

## C-4.1 Report on Nominal Pulse Spacing (NPS)

The USGS Lidar Base Specification Version 1.3 states: "Assessment and reporting of the NPS are made against single swath, single instrument, first-return-only data, including only the geometrically usable part of the swath and excluding acceptable data voids. Higher net densities of lidar point measurements are being achieved more often by flying multiple passes of the lidar instrument over the project area or flying with large amounts (greater than [ $>$ ] 50 percent) of overlap between swaths, creating a need for a new term to describe total pulse density without being confused with NPS and NPD. This specification will use the terms aggregate nominal pulse spacing (ANPS) and aggregate nominal pulse density (ANPD) to describe the net overall pulse spacing and density, respectively. The required ANPS and ANPD by QL are listed in Table 1. Dependent on the local terrain and land cover conditions in a project, a greater pulse density may be required on specific projects."

**Table 1.** Aggregate nominal pulse spacing and density.

[QL, quality level; pls/m<sup>2</sup>, pulses per square meter; m, meter;  $\leq$ , less than or equal to;  $\geq$ , greater than or equal to]

Quality level	Aggregate nominal pulse spacing (m)	Aggregate nominal pulse density (pls/m <sup>2</sup> )
QL0	$\leq 0.35$	$\geq 8.0$
QL1	$\leq 0.35$	$\geq 8.0$
QL2	$\leq 0.71$	$\geq 2.0$
QL3	$\leq 1.41$	$\geq 0.5$

The purpose of this section is to report on the lidar point density and nominal point spacing by LAS file. Averages by files (not including overlap), project boundary polygons (including overlap), and aggregate project boundary polygons (including overlap) are reported.

[Data Source - Y:\Mapping\Projects\65220171\\_USGS-TX\\_West\\_Texas\Production\Final\\_Client\\_Deliverables\Lot10\\_utm13\point\\_cloud\Swaths](Y:\Mapping\Projects\65220171_USGS-TX_West_Texas\Production\Final_Client_Deliverables\Lot10_utm13\point_cloud\Swaths)

Quality level tested: QL2

File	Number of First Returns	Area	Point Density	NPS
CS_00176.las	30,410,124	11,360,192	2.677/0.249	0.611/2.005
CS_00177.las	60,231,784	22,443,792	2.684/0.249	0.610/2.001
CS_00182.las	23,849,410	7,946,832	3.001/0.279	0.577/1.893
CS_00226.las	72,194,300	24,663,888	2.927/0.272	0.584/1.916

## C-4.1 Report on Nominal Pulse Spacing (NPS) - continued

File	Number of First Returns	Area	Point Density	NPS
CS_00243.las	209,945,798	76,773,488	2.735/0.254	0.605/1.985
CS_00245.las	104,708,760	35,414,464	2.957/0.275	0.582/1.909
CS_02002.las	67,585,677	24,924,144	2.712/0.252	0.607/1.991
CS_02032.las	91,373,401	30,519,760	2.994/0.278	0.578/1.896
CS_02034.las	108,116,877	33,474,336	3.230/0.300	0.556/1.824
CS_02037.las	393,973,384	135,166,736	2.915/0.271	0.586/1.923
CS_02040.las	388,360,050	136,369,232	2.848/0.265	0.593/1.946
CS_02043.las	381,820,901	135,462,160	2.819/0.262	0.596/1.955
CS_02045.las	384,624,843	134,727,520	2.855/0.265	0.592/1.942
CS_02049.las	381,442,218	135,340,832	2.818/0.262	0.596/1.955
CS_02059.las	394,872,435	135,312,656	2.918/0.271	0.585/1.919
CS_02063.las	238,635,696	84,204,768	2.834/0.263	0.594/1.949
CS_02073.las	84,408,901	29,548,768	2.857/0.265	0.592/1.942
CS_02075.las	264,278,852	91,627,520	2.884/0.268	0.589/1.932
CS_02077.las	423,853,803	134,100,000	3.161/0.294	0.562/1.844
CS_02083.las	382,431,530	135,763,504	2.817/0.262	0.596/1.955
CS_02088.las	382,436,873	136,194,976	2.808/0.261	0.597/1.959
CS_02090.las	378,854,196	135,439,312	2.797/0.260	0.598/1.962
CS_02097.las	221,971,234	81,675,232	2.718/0.253	0.607/1.991
CS_02107.las	354,689,123	129,253,472	2.744/0.255	0.604/1.982
CS_02114.las	244,507,831	84,118,720	2.907/0.270	0.587/1.926
CS_02116.las	237,782,975	84,687,360	2.808/0.261	0.597/1.959
CS_02118.las	140,309,479	50,788,896	2.763/0.257	0.602/1.975
CS_02120.las	164,109,469	50,959,712	3.220/0.299	0.557/1.827
CS_02121.las	149,842,422	50,356,816	2.976/0.276	0.580/1.903
CS_02132.las	92,142,973	30,444,160	3.027/0.281	0.575/1.886
CS_02134.las	407,513,989	131,682,416	3.095/0.288	0.568/1.864
CS_02136.las	382,054,644	131,004,256	2.916/0.271	0.586/1.923
CS_02139.las	399,994,620	136,033,024	2.940/0.273	0.583/1.913
CS_02143.las	123,917,202	42,719,872	2.901/0.270	0.587/1.926
CS_02147.las	382,975,392	135,405,792	2.828/0.263	0.595/1.952
CS_02149.las	388,381,159	136,854,672	2.838/0.264	0.594/1.949
CS_02154.las	380,657,884	135,759,520	2.804/0.261	0.597/1.959

