AquAeTer

optimizing
resources | water, air, earth

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March 19, 2018 172488

Georgia-Pacific Crossett LLC, Crossett Paper Operations
100 Paper Mill Road
Crossett, Arkansas 71635

Sent via e-mail: Sarah.Ross@gapac.com

RE: Inputs Used for Flood-Flow Modeling

Dear Ms. Ross:

AquAeTer, Inc. (**AquAeTer**) previously presented our findings of water quality modeling for two flood-flow conditions on the Ouachita River: 1) River stage 65 feet (ft) at Felsenthal Dam; and 2) River stage 75 ft at Felsenthal Dam in a letter report dated November 1, 2017. The purpose of this follow-up letter is to provide Georgia-Pacific (GP) with additional data that were used as the basis for some of the inputs into the model.

1. The Qual-2E Model. The model used was the previously calibrated QUAL-2E model. This was discussed in the first report, along with citations for the basis of the original model.
2. Flows: Flows of 17,250 and 43,364 cubic feet per second were used for the 65' and 75' flood elevations, respectively. These flows were within the range measured or predicted at Felsenthal during the respective flood conditions for January 1, 2015 through June 30, 2016. At stages greater than 65' flood elevation, the Felsenthal gage no longer measures flow. For those days where the Felsenthal gage did not record flow, flows were projected by adding the flows from the following upstream gages. For comparison purposes, the Ouachita River at Felsenthal Lock and Dam is approximately 10,852 square miles.
    a. USGS 07362000 Ouachita River at Camden, AR
    5,360 square miles;
    b. USGS 07362100 Smackover Creek near Smackover, AR
    385 square miles;
    c. USGS 07362500 Moro Creek near Fordyce, AR
    240 square miles;
    d. USGS 07363500 Saline River near Rye, AR,
    2,100 square miles; and
    e. Total miles included in gages = 8,085 square miles.

3. Time of Year. In analyzing the frequency of flood events, floods at 65' or greater have occurred through June, while floods at 75' or greater have occurred through May. These two months were used for modeling purposes due to the potential for higher temperatures, which increases rates and decreases the amount of dissolved oxygen potentially present in the stream due to reaeration.

4. Elevation Data: As stated in the previous report, the digital elevation map (DEM) data were downloaded from the United States Department of Agriculture Geospatial website. The DEM filename is 10.2.gda.4357299, which covers Felsenthal Dam, AR-LA. The metadata information and the data dictionary defining the terms are provided in Attachment 1. One transect was drawn for the 65' flood elevation and one transect was drawn for the 75' flood elevation, as shown in Figure 1. The co-ordinates shown on the figure represent the beginning and ending points for each transect. The depth profile along each is presented in Figure 2. These data were derived from the DEM using the geographic information system by ESRI (ArcGIS). The profiles are slightly different due to the offset distance of the two transects.

