all the tiles that intersect the VVA points and created a new bare earth model using the lowest possible elevations within each 0.5 meter DEM cell. The result was a minimal improvement in the VVA by about 6 cm. The negative impact on the quality of the DEMs included much more inconsistency in the surface model as well as introduction of divots throughout the dataset that are legitimate noise.

Conclusion

Based on the review of the VVA points and vegetated areas throughout the project area, Dewberry has determined that the reported accuracy fails the required specifications. We attempted to reprocess the data to improve accuracy in sample areas, but it created more noise and variability in the terrain and considerably less data density. Even after reprocessing to select the lowest elevations, the vegetated vertical accuracy did not meet the project requirements. Dewberry requests that this dataset be accepted by USGS as it meets all requirements of QL2 lidar except the data accuracy in a specific vegetated land cover of grasses and cropland. This project was the first commercial use of Geiger mode technology, developed by Harris Corporation, at a large scale. The lessons learned from this project were used in future projects including the North East Illinois 4-county and Southeast Wisconsin 2-county projects for USGS GPSC3. This issue appears to be specific to the South Dakota project and does not impact the NEIL Geiger mode project which has the VVA tested at 10.4 cm at 95% percentile.

SD Geiger Accuracy Assessment Worksheet

South Dakota - LiDAR Summary Statistics		
	NVA	VVA
# of Points	171.000	130.000
RMSE	0.080	0.221
Mean	0.042	0.165
Median	0.034	0.124
Skew	0.196	1.436
Std Dev	0.068	0.147
Min	-0.105	-0.077
Max	0.238	0.809
Kurtosis	-0.304	3.022
NVA (Accuracyz)	0.156	0.432
VVA (95th Percentile)	0.156	0.447

Point ID	NAD83 UTM Zone 18N		NAVD88 (Geoid 12A)		DeltaZ
	Easting X (m)	Northing Y (m)	Z-Survey (m)	Z-LiDAR (m)	
NVA-001	394713.226	5085428.300	518.809	518.942	0.133
NVA-002	399633.940	5083836.277	502.728	502.823	0.095
NVA-003	416562.031	5084881.901	525.652	525.820	0.168
NVA-004	437393.510	5081693.268	553.444	553.567	0.123
NVA-005	437869.660	5084644.255	600.562	600.676	0.114
NVA-006	437794.805	5074949.822	565.466	565.520	0.054
NVA-007	424765.420	5078308.383	531.117	531.234	0.117
NVA-008	416979.072	5076369.037	513.243	513.360	0.117
NVA-009	401592.484	5076136.203	593.923	594.071	0.148
NVA-010	395651.328	5072519.071	496.357	496.321	-0.036
NVA-011	408841.889	5069840.456	598.696	598.765	0.069
NVA-012	416921.997	5070723.819	518.258	518.290	0.032
NVA-013	426583.289	5071871.794	551.001	551.054	0.053
NVA-014	437750.390	5068519.961	552.536	552.546	0.010
NVA-015	436092.853	5063666.818	563.111	563.125	0.014
NVA-016	416818.125	5064169.031	526.609	526.648	0.039
NVA-017	412296.863	5065673.014	554.926	554.953	0.027
NVA-018	402759.940	5062586.008	524.831	524.790	-0.041
NVA-019	402243.855	5057829.410	599.402	599.430	0.028
NVA-020	391833.992	5053446.560	515.194	515.262	0.068

NVA-021	408642.303	5054452.742	564.600	564.736	0.136
NVA-022	419346.680	5057506.948	530.046	530.129	0.083
NVA-023	428041.532	5058971.000	544.881	544.906	0.025
NVA-024	439260.528	5055609.579	536.692	536.880	0.188
NVA-025	431391.122	5052476.719	535.207	535.320	0.113
NVA-026	424698.258	5051221.561	546.115	546.288	0.173
NVA-027	438333.144	5047644.683	612.665	612.771	0.106
NVA-028	431820.537	5046140.426	604.158	604.217	0.059
NVA-029	420602.741	5046282.020	529.544	529.547	0.003
NVA-030	412583.823	5046368.380	523.057	523.188	0.131
NVA-031	400553.308	5046610.704	525.261	525.287	0.026
NVA-032	386793.653	5045383.682	510.301	510.329	0.028
NVA-033	397158.659	5040201.611	504.859	504.850	-0.009
NVA-034	405953.701	5037067.693	604.915	604.950	0.035
NVA-035	418850.996	5036622.810	589.060	589.119	0.059
NVA-036	430740.097	5039262.980	638.997	639.078	0.081
NVA-037	438250.290	5038560.654	652.104	652.112	0.008
NVA-038	441354.178	5031459.868	601.396	601.448	0.052
NVA-039	433300.903	5033213.391	601.678	601.750	0.072
NVA-040	423653.677	5031718.353	618.357	618.512	0.155
NVA-041	413018.531	5031868.350	593.699	593.679	-0.020
NVA-042	398082.700	5033649.500	508.883	508.897	0.014
NVA-043	407718.371	5025512.226	576.717	576.695	-0.022
NVA-044	418712.134	5025336.816	625.198	625.210	0.012
NVA-045	430048.625	5026811.743	628.434	628.472	0.038
NVA-046	438096.373	5025086.804	587.949	587.955	0.006
NVA-047	442844.481	5016885.600	585.367	585.523	0.156
NVA-048	434824.115	5020207.831	596.282	596.473	0.191
NVA-049	423502.140	5020867.765	586.820	586.939	0.119
NVA-050	417015.669	5020569.612	591.521	591.670	0.149
NVA-051	401999.359	5025565.687	536.483	536.465	-0.018
NVA-052	400664.084	5019195.641	497.538	497.638	0.100
NVA-053	412143.610	5014151.386	580.844	580.971	0.127
NVA-054	416945.428	5010908.430	634.710	634.807	0.097
NVA-055	428279.459	5013949.252	610.273	610.347	0.074
NVA-056	438997.888	5010097.577	581.306	581.377	0.071
NVA-057	440578.499	5003264.124	588.594	588.580	-0.014
NVA-058	451759.133	5005548.347	594.566	594.523	-0.043
NVA-059	431403.762	5009046.813	587.781	587.764	-0.017

NVA-060	421340.278	5005888.294	618.858	618.946	0.088
NVA-061	409600.606	5009277.006	593.116	593.187	0.071
NVA-062	404994.593	5006343.906	567.433	567.500	0.067
NVA-063	405261.632	4998025.975	565.914	565.923	0.009
NVA-064	416888.705	5004320.362	612.265	612.284	0.019
NVA-065	426157.976	4999383.694	594.060	593.979	-0.081
NVA-066	438917.229	4999256.859	588.320	588.280	-0.040
NVA-067	448513.538	4999774.521	583.150	583.140	-0.010
NVA-068	453375.947	4989492.782	602.252	602.147	-0.105
NVA-069	439901.761	4994390.659	590.382	590.346	-0.036
NVA-070	430869.250	4993266.051	623.200	623.116	-0.084
NVA-071	417986.845	4991440.153	618.619	618.533	-0.086
NVA-072	409796.071	4993754.822	563.074	563.080	0.006
NVA-073	400335.776	4991668.047	530.148	530.086	-0.062
NVA-074	403552.655	4991660.198	516.231	516.156	-0.075
NVA-075	405041.298	4985154.549	575.704	575.710	0.006
NVA-076	414899.179	4984808.141	593.387	593.405	0.018
NVA-077	433978.228	4984818.196	628.138	628.120	-0.018
NVA-078	440380.387	4984737.302	624.974	624.949	-0.025
NVA-079	451578.871	4974977.286	591.974	591.902	-0.072
NVA-080	441923.197	4976657.924	580.760	580.732	-0.028
NVA-081	432236.606	4975205.163	580.310	580.222	-0.088
NVA-082	423967.823	4976948.149	600.435	600.408	-0.027
NVA-083	414591.729	4977792.528	594.248	594.233	-0.015
NVA-084	402261.000	4977282.970	565.274	565.339	0.065
NVA-085	398256.819	4984630.760	517.020	517.053	0.033
NVA-086	398409.484	4972493.605	552.700	552.779	0.079
NVA-087	395244.736	4965819.861	557.939	558.019	0.080
NVA-088	401655.143	4965739.409	572.164	572.241	0.077
NVA-089	414981.145	4965559.729	562.508	562.589	0.081
NVA-090	428992.818	4966112.643	552.985	552.950	-0.035
NVA-091	440263.847	4965254.907	584.599	584.500	-0.099
NVA-092	451741.102	4968510.865	583.084	582.994	-0.090
NVA-093	464408.212	4965011.972	564.032	563.993	-0.039
NVA-094	481718.598	4968169.036	583.367	583.362	-0.005
NVA-095	500966.966	4968153.516	446.757	446.730	-0.027
NVA-096	517153.167	4963328.098	414.891	414.865	-0.026
NVA-097	510575.353	4956901.224	421.306	421.327	0.021
NVA-098	492966.144	4958466.540	479.087	479.100	0.013

NVA-099	481678.300	4956181.027	508.439	508.450	0.011
NVA-100	464370.670	4958587.619	550.157	550.136	-0.021
NVA-101	446598.308	4957108.816	548.373	548.353	-0.020
NVA-102	429338.170	4957440.955	590.198	590.180	-0.018
NVA-103	412844.346	4955900.095	573.903	573.910	0.007
NVA-104	395166.869	4956136.272	574.204	574.258	0.054
NVA-105	382194.376	4951365.154	597.607	597.608	0.001
NVA-106	357986.367	4950002.834	605.742	605.750	0.008
NVA-107	332335.441	4953872.691	562.744	562.793	0.049
NVA-108	329942.821	4946840.547	629.720	629.766	0.046
NVA-109	354697.990	4946153.216	619.524	619.557	0.033
NVA-110	373959.671	4943525.772	544.357	544.403	0.046
NVA-111	389341.786	4944902.768	521.040	520.999	-0.041
NVA-112	397320.369	4936764.067	535.348	535.408	0.060
NVA-113	415914.255	4950606.260	571.132	571.034	-0.098
NVA-114	415171.199	4928336.358	546.165	546.185	0.020
NVA-115	431952.326	4946053.566	527.387	527.400	0.013
NVA-116	438354.723	4941096.586	513.225	513.322	0.097
NVA-117	451308.378	4947415.935	540.554	540.550	-0.004
NVA-118	458348.349	4937724.399	545.772	545.801	0.029
NVA-119	464127.345	4944097.258	520.773	520.779	0.006
NVA-120	464613.460	4929504.472	580.427	580.520	0.093
NVA-121	481624.563	4947261.543	497.077	497.097	0.020
NVA-122	483171.908	4937549.990	497.970	498.002	0.032
NVA-123	496053.194	4943954.518	468.903	468.886	-0.017
NVA-124	499290.658	4937830.986	456.772	456.833	0.061
NVA-125	507618.745	4945612.710	428.874	428.847	-0.027
NVA-126	515286.760	4939983.532	425.952	425.975	0.023
NVA-127	515644.336	4930744.549	445.472	445.521	0.049
NVA-128	506002.299	4922684.751	507.415	507.457	0.042
NVA-129	493276.447	4925937.596	539.096	539.160	0.064
NVA-130	472893.068	4928970.883	561.825	561.912	0.087
NVA-131	456880.467	4929368.607	550.970	551.129	0.159
NVA-132	447247.988	4930590.436	548.021	548.055	0.034
NVA-133	427968.188	4933198.826	511.886	511.989	0.103
NVA-134	408646.895	4930194.126	558.246	558.271	0.025
NVA-135	383131.147	4933752.675	506.086	506.129	0.043
NVA-136	372404.483	4932058.803	558.869	558.956	0.087
NVA-137	361015.651	4935771.806	653.596	653.682	0.086
NVA-138	344427.855	4932746.924	586.096	586.215	0.119
NVA-139	330137.753	4923454.818	648.638	648.593	-0.045
NVA-140	352435.051	4918905.333	612.350	612.369	0.019
NVA-141	372177.041	4924142.840	593.785	593.730	-0.055