## C-4.1 Report on Nominal Pulse Spacing (NPS) - continued

File	Number of First Returns	Area	Point Density	NPS
CS_02158.las	379,506,328	135,985,776	2.791/0.259	0.599/1.965
CS_02163.las	293,983,974	79,293,872	3.708/0.344	0.519/1.703
CS_02168.las	265,311,273	88,873,376	2.985/0.277	0.579/1.900
CS_02177.las	231,417,289	83,935,840	2.757/0.256	0.602/1.975
CS_02179.las	239,960,827	84,196,352	2.850/0.265	0.592/1.942
CS_02183.las	143,280,321	50,892,368	2.815/0.262	0.596/1.955
CS_02184.las	151,929,433	50,273,872	3.022/0.281	0.575/1.886
CS_02185.las	153,397,384	50,488,160	3.038/0.282	0.574/1.883
CS_02200.las	87,804,422	31,182,832	2.816/0.262	0.596/1.955
CS_02203.las	391,867,988	133,047,600	2.945/0.274	0.583/1.913
CS_02208.las	394,730,861	135,711,504	2.909/0.270	0.586/1.923
CS_02216.las	381,705,561	135,950,416	2.808/0.261	0.597/1.959
CS_02218.las	378,640,044	135,723,456	2.790/0.259	0.599/1.965
CS_02223.las	379,314,822	135,149,808	2.807/0.261	0.597/1.959
CS_02227.las	404,011,467	135,117,360	2.990/0.278	0.578/1.896
CS_02228.las	247,176,101	80,855,776	3.057/0.284	0.572/1.877
CS_02230.las	376,785,645	135,005,936	2.791/0.259	0.599/1.965
CS_02234.las	383,035,816	135,761,504	2.821/0.262	0.595/1.952
CS_02238.las	237,603,459	83,375,504	2.850/0.265	0.592/1.942
CS_02248.las	253,462,137	83,941,456	3.020/0.281	0.575/1.886
CS_02250.las	239,458,501	84,459,504	2.835/0.263	0.594/1.949
CS_02253.las	163,711,258	48,773,456	3.357/0.312	0.546/1.791
CS_02254.las	141,443,930	50,251,040	2.815/0.262	0.596/1.955
CS_02256.las	149,679,161	50,344,000	2.973/0.276	0.580/1.903
CS_02268.las	7,099,109	1,532,608	4.632/0.430	0.465/1.526
CS_02271.las	89,690,198	30,834,352	2.909/0.270	0.586/1.923
CS_02274.las	412,827,725	132,159,936	3.124/0.290	0.566/1.857
CS_02280.las	363,511,137	127,814,336	2.844/0.264	0.593/1.946
CS_02283.las	389,369,848	135,794,240	2.867/0.266	0.591/1.939
CS_02289.las	381,331,187	135,719,184	2.810/0.261	0.597/1.959
CS_02290.las	391,585,060	135,952,512	2.880/0.268	0.589/1.932
CS_02295.las	376,041,639	136,256,704	2.760/0.256	0.602/1.975
CS_02296.las	388,502,796	135,356,480	2.870/0.267	0.590/1.936