Figure 1. Transects selected for Flood Elevation Profiles

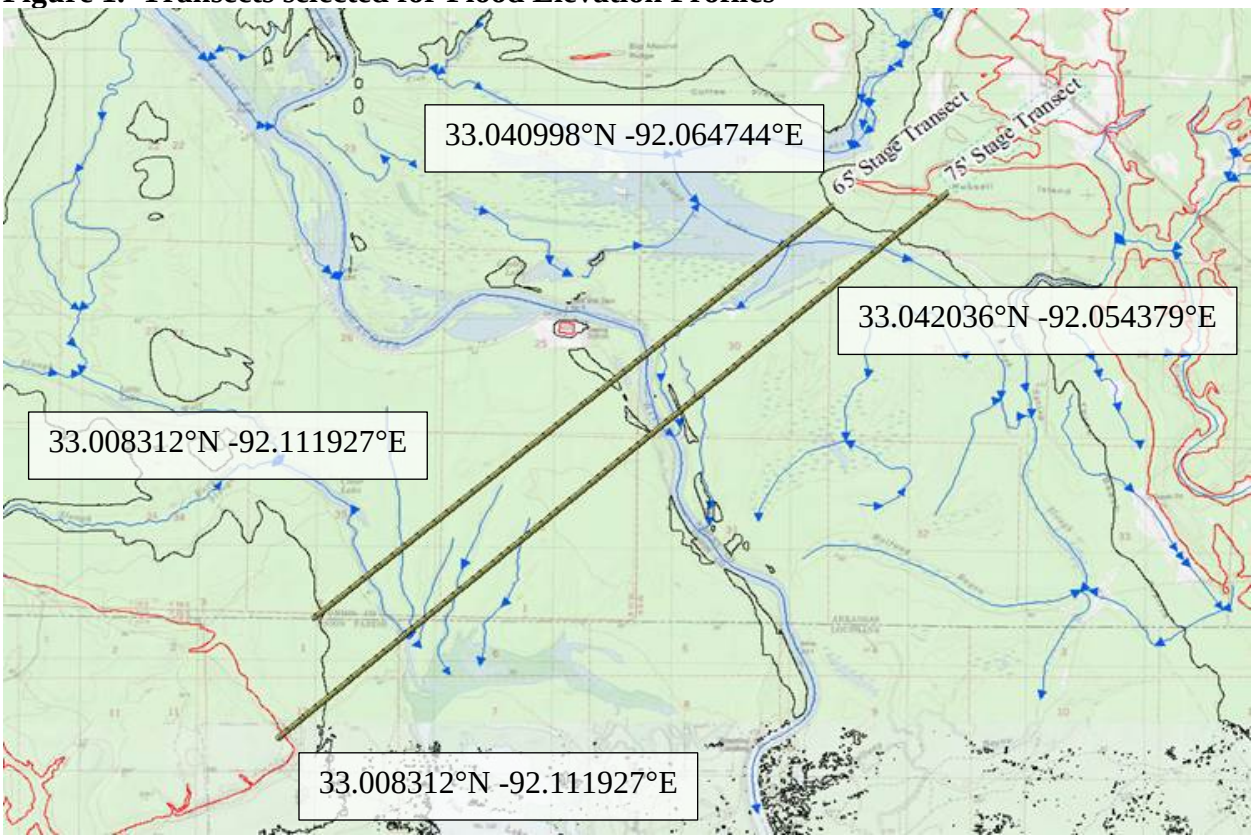
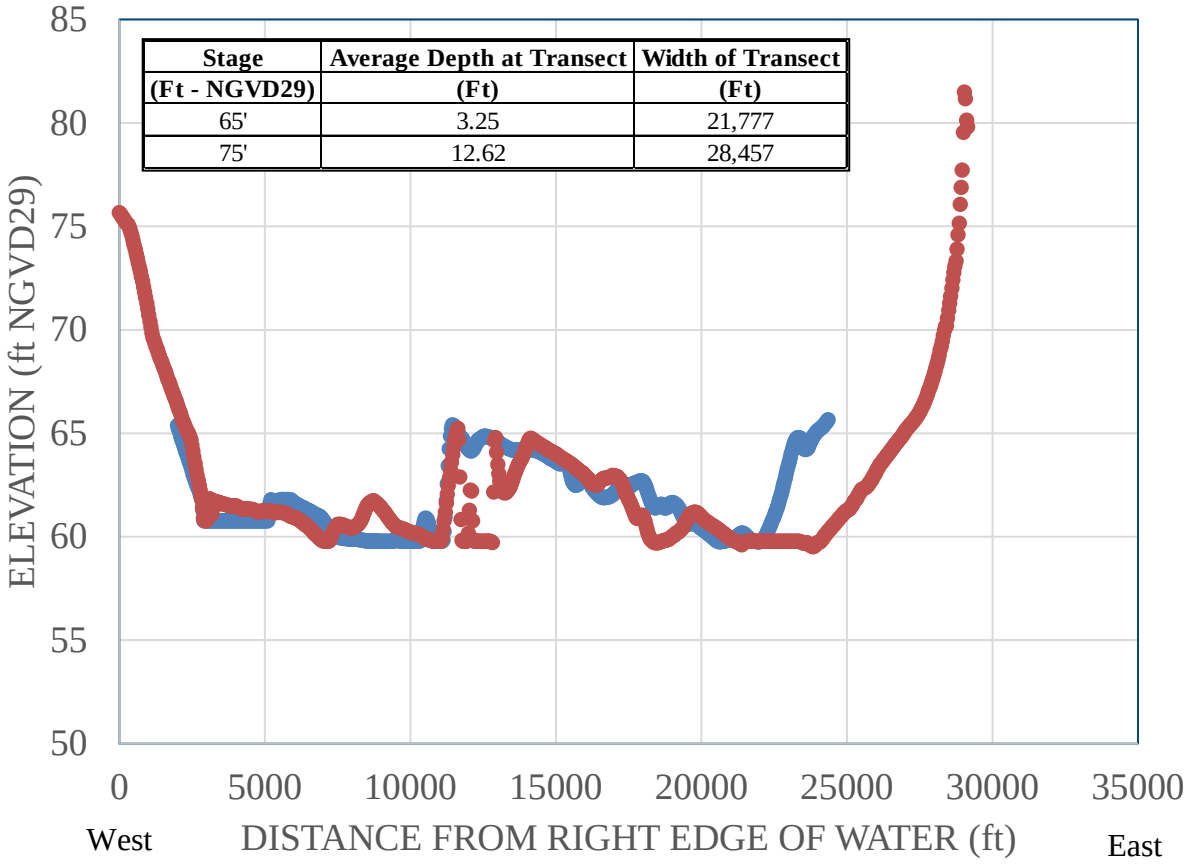