NVA-142	392456.300	4920292.824	542.491	542.529	0.038
NVA-143	416618.431	4921284.511	551.476	551.439	-0.037
NVA-144	435944.390	4921043.772	567.965	568.014	0.049
NVA-145	451997.983	4920881.495	608.033	608.043	0.010
NVA-146	464835.524	4923301.884	595.070	595.055	-0.015
NVA-147	483643.082	4920306.567	620.363	620.371	0.008
NVA-148	501315.540	4917872.340	538.733	538.844	0.111
NVA-149	523772.035	4917922.657	436.096	436.212	0.116
NVA-150	512650.562	4909811.838	559.524	559.716	0.192
NVA-151	493264.588	4913040.242	600.947	601.030	0.083
NVA-152	464808.271	4911231.036	657.244	657.347	0.103
NVA-153	458385.717	4914427.595	622.199	622.304	0.105
NVA-154	442271.670	4912915.421	561.357	561.429	0.072
NVA-155	427767.566	4913083.586	510.952	511.190	0.238
NVA-156	406804.306	4909459.294	441.680	441.804	0.124
NVA-157	383239.833	4915823.579	535.623	535.592	-0.031
NVA-158	365198.334	4915156.101	585.195	585.288	0.093
NVA-159	338671.537	4913148.045	610.519	610.630	0.111
NVA-160	334945.568	4900687.756	620.926	621.070	0.144
NVA-161	344485.460	4897164.376	627.048	627.160	0.112
NVA-162	363444.069	4897896.286	492.758	492.914	0.156
NVA-163	384514.290	4897854.342	575.173	575.350	0.177
NVA-164	410219.730	4898151.758	547.756	547.891	0.135
NVA-165	430643.192	4907074.007	495.634	495.757	0.123
NVA-166	432131.799	4895358.016	515.651	515.718	0.067
NVA-167	453456.476	4902508.131	626.930	626.940	0.010
NVA-168	463291.691	4899565.110	561.129	561.169	0.040
NVA-169	488413.255	4901765.662	582.395	582.450	0.055
NVA-170	501308.356	4900140.786	546.660	546.683	0.023
NVA-171	515855.077	4896942.277	579.611	579.605	-0.006
VVA-001	515767.442	4904278.985	535.808	535.930	0.122
VVA-002	498858.426	4897269.150	564.918	565.017	0.099
VVA-003	480772.584	4901594.490	571.887	571.989	0.102
VVA-004	463009.024	4893494.977	527.816	527.962	0.146
VVA-005	443009.957	4890387.342	441.840	441.969	0.129
VVA-006	483397.166	4926521.161	568.235	568.630	0.395
VVA-007	400273.842	4895884.649	541.606	541.844	0.238
VVA-008	371149.949	4902206.389	476.701	476.740	0.039
VVA-009	362182.622	4899275.869	549.303	549.435	0.132
VVA-010	331303.013	4895961.422	636.315	636.776	0.461
VVA-011	334755.978	4916877.858	621.171	621.253	0.082
VVA-012	356304.297	4915149.445	581.677	581.742	0.065
VVA-013	382542.599	4908238.728	538.080	538.383	0.303

VVA-014	414969.354	4908370.176	438.491	438.804	0.313
VVA-015	431284.041	4917863.440	533.155	533.360	0.205
VVA-016	447844.459	4906445.360	618.446	618.673	0.227
VVA-017	464796.819	4916833.100	631.499	631.739	0.240
VVA-018	483585.953	4915094.672	604.354	604.529	0.175
VVA-019	501269.223	4912514.691	564.261	564.411	0.150
VVA-020	520209.400	4916261.685	458.120	458.309	0.189
VVA-021	515676.537	4925917.153	457.169	457.206	0.037
VVA-022	498400.711	4925942.409	496.243	496.306	0.063
VVA-023	435924.746	4902296.314	519.175	519.239	0.064
VVA-024	466524.721	4925764.692	565.529	565.590	0.061
VVA-025	451990.932	4925935.167	571.023	571.092	0.069
VVA-026	446468.203	4925736.743	581.371	581.677	0.306
VVA-027	429561.089	4925699.688	532.353	532.570	0.217
VVA-028	406819.901	4918185.262	525.722	525.993	0.271
VVA-029	385248.505	4928861.728	531.475	531.498	0.023
VVA-030	383779.417	4922637.742	511.024	510.994	-0.030
VVA-031	363619.710	4924982.922	590.673	590.597	-0.076
VVA-032	356920.492	4929275.814	640.292	640.383	0.091
VVA-033	338236.654	4926476.220	643.087	643.055	-0.032
VVA-034	330492.566	4936292.186	629.444	629.669	0.225
VVA-035	337047.786	4943068.230	607.809	608.025	0.216
VVA-036	353656.366	4938305.866	601.287	601.361	0.074
VVA-037	362489.823	4936299.009	634.627	634.761	0.134
VVA-038	385320.873	4942134.384	498.856	498.944	0.088
VVA-039	398091.882	4933563.349	538.969	539.151	0.182
VVA-040	435911.417	4936347.334	509.277	509.378	0.101
VVA-041	444961.286	4936193.961	531.404	531.537	0.133
VVA-042	465575.024	4934359.008	545.524	545.634	0.110
VVA-043	478849.070	4929870.008	536.275	536.451	0.176
VVA-044	494450.971	4935818.258	474.736	474.810	0.074
VVA-045	508931.870	4937547.946	441.257	441.340	0.083
VVA-046	520159.761	4938770.535	423.978	424.062	0.084
VVA-047	515178.661	4950388.458	413.280	413.315	0.035
VVA-048	500116.464	4948793.465	462.571	462.620	0.049
VVA-049	480602.069	4942399.974	498.713	498.855	0.142
VVA-050	470434.587	4944255.784	510.227	510.306	0.079
VVA-051	457737.137	4947375.400	530.563	530.594	0.031
VVA-052	439709.289	4951031.133	512.974	513.059	0.085
VVA-053	420760.779	4946072.986	546.571	546.968	0.397
VVA-054	396636.785	4946416.086	535.516	535.629	0.113
VVA-055	377238.767	4946649.597	548.228	548.287	0.059
VVA-056	358516.524	4946872.171	624.576	624.602	0.026

VVA-057	334941.344	4954537.399	551.281	551.359	0.078
VVA-058	330597.465	4942728.636	644.203	644.312	0.109
VVA-059	355603.569	4954140.362	605.917	606.043	0.126
VVA-060	391950.498	4959421.974	556.376	556.466	0.090
VVA-061	405617.368	4955989.370	558.599	558.706	0.107
VVA-062	409690.311	4964005.030	574.303	574.438	0.135
VVA-063	423203.724	4959040.957	563.344	563.447	0.103
VVA-064	434503.165	4955604.462	568.594	568.699	0.105
VVA-065	451478.643	4957087.545	564.651	564.652	0.001
VVA-066	464215.005	4952544.041	525.424	525.424	0.000
VVA-067	474489.422	4960215.125	540.587	540.746	0.159
VVA-068	486502.940	4958413.466	503.653	503.663	0.010
VVA-069	521676.666	4957056.695	415.056	415.154	0.098
VVA-070	501420.046	4960105.182	455.164	455.286	0.122
VVA-071	510544.969	4969827.804	420.643	420.650	0.007
VVA-072	488436.383	4964976.998	513.017	513.337	0.320
VVA-073	461263.513	4964952.194	568.135	568.113	-0.022
VVA-074	435409.180	4971908.929	564.308	564.490	0.182
VVA-075	414598.552	4971006.321	575.558	575.787	0.229
VVA-076	398455.483	4968293.834	561.868	561.950	0.082
VVA-077	398616.362	4982115.311	580.862	581.019	0.157
VVA-078	408230.747	4985083.567	581.677	581.821	0.144
VVA-079	424245.975	4980631.523	617.669	617.719	0.050
VVA-080	437164.701	4978333.947	597.258	597.720	0.462
VVA-081	444065.393	4975066.573	575.280	575.203	-0.077
VVA-082	450097.348	4988232.350	607.052	607.143	0.091
VVA-083	438815.507	4986364.520	612.833	612.889	0.056
VVA-084	425603.347	4992924.426	626.326	626.269	-0.057
VVA-085	411509.365	4990011.470	608.461	608.491	0.030
VVA-086	403576.790	4993392.784	564.068	564.038	-0.030
VVA-087	404503.056	5001286.125	560.754	560.851	0.097
VVA-088	410486.197	5004444.428	600.740	600.929	0.189
VVA-089	418127.501	5001049.095	607.448	607.538	0.090
VVA-090	433008.967	5005846.151	577.169	577.311	0.142
VVA-091	443034.387	4999227.508	592.045	592.063	0.018
VVA-092	446937.925	5005632.975	587.972	588.028	0.056
VVA-093	425026.879	5010801.706	633.768	634.187	0.419
VVA-094	408033.493	5011013.969	561.691	562.067	0.376
VVA-095	406436.264	5019715.298	516.538	516.741	0.203
VVA-096	418728.007	5023833.954	611.587	612.017	0.430
VVA-097	437656.140	5018669.004	589.006	589.515	0.509
VVA-098	437973.674	5031552.152	611.020	611.255	0.235
VVA-099	426822.705	5032328.156	621.226	621.413	0.187

VVA-100	415573.031	5030223.868	598.452	598.781	0.329
VVA-101	404323.826	5031958.313	611.616	611.660	0.044
VVA-102	401273.470	5040597.789	538.551	538.618	0.067
VVA-103	412081.869	5036781.906	568.533	568.620	0.087
VVA-104	422108.188	5041433.806	585.937	586.155	0.218
VVA-105	436068.083	5034759.805	633.370	633.590	0.220
VVA-106	439548.126	5044342.632	628.798	629.317	0.519
VVA-107	431046.516	5049217.822	571.048	571.260	0.212
VVA-108	422153.917	5043857.968	553.258	553.461	0.203
VVA-109	405365.642	5049720.603	534.494	535.303	0.809
VVA-110	393542.202	5048339.738	578.703	578.761	0.058
VVA-111	398953.252	5054626.291	588.197	588.455	0.258
VVA-112	408722.539	5062554.930	577.410	577.528	0.118
VVA-113	421390.567	5054275.230	546.893	546.990	0.097
VVA-114	429509.591	5057301.730	529.925	530.241	0.316
VVA-115	442469.893	5053413.792	535.340	535.888	0.548
VVA-116	442567.953	5065239.907	568.997	569.030	0.033
VVA-117	426569.506	5067037.319	537.878	538.279	0.401
VVA-118	417163.249	5068776.150	516.281	516.559	0.278
VVA-119	407133.719	5064118.807	617.162	617.275	0.113
VVA-120	400796.194	5069544.445	608.151	608.431	0.280
VVA-121	408117.198	5077020.919	502.992	503.219	0.227
VVA-122	421794.911	5075125.548	539.980	540.243	0.263
VVA-123	434825.233	5075024.489	565.080	565.284	0.204
VVA-124	440521.762	5081371.465	554.494	554.857	0.363
VVA-125	430008.956	5086341.784	614.875	615.120	0.245
VVA-126	417109.437	5084199.890	534.243	534.599	0.356
VVA-127	408227.684	5084944.010	519.996	520.215	0.219
VVA-128	395824.123	5078891.353	514.348	514.508	0.160
VVA-129	402662.536	5085171.756	501.365	501.464	0.099
VVA-130	388974.545	5087595.417	494.647	495.317	0.670