## C-4.1 Report on Nominal Pulse Spacing (NPS) - continued

File	Number of First Returns	Area	Point Density	NPS
CS_02299.las	380,174,833	134,939,104	2.817/0.262	0.596/1.955
CS_02300.las	219,051,068	79,928,176	2.741/0.255	0.604/1.982
CS_02302.las	386,757,511	135,300,256	2.859/0.266	0.591/1.939
CS_02306.las	395,490,231	135,484,832	2.919/0.271	0.585/1.919
CS_02308.las	244,265,463	83,490,640	2.926/0.272	0.585/1.919
CS_02316.las	233,539,597	84,239,696	2.772/0.258	0.601/1.972
CS_02317.las	240,929,982	84,266,336	2.859/0.266	0.591/1.939
CS_02319.las	157,603,193	48,701,712	3.236/0.301	0.556/1.824
CS_02320.las	135,651,917	47,295,520	2.868/0.266	0.590/1.936
CS_02323.las	161,754,089	54,657,424	2.959/0.275	0.581/1.906
CS_02338.las	84,826,611	29,843,072	2.842/0.264	0.593/1.946
CS_02341.las	372,393,281	133,152,576	2.797/0.260	0.598/1.962
CS_02350.las	387,563,932	136,116,688	2.847/0.264	0.593/1.946
CS_02355.las	379,644,453	136,299,760	2.785/0.259	0.599/1.965
CS_02356.las	378,720,653	136,109,552	2.782/0.258	0.599/1.965
CS_02360.las	385,498,128	134,791,776	2.860/0.266	0.591/1.939
CS_02362.las	213,832,512	78,542,560	2.723/0.253	0.606/1.988
CS_02363.las	334,096,936	112,258,656	2.976/0.276	0.580/1.903
CS_02364.las	234,031,337	77,803,136	3.008/0.279	0.577/1.893
CS_02368.las	229,879,732	76,616,208	3.000/0.279	0.577/1.893
CS_02369.las	44,376,186	15,195,040	2.920/0.271	0.585/1.919
CS_02371.las	237,594,952	83,480,576	2.846/0.264	0.593/1.946
CS_02379.las	252,018,048	83,894,912	3.004/0.279	0.577/1.893
CS_02380.las	190,750,594	67,970,144	2.806/0.261	0.597/1.959
CS_02382.las	134,499,558	48,404,448	2.779/0.258	0.600/1.969
CS_02383.las	163,340,930	48,760,432	3.350/0.311	0.546/1.791
CS_02384.las	169,445,388	50,810,816	3.335/0.310	0.548/1.798
CS_02386.las	151,251,189	50,234,448	3.011/0.280	0.576/1.890
CS_02400.las	86,895,103	30,551,488	2.844/0.264	0.593/1.946
CS_02409.las	393,876,564	135,616,352	2.904/0.270	0.587/1.926
CS_02415.las	391,311,908	135,115,536	2.896/0.269	0.588/1.929
CS_02419.las	378,291,142	135,595,968	2.790/0.259	0.599/1.965
CS_02420.las	389,526,076	134,360,576	2.899/0.269	0.587/1.926

