# C-4 Report on Nominal Pulse Spacing (NPS)

The USGS Lidar Base Specification 2022 rev. A states: "The required ANPS and ANPD by QL are listed in table 1. Aggregate Nominal Pulse Density (ANPD) and Aggregate Nominal Pulse Spacing (ANPS) shall meet the requirements of the Quality Level (QL) of the project with a minimum of QL2 for 3DEP collections. Aggregate Nominal Pulse Density (ANPD) shall be no less than 2 points per square meter (QL2); assessment to be made against single swath, first return data located within the geometrically usable center portion (typically ~95%) of each swath. Aggregate Nominal Pulse Spacing (ANPS) shall be no greater than 0.70 meters (QL2); assessment to be made against single swath, first return data located within the geometrically usable center portion (typically ~95%) of each swath. 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$^2$, 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/m²) |
|---|---|---|
| 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. Any 'Exclusion Shapefile' pathed out on the Input Tab of this tool was applied to the processing for this test to avoid skewing the results with known areas of no data.

Data Source - C:\00_ISGS\Swaths

Quality level tested: QL2

| File | Number of First Returns | Area | Point Density | NPS |
|---|---|---|---|---|
| CS_00001.las | 543,428,573 | 858,493,631 | 6.814/0.633 | 0.383/1.257 |
| CS_00002.las | 529,373,580 | 855,731,191 | 6.663/0.619 | 0.387/1.271 |
| CS_00003.las | 854,557,951 | 1,490,324,417 | 6.168/0.573 | 0.403/1.321 |
| CS_00004.las | 946,776,828 | 1,467,444,555 | 6.943/0.645 | 0.379/1.245 |
| CS_00005.las | 161,998,478 | 274,446,924 | 6.351/0.590 | 0.397/1.302 |

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| File | Number of First Returns | Area | Point Density | NPS |
|---|---|---|---|---|
| CS_00006.las | 732,891,854 | 1,163,171,609 | 6.781/0.630 | 0.384/1.260 |
| CS_00008.las | 630,536,588 | 1,065,253,720 | 6.372/0.592 | 0.396/1.300 |
| CS_00009.las | 79,998,178 | 115,711,737 | 7.438/0.691 | 0.367/1.203 |
| CS_00010.las | 303,171,442 | 514,556,636 | 6.340/0.589 | 0.397/1.303 |
| CS_00011.las | 328,389,169 | 556,006,623 | 6.361/0.591 | 0.397/1.301 |
| CS_00012.las | 675,402,807 | 1,108,399,678 | 6.555/0.609 | 0.390/1.281 |
| CS_00013.las | 1,072,159,121 | 1,634,471,866 | 7.061/0.656 | 0.376/1.235 |
| CS_00014.las | 292,981,843 | 463,128,949 | 6.814/0.633 | 0.383/1.257 |
| CS_00015.las | 1,216,460,122 | 1,859,116,344 | 7.040/0.654 | 0.377/1.236 |
| CS_00016.las | 1,114,587,124 | 1,734,036,019 | 6.921/0.643 | 0.380/1.247 |
| CS_00017.las | 601,984,464 | 920,557,807 | 7.040/0.654 | 0.377/1.237 |
| CS_00018.las | 890,753,980 | 1,640,731,319 | 5.845/0.543 | 0.414/1.357 |
| CS_00019.las | 1,018,473,557 | 1,872,503,002 | 5.856/0.544 | 0.413/1.356 |
| CS_00021.las | 42,778,973 | 69,617,587 | 6.609/0.614 | 0.389/1.276 |
| CS_00026.las | 204,819,103 | 338,526,053 | 6.512/0.605 | 0.392/1.286 |
| CS_00027.las | 507,412,047 | 857,203,429 | 6.372/0.592 | 0.396/1.300 |
| CS_00032.las | 495,461,034 | 857,554,933 | 6.222/0.578 | 0.401/1.316 |
| CS_00042.las | 1,526,589,626 | 2,508,999,996 | 6.544/0.608 | 0.391/1.282 |
| CS_00044.las | 1,468,230,688 | 2,511,067,799 | 6.297/0.585 | 0.399/1.308 |
| CS_00045.las | 1,018,044,657 | 1,850,867,333 | 5.920/0.550 | 0.411/1.348 |
| CS_00047.las | 1,286,504,869 | 2,170,131,958 | 6.383/0.593 | 0.396/1.299 |
| CS_00049.las | 1,052,434,461 | 1,849,086,623 | 6.125/0.569 | 0.404/1.326 |
| CS_00050.las | 1,117,012,451 | 2,018,582,361 | 5.952/0.553 | 0.410/1.344 |
| CS_00051.las | 504,896,778 | 848,611,482 | 6.405/0.595 | 0.395/1.296 |
| CS_00052.las | 530,880,920 | 939,265,896 | 6.082/0.565 | 0.405/1.330 |
| CS_00053.las | 231,024,169 | 387,453,173 | 6.415/0.596 | 0.395/1.295 |
| CS_00055.las | 1,264,378,942 | 2,038,914,380 | 6.674/0.620 | 0.387/1.270 |
| CS_00057.las | 284,117,727 | 509,726,952 | 5.995/0.557 | 0.408/1.339 |
| CS_00058.las | 1,430,408,056 | 2,501,064,272 | 6.157/0.572 | 0.403/1.322 |
| CS_00059.las | 1,532,599,648 | 2,504,425,397 | 6.588/0.612 | 0.390/1.278 |
| CS_00060.las | 188,863,200 | 338,380,256 | 6.006/0.558 | 0.408/1.339 |
| CS_00062.las | 1,548,364,820 | 2,506,823,153 | 6.652/0.618 | 0.388/1.272 |
| CS_00063.las | 1,430,679,650 | 2,505,522,641 | 6.146/0.571 | 0.403/1.323 |