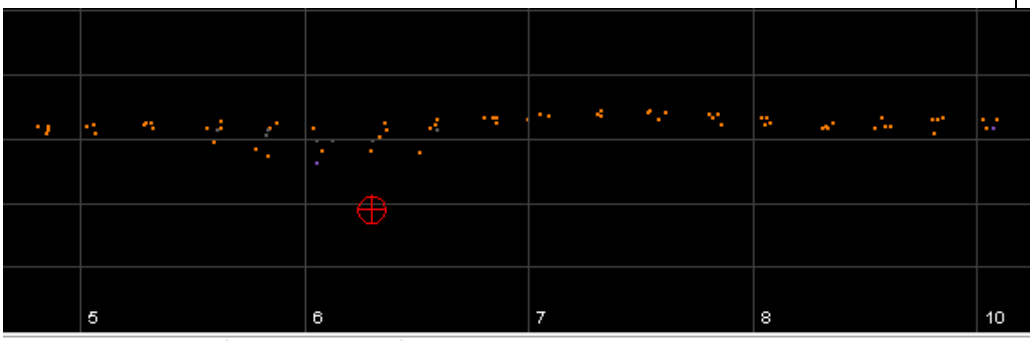
VVA Point Details

The following pages provide more detail for each of the 21 points that had a Delta Z greater than 29 centimeters when compared with the LiDAR data. The cross section for each example is 2 meters in width to give a better comparison with all possible nearby LiDAR points. In the majority of cases there are no additional LiDAR points near the checkpoint. Where points are present they are typically isolated in nature and were classified as noise because there were not enough points to define a surface. If the lowest points were used in the surrounding area the VVA would improve by no more than 6 cm but the overall surface definition would result in significant voids in fields where vegetation was present.

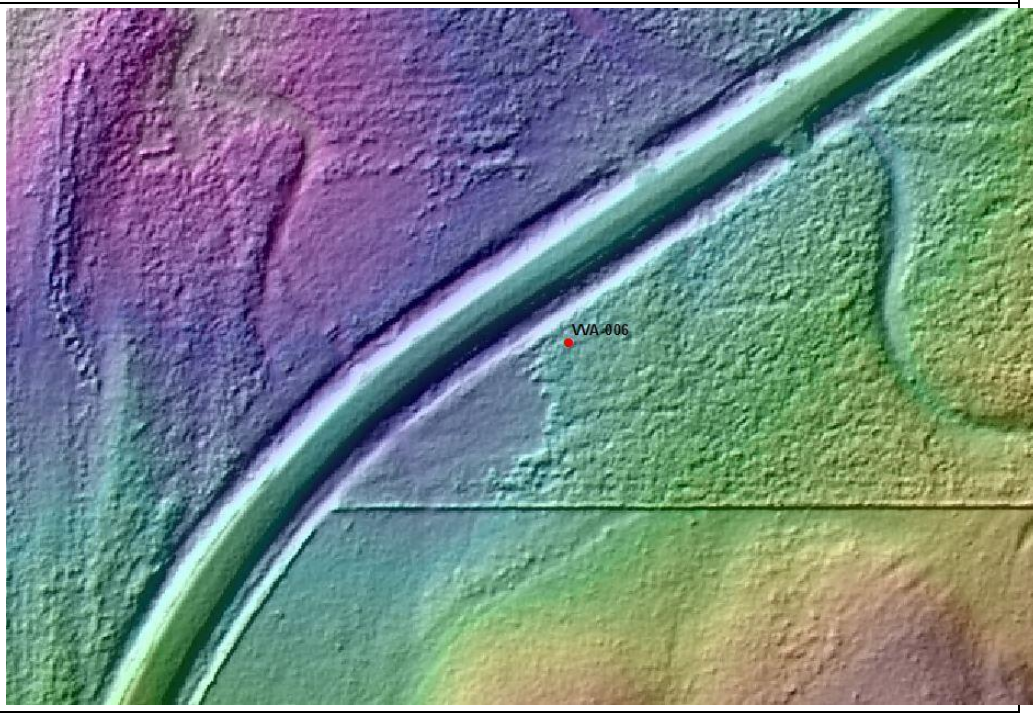
Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-006	483397.166	4926521.161	568.235	568.630	0.395

Survey Photo

Cross Section



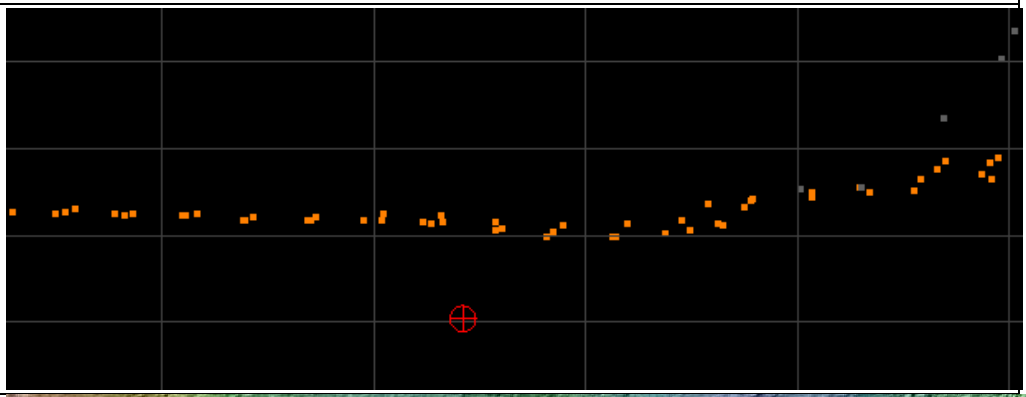
Bare Earth DEM (classified ground only)



Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-010	331303.013	4895961.422	636.315	636.776	0.461

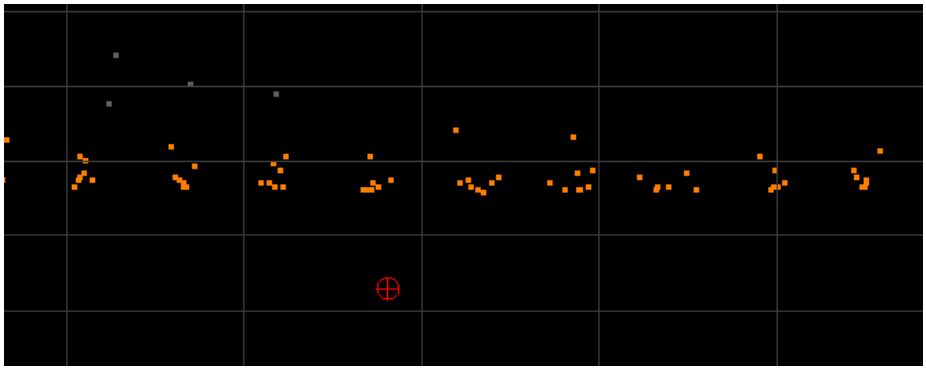
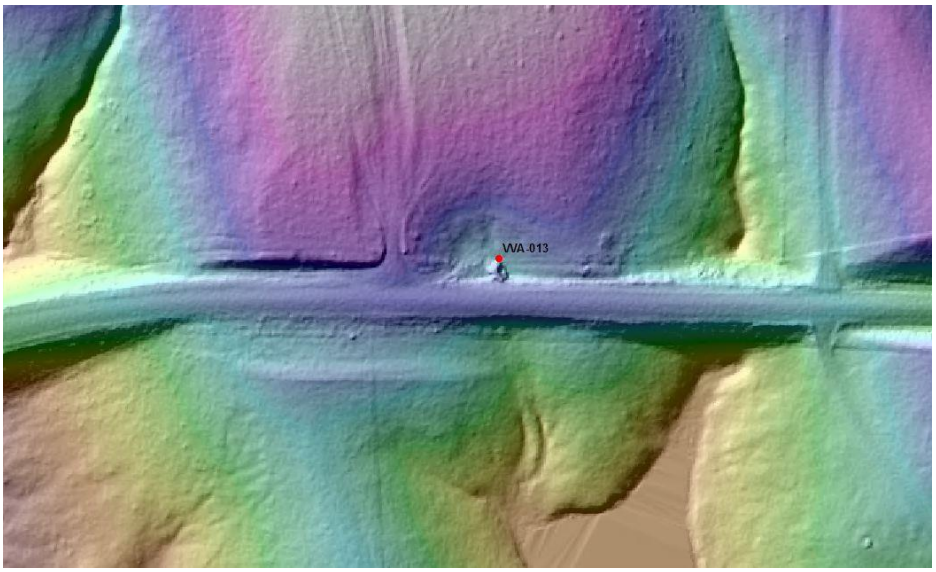
Survey Photo

Cross Section



Bare Earth DEM (classified ground only)

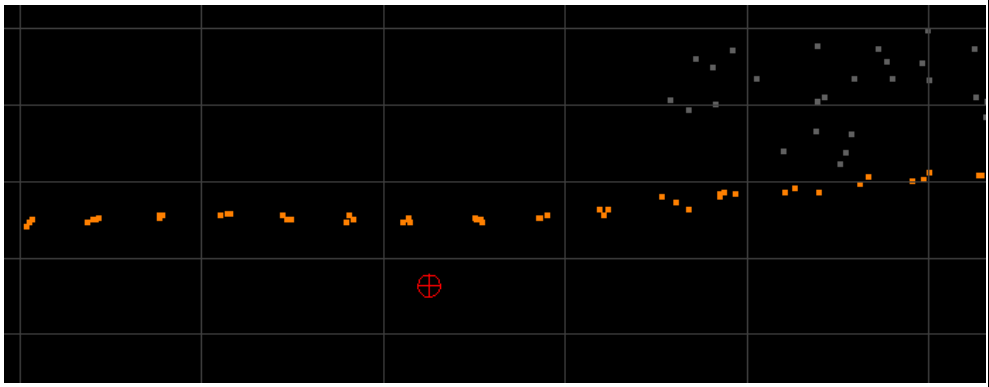
Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-013	382542.599	4908238.728	538.080	538.383	0.303

Survey Photo	
Cross Section • Ground • Low Point (noise) • Water • Rail • Bridge Deck • High Noise	
Bare Earth DEM (classified ground only)	