## C-4.1 Report on Nominal Pulse Spacing (NPS) - continued

File	Number of First Returns	Area	Point Density	NPS
CS_02422.las	212,066,589	78,090,928	2.716/0.252	0.607/1.991
CS_02424.las	212,674,425	76,968,528	2.763/0.257	0.602/1.975
CS_02426.las	384,777,033	135,432,080	2.841/0.264	0.593/1.946
CS_02428.las	219,237,071	76,040,496	2.883/0.268	0.589/1.932
CS_02430.las	373,614,839	134,948,480	2.769/0.257	0.601/1.972
CS_02432.las	245,673,205	83,588,256	2.939/0.273	0.583/1.913
CS_02441.las	152,774,383	48,305,584	3.163/0.294	0.562/1.844
CS_02442.las	144,414,244	48,159,488	2.999/0.279	0.577/1.893
CS_02443.las	144,989,231	50,122,960	2.893/0.269	0.588/1.929
CS_02444.las	158,952,176	52,687,056	3.017/0.280	0.576/1.890
CS_02445.las	146,993,542	50,517,760	2.910/0.270	0.586/1.923
CS_02450.las	31,449,523	9,847,040	3.194/0.297	0.560/1.837
CS_02458.las	87,597,762	29,881,568	2.931/0.272	0.584/1.916
CS_02467.las	385,072,866	135,754,144	2.837/0.264	0.594/1.949
CS_02473.las	380,911,893	135,717,792	2.807/0.261	0.597/1.959
CS_02477.las	381,020,374	135,962,784	2.802/0.260	0.597/1.959
CS_02478.las	379,331,977	134,629,728	2.818/0.262	0.596/1.955
CS_02480.las	215,142,132	78,317,968	2.747/0.255	0.603/1.978
CS_02482.las	231,176,242	77,006,768	3.002/0.279	0.577/1.893
CS_02484.las	383,949,400	135,648,896	2.830/0.263	0.594/1.949
CS_02486.las	217,176,373	76,356,000	2.844/0.264	0.593/1.946
CS_02487.las	387,602,361	135,237,568	2.866/0.266	0.591/1.939
CS_02489.las	234,364,470	83,323,680	2.813/0.261	0.596/1.955
CS_02500.las	137,919,953	48,623,728	2.836/0.263	0.594/1.949
CS_02501.las	165,430,626	48,451,008	3.414/0.317	0.541/1.775
CS_02502.las	163,001,747	50,429,088	3.232/0.300	0.556/1.824
CS_02503.las	155,461,221	52,262,096	2.975/0.276	0.580/1.903
CS_02504.las	21,452,223	7,886,000	2.720/0.253	0.606/1.988
CS_02515.las	89,933,242	30,510,368	2.948/0.274	0.582/1.909
CS_02529.las	387,526,803	135,364,336	2.863/0.266	0.591/1.939
CS_02531.las	30,635,353	9,132,624	3.354/0.312	0.546/1.791
CS_02533.las	377,025,418	134,804,736	2.797/0.260	0.598/1.962
CS_02534.las	393,837,775	134,334,288	2.932/0.272	0.584/1.916

## C-4.1 Report on Nominal Pulse Spacing (NPS) - continued

File	Number of First Returns	Area	Point Density	NPS
CS_02536.las	214,296,502	77,805,504	2.754/0.256	0.603/1.978
CS_02538.las	217,449,784	77,119,728	2.820/0.262	0.596/1.955
CS_02540.las	385,554,735	135,406,464	2.847/0.264	0.593/1.946
CS_02542.las	207,445,084	76,432,592	2.714/0.252	0.607/1.991
CS_02543.las	379,094,163	135,123,248	2.806/0.261	0.597/1.959
CS_02545.las	240,628,556	83,682,016	2.876/0.267	0.590/1.936
CS_02554.las	122,513,715	43,798,896	2.797/0.260	0.598/1.962
CS_02556.las	148,302,275	48,239,968	3.074/0.286	0.570/1.870
CS_02557.las	135,910,366	47,862,512	2.840/0.264	0.593/1.946
CS_02558.las	150,493,683	50,263,712	2.994/0.278	0.578/1.896
CS_02559.las	152,671,060	51,509,920	2.964/0.275	0.581/1.906
CS_02583.las	383,301,382	136,090,752	2.817/0.262	0.596/1.955
CS_02585.las	184,551,360	68,540,832	2.693/0.250	0.609/1.998
CS_02587.las	380,606,735	135,586,784	2.807/0.261	0.597/1.959
CS_02588.las	374,938,602	134,852,864	2.780/0.258	0.600/1.969
CS_02590.las	219,520,162	79,288,800	2.769/0.257	0.601/1.972
CS_02591.las	222,581,515	77,333,344	2.878/0.267	0.589/1.932
CS_02593.las	388,600,418	135,750,176	2.863/0.266	0.591/1.939
CS_02595.las	218,552,219	76,299,216	2.864/0.266	0.591/1.939
CS_02596.las	384,600,768	135,131,376	2.846/0.264	0.593/1.946
CS_02598.las	237,541,207	83,460,480	2.846/0.264	0.593/1.946
CS_02599.las	230,000,730	84,719,344	2.715/0.252	0.607/1.991
CS_02606.las	140,704,412	48,620,224	2.894/0.269	0.588/1.929
CS_02608.las	138,286,093	48,565,056	2.847/0.264	0.593/1.946
CS_02609.las	164,537,259	48,507,504	3.392/0.315	0.543/1.781
CS_02610.las	160,463,149	50,437,344	3.181/0.296	0.561/1.841
CS_02612.las	152,018,270	50,341,312	3.020/0.281	0.575/1.886
CS_02633.las	388,183,714	134,102,000	2.895/0.269	0.588/1.929
CS_02635.las	198,378,487	74,370,400	2.667/0.248	0.612/2.008
CS_02636.las	385,678,368	135,127,744	2.854/0.265	0.592/1.942
CS_02637.las	395,282,492	134,805,904	2.932/0.272	0.584/1.916
CS_02639.las	221,741,806	80,349,712	2.760/0.256	0.602/1.975
CS_02640.las	218,319,777	77,141,264	2.830/0.263	0.594/1.949