Figure 2. Transect Profiles for Flood Elevations



5. Development of Velocity Coefficient and Exponent. The coefficient and exponents for determining the velocity for the original model and for the flood model are presented in Table 1.

Table 1. Velocity Coefficient and Exponent

Reach	Original Model Coefficient	Original Model Exponent	Flood Model Coefficient	Flood Model Exponent
1	0.00046	0.897	128.756	-0.643
2	0.00046	0.897	128.756	-0.643
3	0.00046	0.897	128.756	-0.643
4	0.00046	0.897	128.756	-0.643
5	0.00028	0.946	128.756	-0.643
6	0.00028	0.946	128.756	-0.643
7	0.00020	0.930	128.756	-0.643
8	0.00020	0.930	128.756	-0.643

It is important to remember that the original model variables were based on a low-flow scenario modeling the situation where the River was contained within its banks. At the two different flood scenarios, the River is no longer contained within a defined channel:

to the contrary, it is primarily flowing through overbank areas that are frequently forested, which in turns slows the water velocity in these areas. The overall average velocity is thus significantly affected by these areas. During normal non-flooded conditions, the River is roughly 300 feet wide. The two transects for these flood elevations are over 21,000 and 28,000 feet wide, for the two modeled flood conditions. The original low-flow variables for velocity developed for when the river is in-channel, did not predict the non-channel flow conditions, as discussed below and shown in Table 2.

While the negative exponent is not intuitive for channel-based flow calculations, it is expected when the River leaves its banks. In the overbank areas near Felsenthal, there is an increase in cross-sectional area flowing through the forested areas as the River stage rises. Additionally, the downstream dam location near Sterlington begins having a greater impact on water backing up at these higher stages. Thus, outside of the channel at higher stage, the average velocity should slow down. An example of the River in flood is shown in Figure 3. Additional pictures of the Ouachita River during flooded conditions are provided in Attachment 2.

Figure 3. Ouachita River in Flood (at an estimated 62 Feet elevation) Viewed from the Dike at Mossy Lake