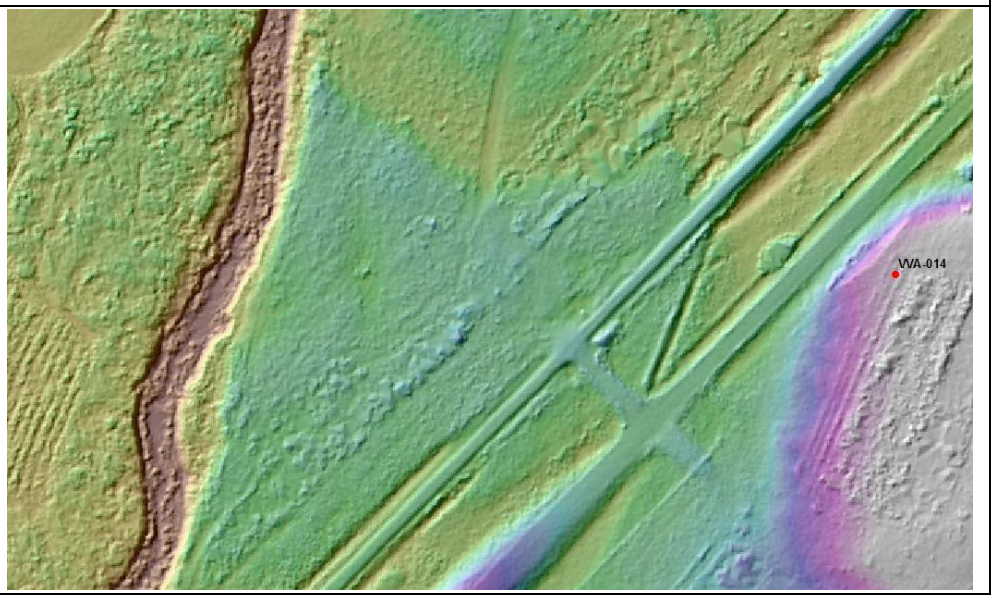
Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-014	414969.354	4908370.176	438.491	438.804	0.313

Survey Photo

Cross Section



Bare Earth DEM (classified ground only)

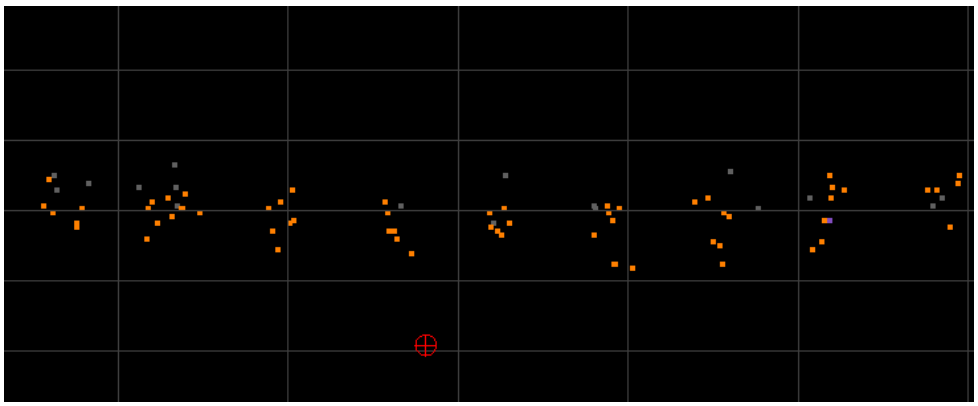


Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-026	446468.203	4925736.743	581.371	581.677	0.306

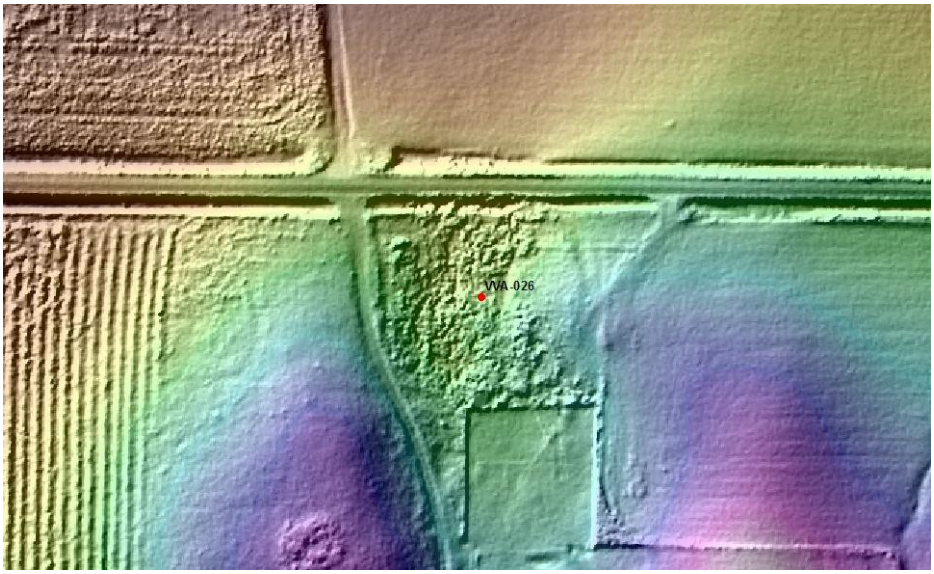
Survey Photo

Cross Section

- Ground
- Low Point (noise)
- Water
- Rail
- Bridge Deck
- High Noise



Bare Earth DEM (classified ground only)

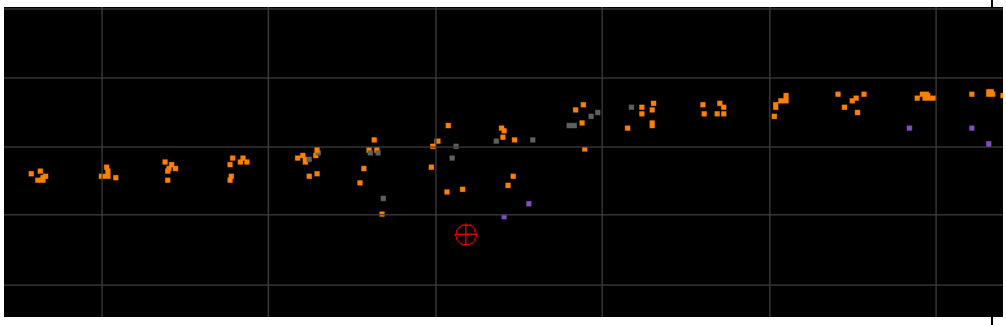


Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-053	420760.779	4946072.986	546.571	546.968	0.397

Survey Photo

Cross Section

- Ground
- Low Point (noise)
- Water
- Rail
- Bridge Deck
- High Noise



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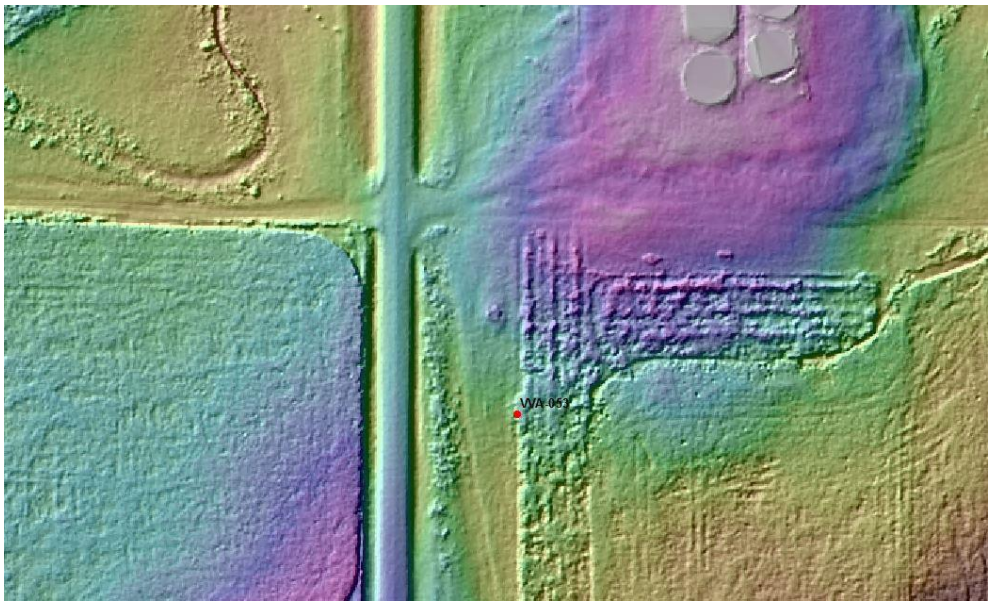
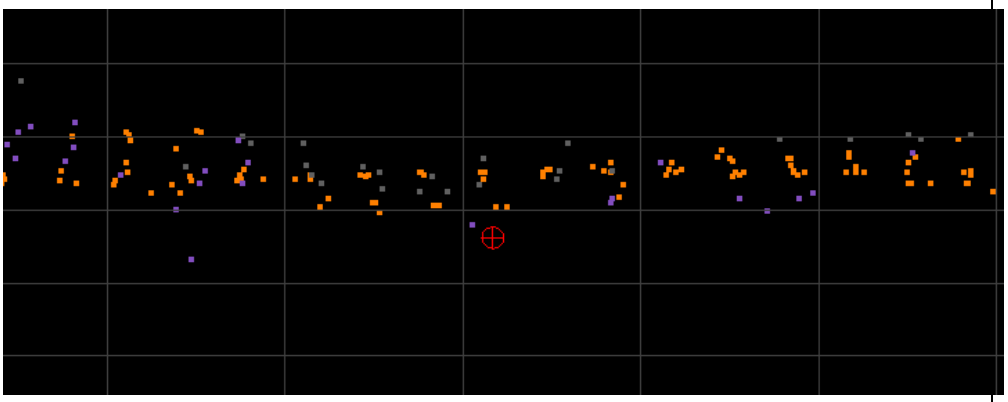


Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-072	488436.383	4964976.998	513.017	513.337	0.320

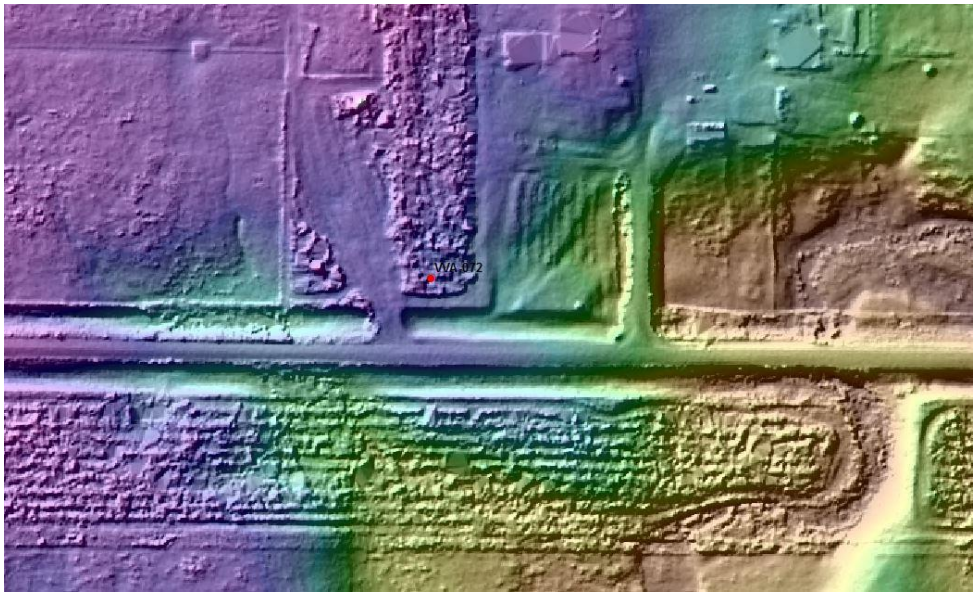
Survey Photo

Cross Section

- Ground
- Low Point (noise)
- Water
- Rail
- Bridge Deck
- High Noise



Bare Earth DEM (classified ground only)