## C-4.1 Report on Nominal Pulse Spacing (NPS) - continued

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CS_02642.las	399,844,908	135,581,744	2.949/0.274	0.582/1.909
CS_02644.las	218,763,067	75,640,560	2.892/0.269	0.588/1.929
CS_02645.las	381,989,997	135,349,440	2.822/0.262	0.595/1.952
CS_02654.las	136,366,073	48,652,304	2.803/0.260	0.597/1.959
CS_02656.las	146,821,940	47,937,808	3.063/0.285	0.571/1.873
CS_02657.las	147,829,528	48,018,576	3.079/0.286	0.570/1.870
CS_02658.las	150,991,857	50,136,560	3.012/0.280	0.576/1.890
CS_02659.las	159,248,989	52,303,248	3.045/0.283	0.573/1.880
CS_02660.las	145,499,290	50,575,792	2.877/0.267	0.590/1.936
CS_02680.las	383,710,227	134,716,224	2.848/0.265	0.593/1.946
CS_02682.las	227,417,385	81,114,736	2.804/0.261	0.597/1.959
CS_02683.las	382,722,193	135,598,336	2.822/0.262	0.595/1.952
CS_02684.las	376,253,770	134,914,448	2.789/0.259	0.599/1.965
CS_02686.las	227,986,238	81,034,800	2.813/0.261	0.596/1.955
CS_02687.las	229,383,622	77,336,976	2.966/0.276	0.581/1.906
CS_02691.las	226,689,852	76,787,216	2.952/0.274	0.582/1.909
CS_02692.las	380,256,247	134,730,240	2.822/0.262	0.595/1.952
CS_02696.las	250,010,855	83,472,496	2.995/0.278	0.578/1.896
CS_02703.las	140,244,890	48,763,536	2.876/0.267	0.590/1.936
CS_02704.las	135,282,439	48,415,488	2.794/0.260	0.598/1.962
CS_02705.las	157,908,661	47,347,696	3.335/0.310	0.548/1.798
CS_02706.las	157,426,104	50,486,112	3.118/0.290	0.566/1.857
CS_02707.las	159,616,208	51,922,480	3.074/0.286	0.570/1.870
CS_02708.las	152,208,123	50,350,768	3.023/0.281	0.575/1.886
CS_02728.las	222,824,979	82,169,056	2.712/0.252	0.607/1.991
CS_02729.las	383,551,751	135,213,328	2.837/0.264	0.594/1.949
CS_02732.las	224,863,866	80,803,440	2.783/0.259	0.599/1.965
CS_02733.las	214,937,305	77,174,704	2.785/0.259	0.599/1.965
CS_02738.las	385,527,351	135,035,728	2.855/0.265	0.592/1.942
CS_02747.las	130,959,374	48,715,152	2.688/0.250	0.610/2.001
CS_02749.las	148,144,844	47,758,736	3.102/0.288	0.568/1.864
CS_02750.las	143,024,443	49,875,616	2.868/0.266	0.591/1.939
CS_02751.las	147,801,344	50,005,488	2.956/0.275	0.582/1.909