# C-4 Report on Nominal Pulse Spacing (NPS) - continued

| File | Number of First Returns | Area | Point Density | NPS |
|---|---|---|---|---|
| CS_00064.las | 1,641,156,019 | 2,508,671,857 | 7.040/0.654 | 0.377/1.236 |
| CS_00065.las | 1,439,451,728 | 2,504,651,868 | 6.189/0.575 | 0.402/1.319 |
| CS_00066.las | 1,072,009,211 | 1,822,372,088 | 6.329/0.588 | 0.397/1.304 |
| CS_00067.las | 1,064,359,548 | 1,815,606,307 | 6.308/0.586 | 0.398/1.306 |
| CS_00068.las | 1,017,811,439 | 1,816,174,879 | 6.028/0.560 | 0.407/1.336 |
| CS_00069.las | 1,083,672,142 | 1,821,834,900 | 6.405/0.595 | 0.395/1.297 |
| CS_00070.las | 1,036,676,380 | 1,820,564,858 | 6.125/0.569 | 0.404/1.325 |
| CS_00071.las | 1,256,842,837 | 2,151,781,388 | 6.286/0.584 | 0.399/1.308 |
| CS_00072.las | 1,316,822,183 | 2,152,496,180 | 6.588/0.612 | 0.390/1.279 |
| CS_00073.las | 1,258,083,597 | 2,150,529,119 | 6.297/0.585 | 0.398/1.307 |
| CS_00074.las | 1,013,970,476 | 1,824,340,104 | 5.985/0.556 | 0.409/1.341 |
| CS_00077.las | 1,086,931,548 | 1,702,030,309 | 6.878/0.639 | 0.381/1.251 |
| CS_00079.las | 566,995,138 | 875,720,155 | 6.964/0.647 | 0.379/1.243 |
| CS_00080.las | 436,640,162 | 739,798,331 | 6.351/0.590 | 0.397/1.302 |
| CS_04131.las | 7,953,798 | 10,786,561 | 7.933/0.737 | 0.355/1.165 |
| CS_05921.las | 257,725,430 | 437,638,679 | 6.340/0.589 | 0.397/1.303 |
| CS_06931.las | 48,840,355 | 77,776,572 | 6.760/0.628 | 0.385/1.262 |
| Average | | | 6.458/0.600 | 0.393/1.291 |
| | | | pp Square Meter/ pp Square US Survey Foot | Meter/ US Survey Feet |
| IL_MidNorth_D22_IL_East | 45,264,685,560 | 59,272,000,000 | 8.224/0.764 | 0.349/1.144 |
| Aggregate | 45,264,685,560 | 59,272,000,000 | 8.224/0.764 | 0.349/1.144 |
| | | | pp Square Meter/ pp Square US Survey Foot | Meter/ US Survey Feet |

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