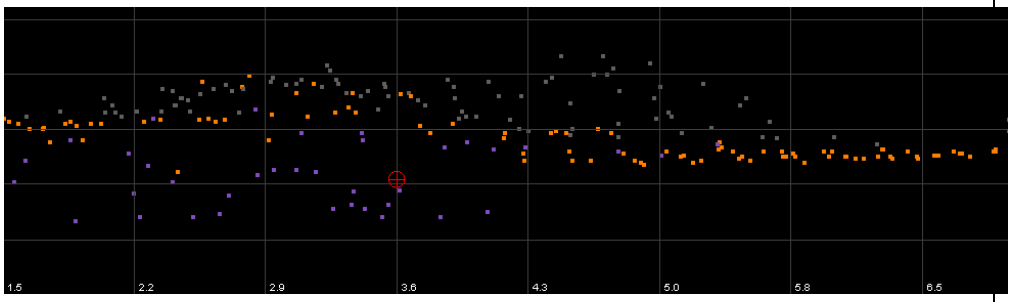


Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-080	437164.701	4978333.947	597.258	597.720	0.462

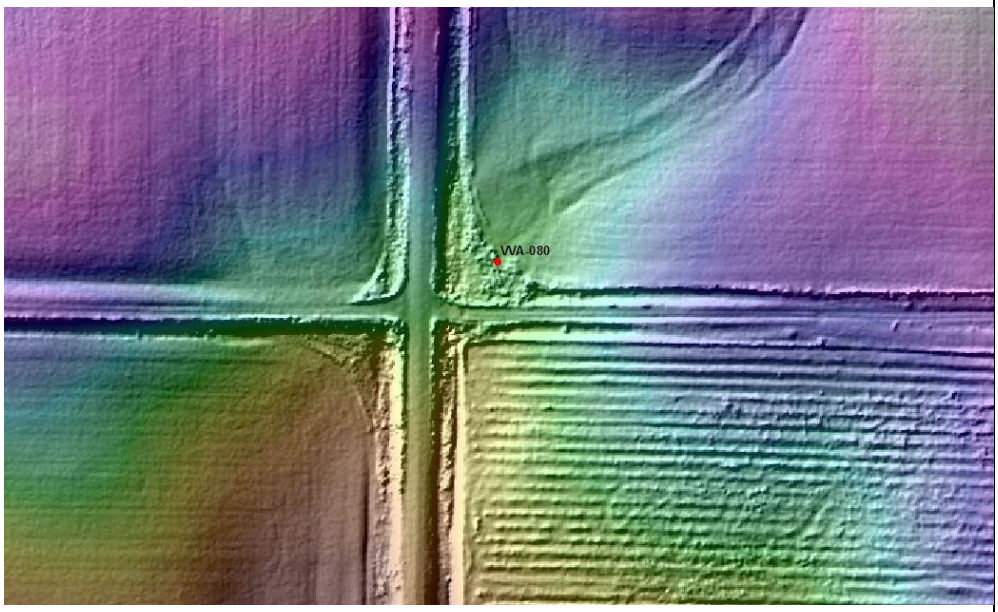
Survey Photo

Cross Section

- Ground
- Low Point (noise)
- Water
- Rail
- Bridge Deck
- High Noise



Bare Earth DEM (classified ground only)

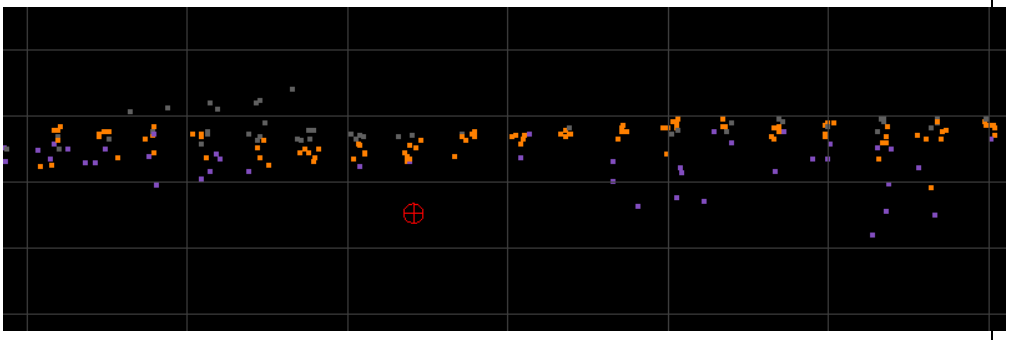


Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-093	425026.879	5010801.706	633.768	634.187	0.419

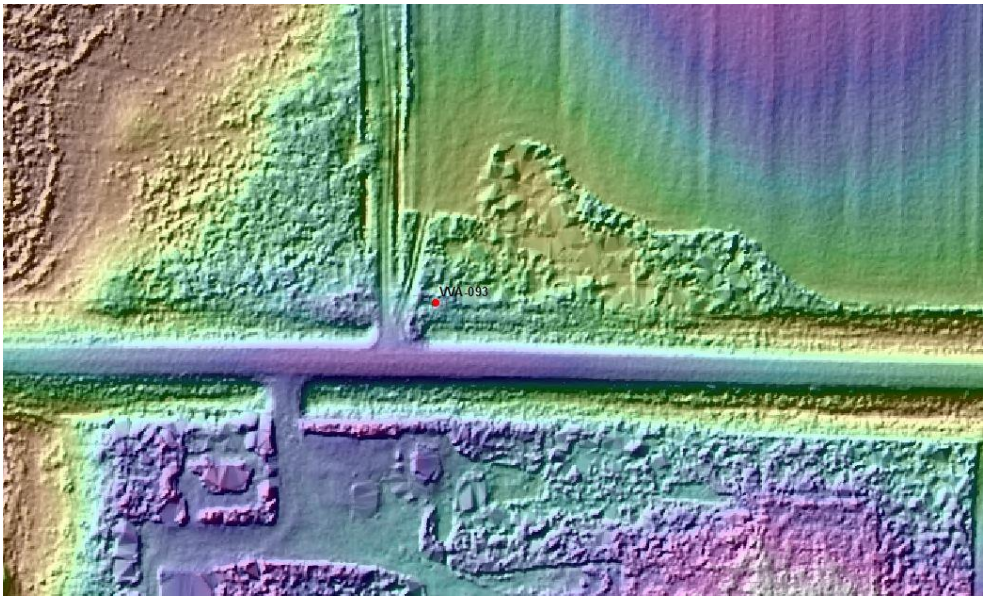
Survey Photo

Cross Section

- Ground
- Low Point (noise)
- Water
- Rail
- Bridge Deck
- High Noise



Bare Earth DEM (classified ground only)

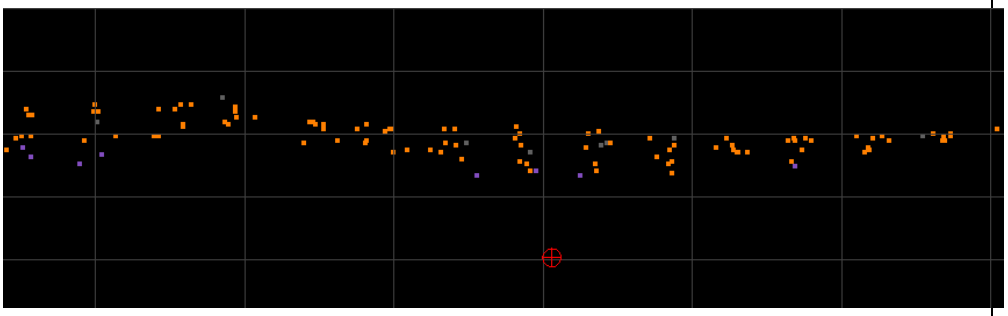


Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-094	408033.493	5011013.969	561.691	562.067	0.376

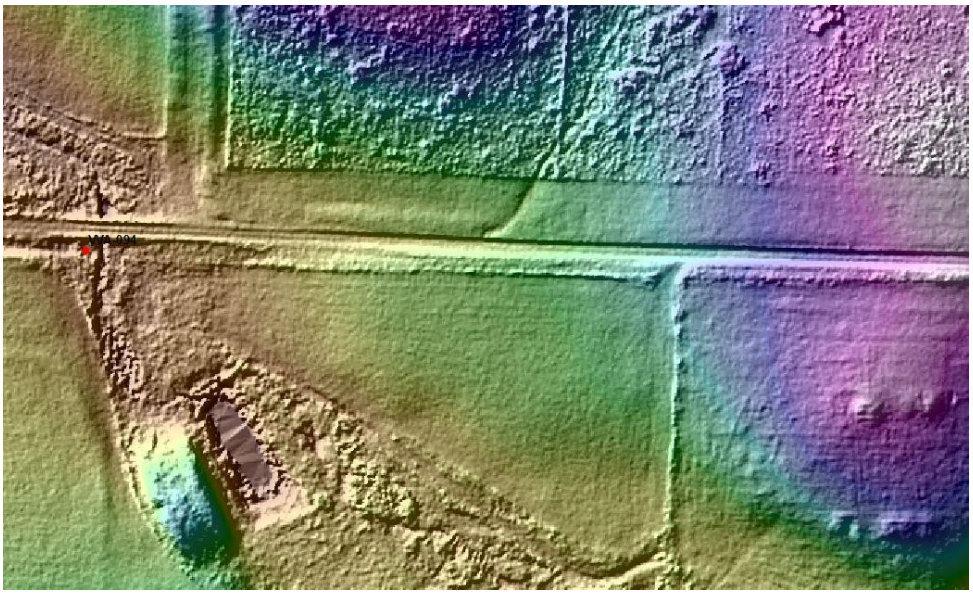
Survey Photo

Cross Section

- Ground
- Low Point (noise)
- Water
- Rail
- Bridge Deck
- High Noise



Bare Earth DEM (classified ground only)

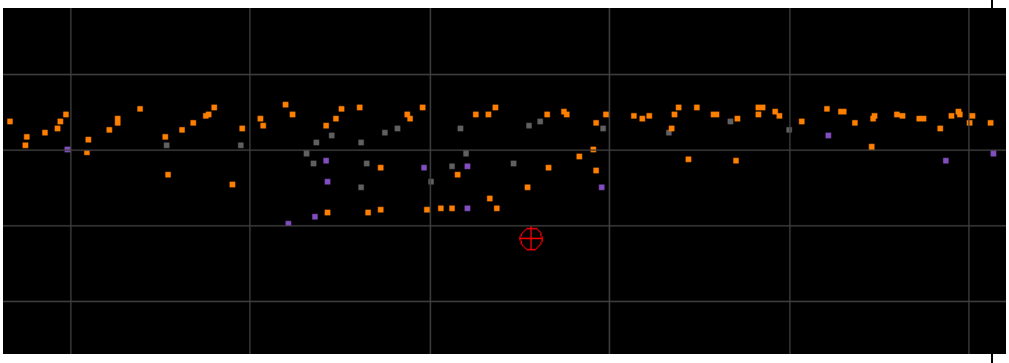


Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-096	418728.007	5023833.954	611.587	612.017	0.430