## *C-4.1 Report on Nominal Pulse Spacing (NPS) - continued*

File	Number of First Returns	Area	Point Density	NPS
CS_02752.las	158,612,776	52,230,512	3.037/0.282	0.574/1.883
CS_02753.las	151,064,167	53,713,040	2.812/0.261	0.596/1.955
CS_02773.las	224,943,500	81,608,832	2.756/0.256	0.602/1.975
CS_02781.las	224,784,668	77,344,240	2.906/0.270	0.587/1.926
CS_02782.las	381,789,672	134,894,752	2.830/0.263	0.594/1.949
CS_02785.las	234,755,123	83,818,480	2.801/0.260	0.598/1.962
CS_02792.las	138,565,979	48,337,552	2.867/0.266	0.591/1.939
CS_02793.las	172,110,902	50,582,592	3.403/0.316	0.542/1.778
CS_02794.las	153,071,876	49,533,824	3.090/0.287	0.569/1.867
CS_02795.las	161,788,897	54,941,328	2.945/0.274	0.583/1.913
CS_02796.las	152,983,296	50,322,224	3.040/0.282	0.574/1.883
CS_02815.las	219,882,958	81,671,520	2.692/0.250	0.609/1.998
CS_02816.las	383,892,456	135,522,368	2.833/0.263	0.594/1.949
CS_02822.las	228,764,273	77,318,976	2.959/0.275	0.581/1.906
CS_02823.las	390,764,785	135,183,744	2.891/0.269	0.588/1.929
CS_02834.las	149,275,546	47,834,432	3.121/0.290	0.566/1.857
CS_02835.las	147,308,318	49,830,992	2.956/0.275	0.582/1.909
CS_02836.las	151,806,867	50,008,224	3.036/0.282	0.574/1.883
CS_02837.las	143,047,660	50,506,944	2.832/0.263	0.594/1.949
CS_02853.las	224,855,104	81,255,984	2.767/0.257	0.601/1.972
CS_02859.las	214,151,921	77,647,168	2.758/0.256	0.602/1.975
CS_02860.las	377,488,362	134,612,608	2.804/0.261	0.597/1.959
CS_02863.las	248,211,831	83,617,392	2.968/0.276	0.580/1.903
CS_02867.las	234,431,447	83,876,256	2.795/0.260	0.598/1.962
CS_02873.las	151,860,763	50,307,056	3.019/0.280	0.576/1.890
CS_02900.las	255,656,182	83,934,672	3.046/0.283	0.573/1.880
CS_02927.las	234,967,752	84,135,648	2.793/0.259	0.598/1.962
CS_02933.las	379,236,941	135,713,712	2.794/0.260	0.598/1.962
CS_02979.las	101,755,352	35,773,440	2.844/0.264	0.593/1.946
CS_02990.las	61,709,528	25,396,240	2.430/0.226	0.642/2.106
CS_03036.las	233,925,330	83,824,432	2.791/0.259	0.599/1.965
CS_03040.las	255,539,803	84,211,088	3.035/0.282	0.574/1.883



## C-4.1 Report on Nominal Pulse Spacing (NPS) - continued

File	Number of First Returns	Area	Point Density	NPS
Average			2.901/0.270 <small>pp Square Meter/ pp Square US Survey Foot</small>	0.587/1.926 <small>Meter/ US Survey Feet</small>
Lot_10	57,321,269,629	14,857,815,185	3.858/0.358	0.509/1.670
Aggregate	57,321,269,629	14,857,815,185	3.858/0.358 <small>pp Square Meter/ pp Square US Survey Foot</small>	0.509/1.670 <small>Meter/ US Survey Feet</small>

\* - indicates a swath whose NPS and Point Density were brought up to specifications due to the inclusion of one or more re-flight swaths.