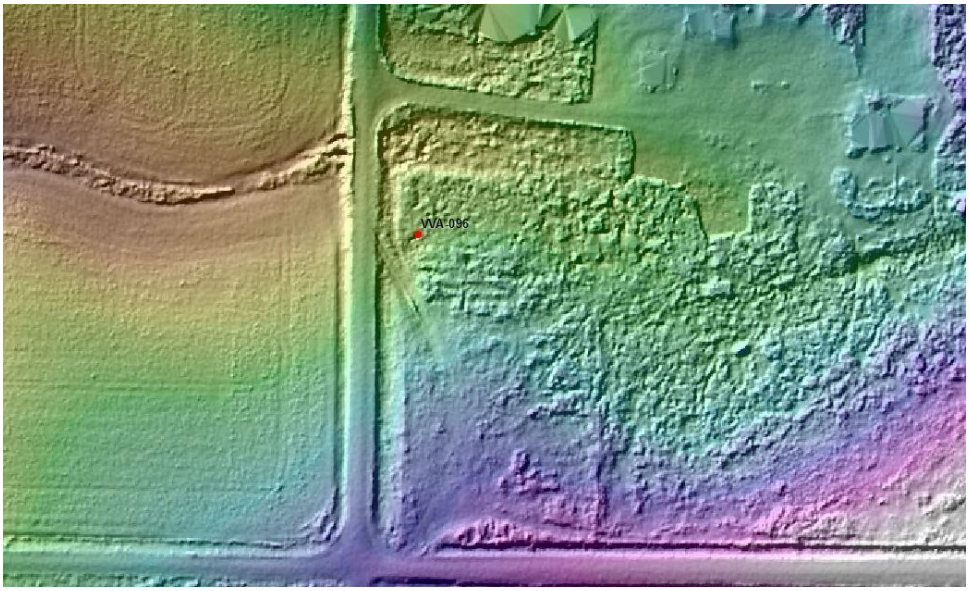
Survey Photo

Cross Section

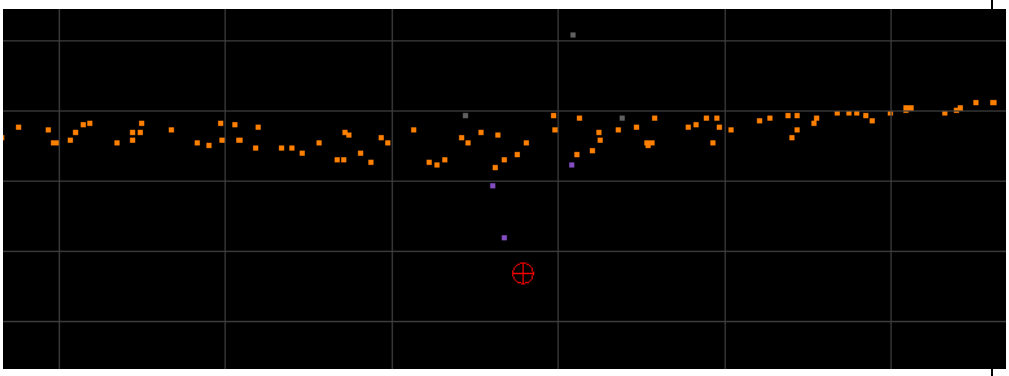
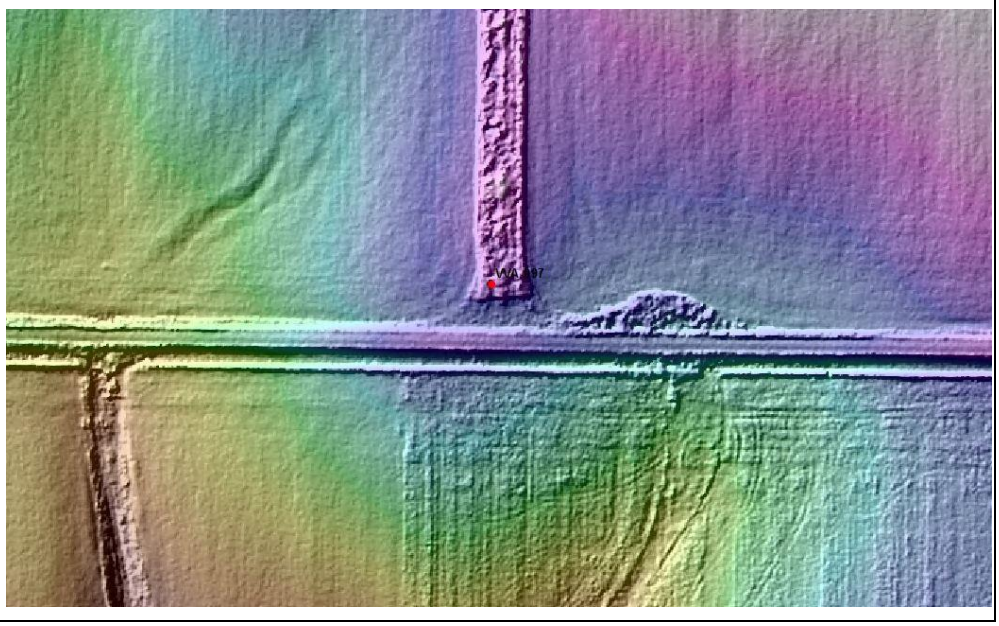
- Ground
- Low Point (noise)
- Water
- Rail
- Bridge Deck
- High Noise



Bare Earth DEM (classified ground only)



Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-097	437656.140	5018669.004	589.006	589.515	0.509

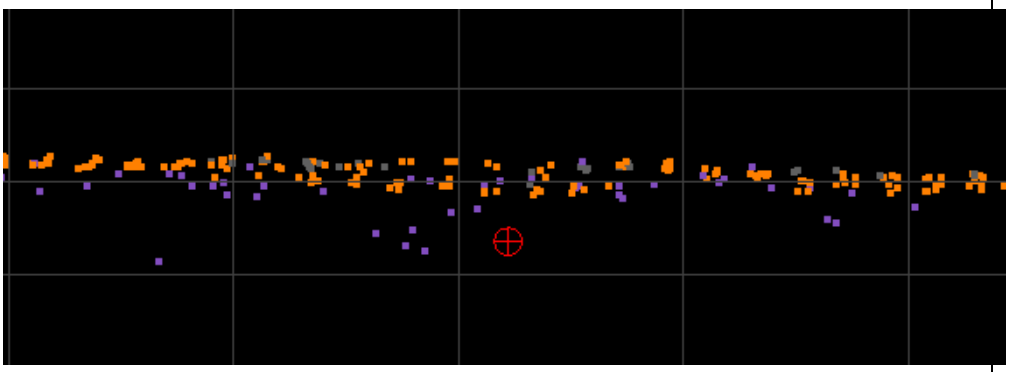
Survey Photo	
Cross Section • Ground • Low Point (noise) • Water • Rail • Bridge Deck • High Noise	
Bare Earth DEM (classified ground only)	

Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-100	415573.031	5030223.868	598.452	598.781	0.329

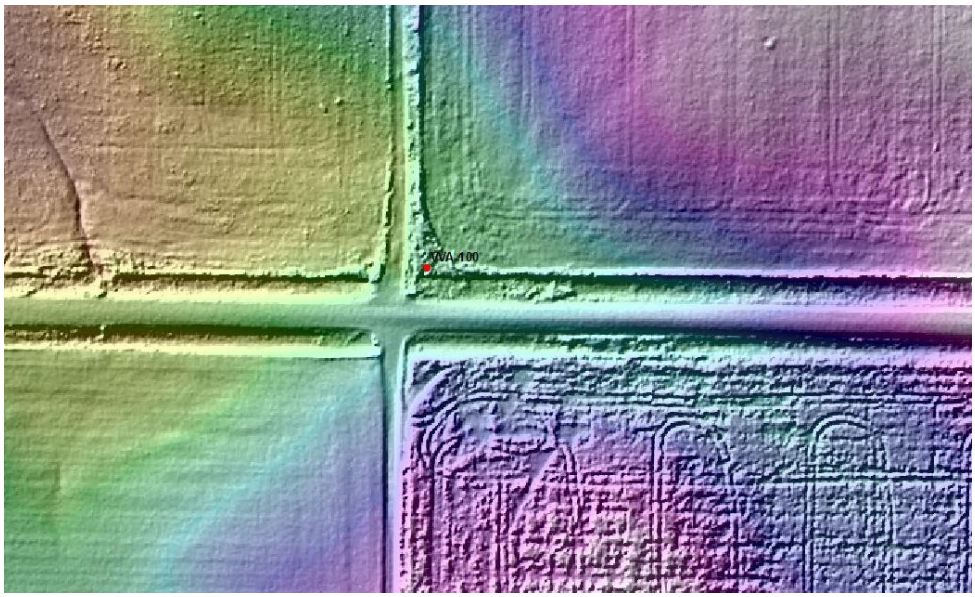
Survey Photo

Cross Section

- Ground
- Low Point (noise)
- Water
- Rail
- Bridge Deck
- High Noise



Bare Earth DEM (classified ground only)

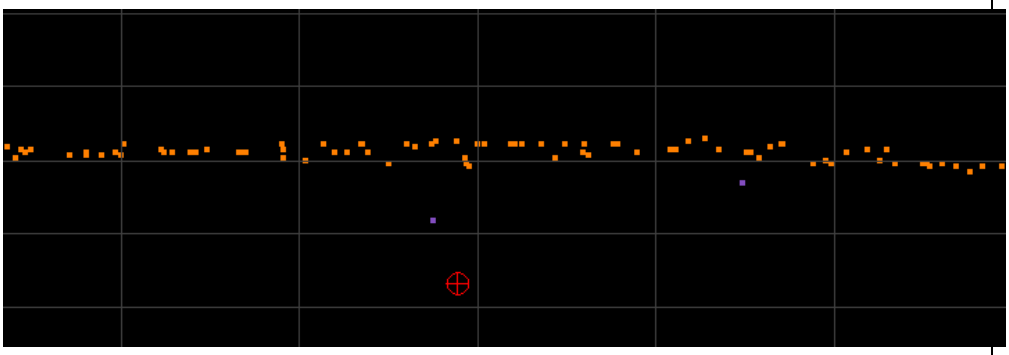


Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-106	439548.126	5044342.632	628.798	629.317	0.519

Survey Photo

Cross Section

- Ground
- Low Point (noise)
- Water
- Rail
- Bridge Deck
- High Noise



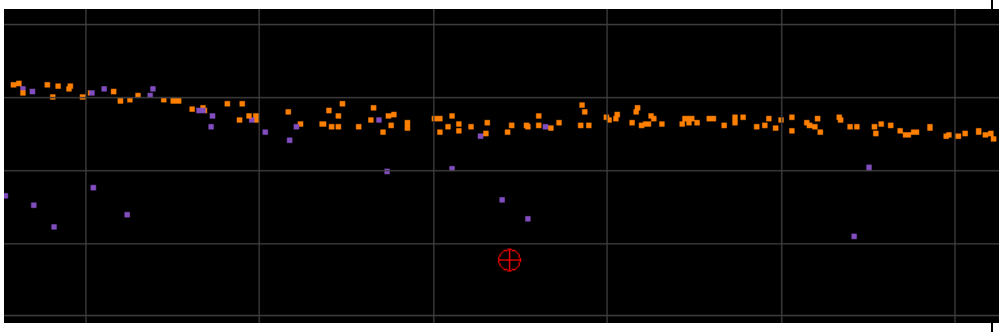
Bare Earth DEM (classified ground only)

Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-109	405365.642	5049720.603	534.494	535.303	0.809

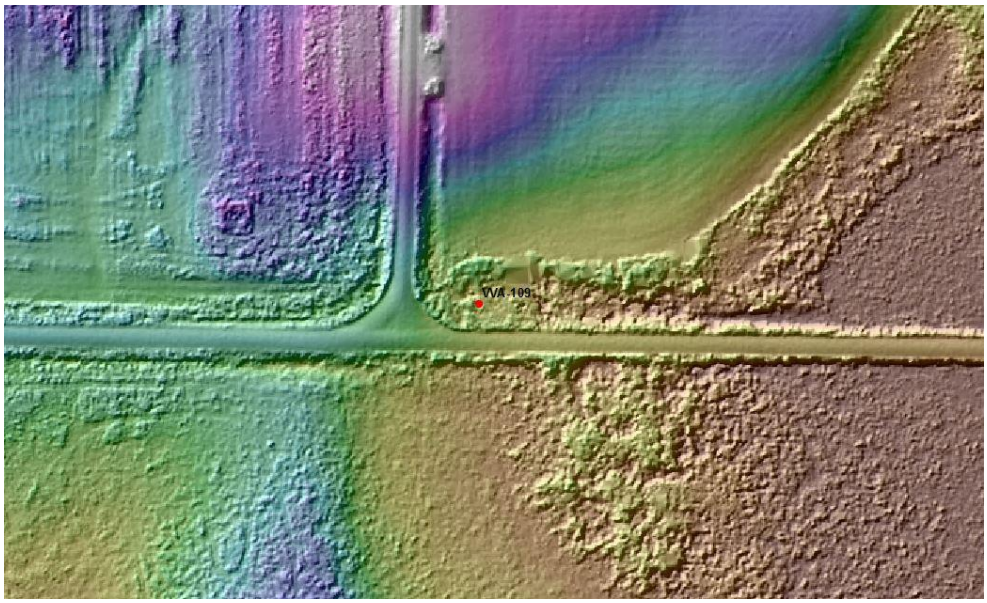
Survey Photo

Cross Section

- Ground
- Low Point (noise)
- Water
- Rail
- Bridge Deck
- High Noise



Bare Earth DEM (classified ground only)

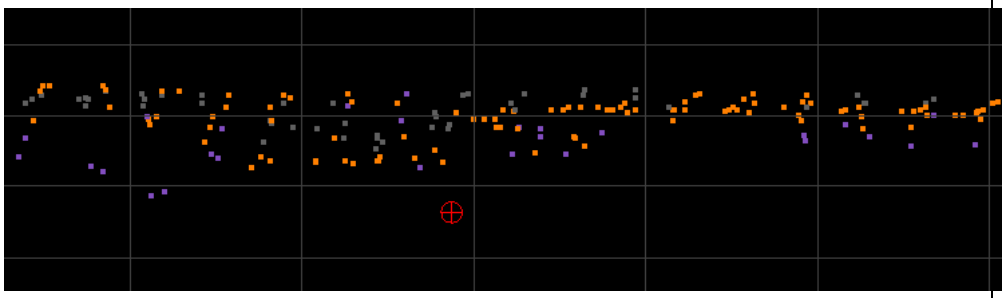


Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-114	429509.591	5057301.730	529.925	530.241	0.316

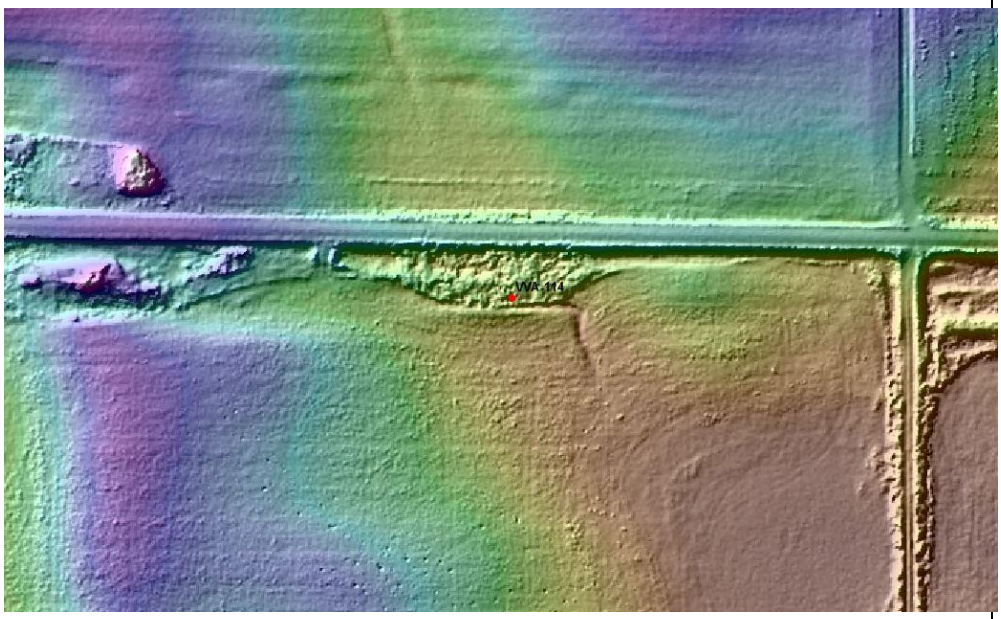
Survey Photo

Cross Section

- Ground
- Low Point (noise)
- Water
- Rail
- Bridge Deck
- High Noise

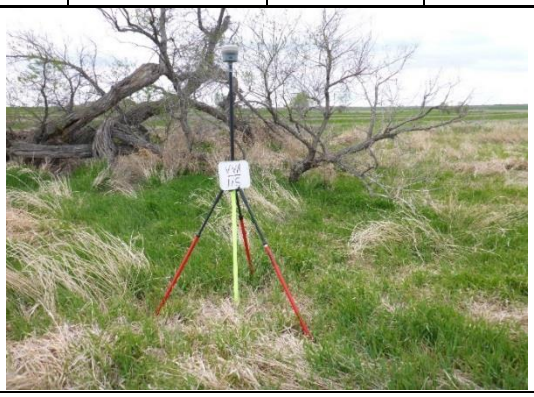


Bare Earth DEM (classified ground only)



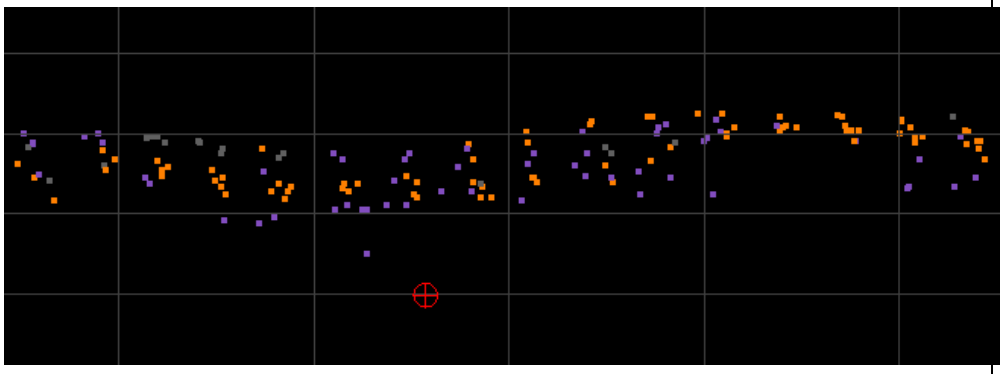
Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-115	442469.893	5053413.792	535.340	535.888	0.548

Survey Photo

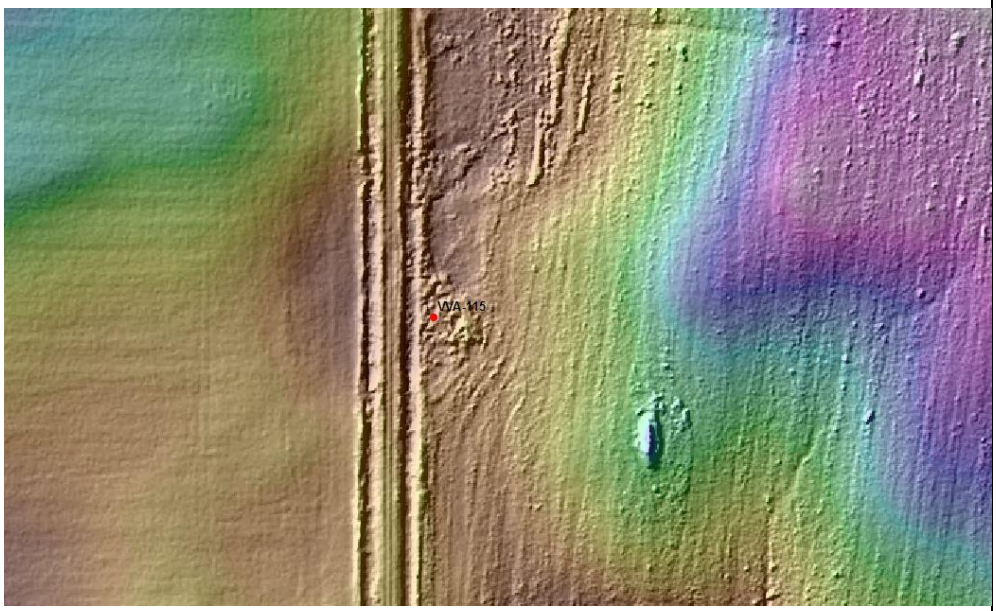


Cross Section

- Ground
- Low Point (noise)
- Water
- Rail
- Bridge Deck
- High Noise



Bare Earth DEM (classified ground only)

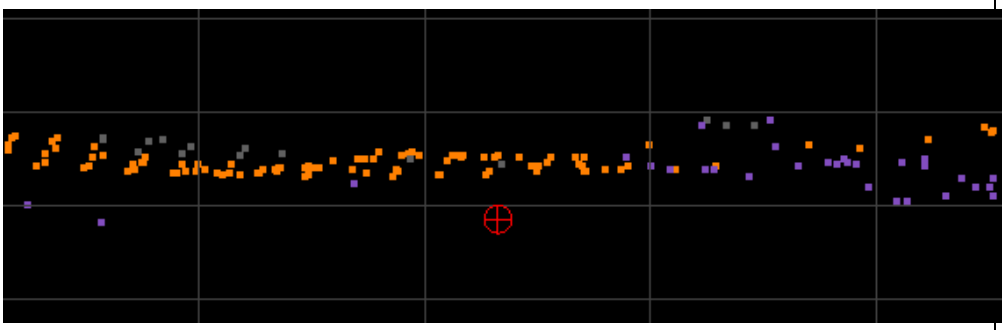


Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-117	426569.506	5067037.319	537.878	538.279	0.401

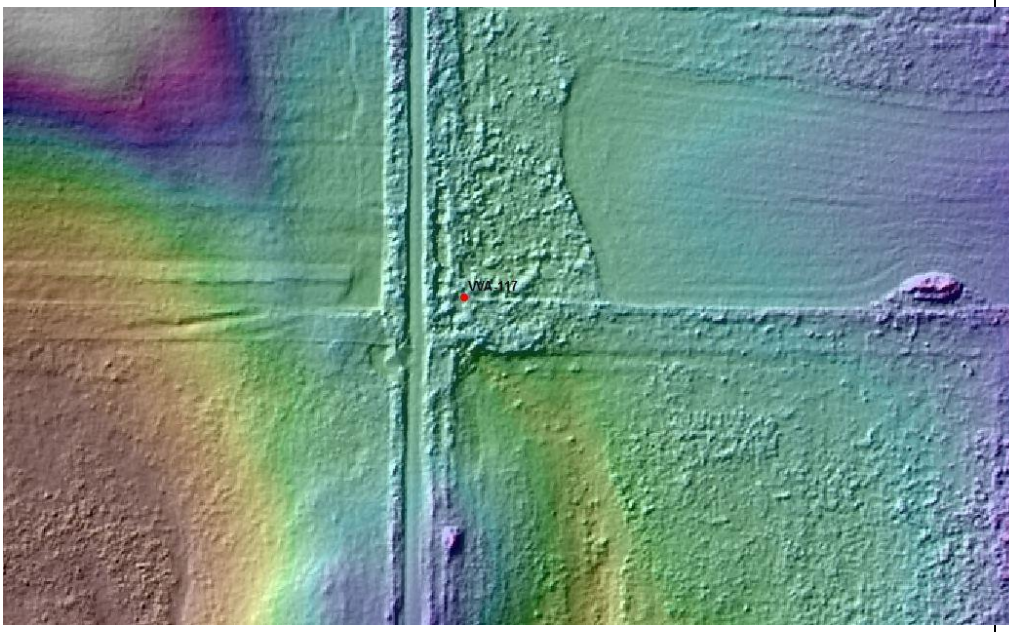
Survey Photo

Cross Section

- Ground
- Low Point (noise)
- Water
- Rail
- Bridge Deck
- High Noise



Bare Earth DEM (classified ground only)

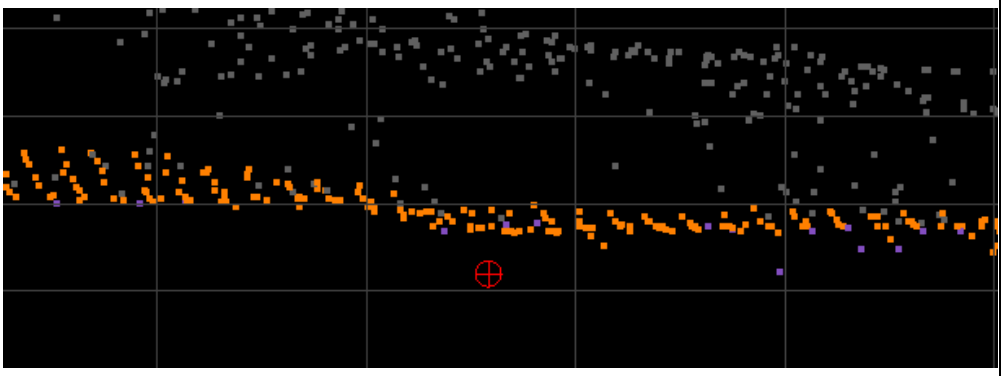


Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-124	440521.762	5081371.465	554.494	554.857	0.363

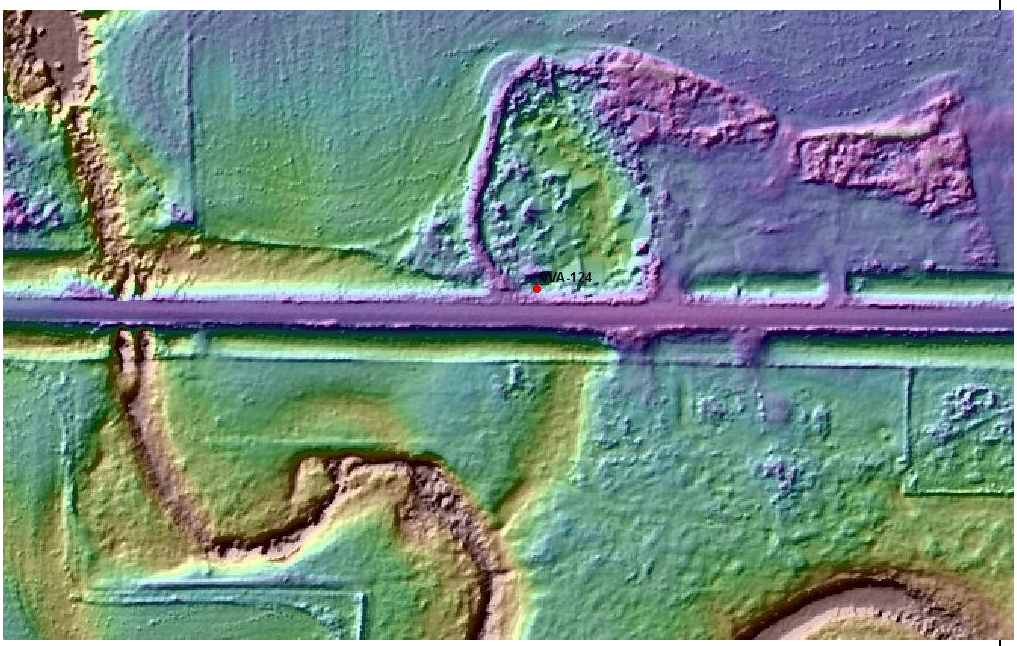
Survey Photo

Cross Section

- Ground
- Low Point (noise)
- Water
- Rail
- Bridge Deck
- High Noise



Bare Earth DEM (classified ground only)

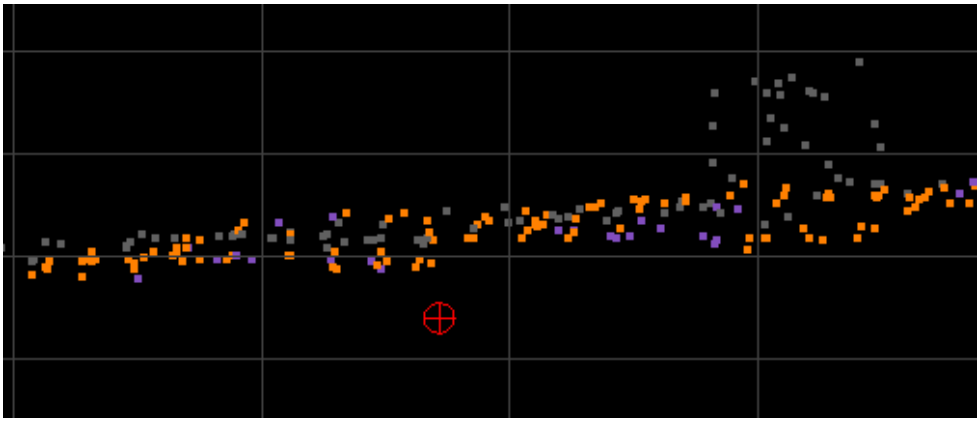


Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-126	417109.437	5084199.890	534.243	534.599	0.356

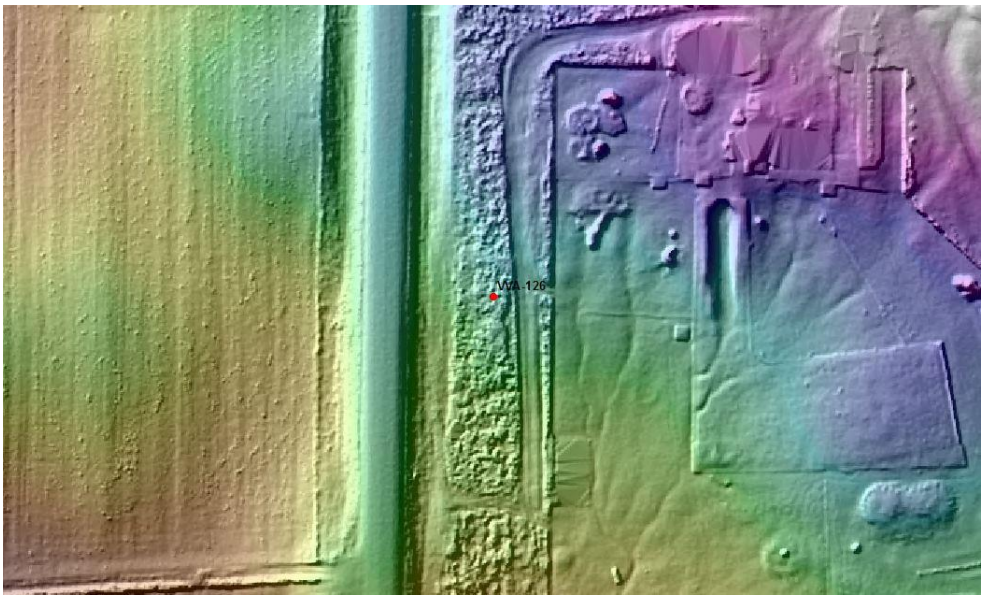
Survey Photo

Cross Section

- Ground
- Low Point (noise)
- Water
- Rail
- Bridge Deck
- High Noise



Bare Earth DEM (classified ground only)

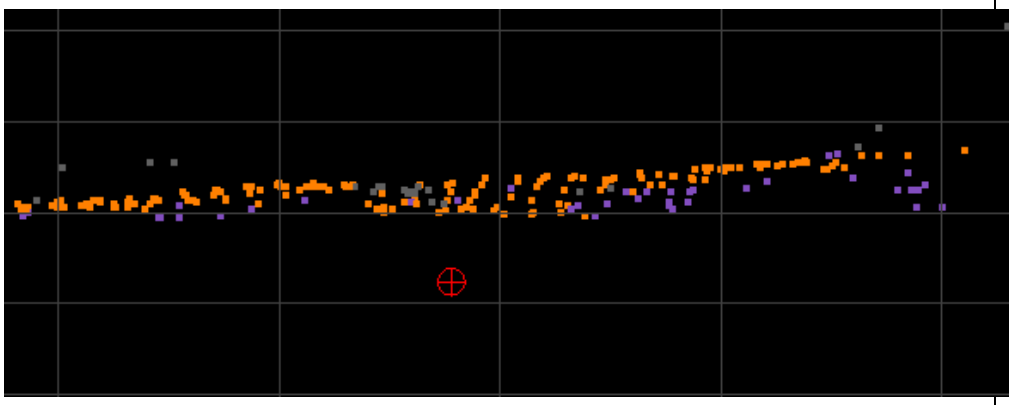


Name	X	Y	SurveyZ	LiDARZ	Delta
VVA-130	388974.545	5087595.417	494.647	495.317	0.670

Survey Photo

Cross Section

- Ground
- Low Point (noise)
- Water
- Rail
- Bridge Deck
- High Noise



Bare Earth DEM (classified ground only)