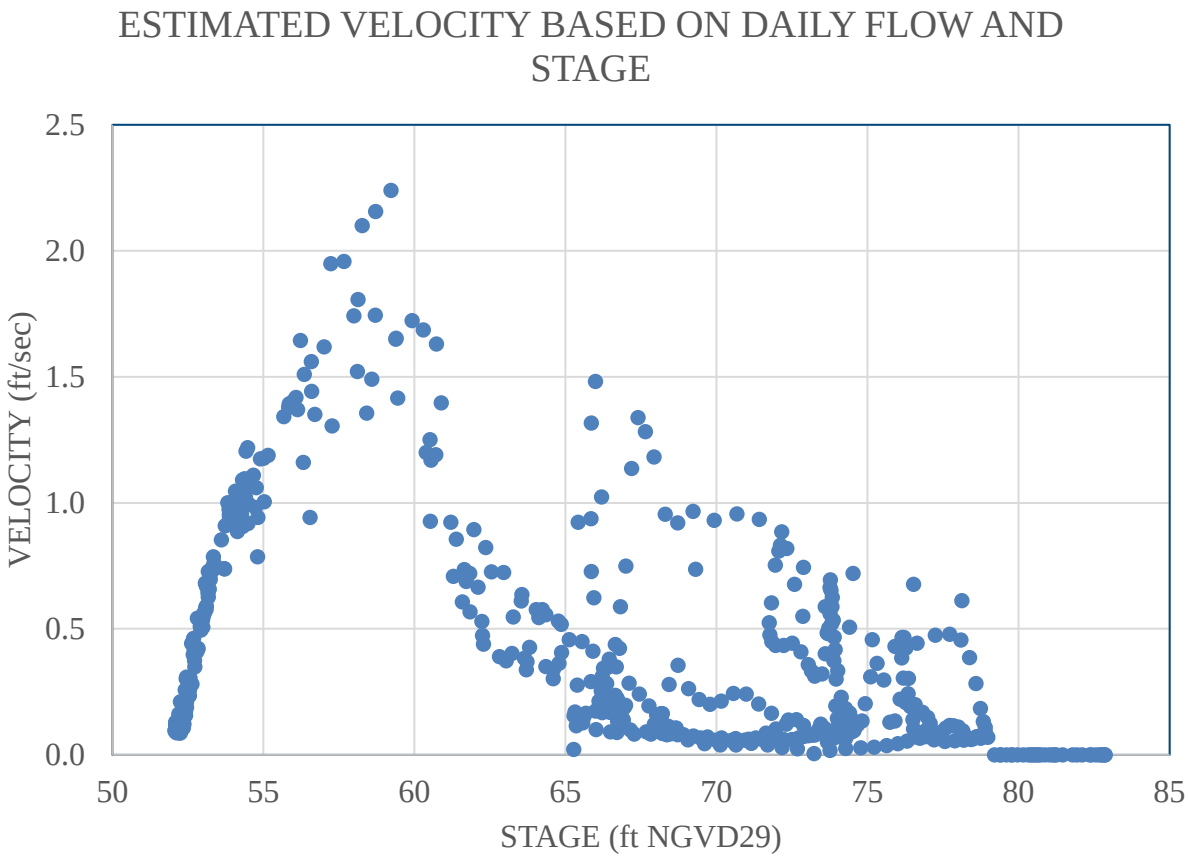
Based on the width and the average depth for each transect, the cross-sectional area present during each flooded condition was determined. The flow for each condition was divided by the cross-sectional area for each respective flood condition. This gave the velocity for each flood condition, based on the flows. This was then compared to the predicted velocity using the original model variables. The comparisons are shown in Table 2.

Table 2. Evaluation of Velocity Coefficient and Exponent

Stage	Total Area (ft^2)	Flow (cfs)	Average Velocity Calculated by Area (ft/sec)	Average Velocity Calculated using Original Variables (ft/sec)	Average Velocity Calculated using Flood-Flow Variables (ft/sec)
65	70,774	17,250	0.24	0.07	0.24
75	359,105	43,364	0.12	0.073	0.12

Using the same transect cross-sectional data to determine the velocity of the flows during the period from January 1, 2015 through June 30, 2016, the peak average velocity does not occur during the flood conditions. For this calculation, all stages less than or equal to the 65' used the transect for the 65' flood condition, while all stages greater than 65' used the 75' flood condition. The daily flow value was divided by the cross-sectional area of the River for the same daily stage to determine the velocity. The estimated River velocity is presented in Figure 4. There is clearly a reduction in the velocity at the higher stage events.

Figure 4. Estimated Velocity for Flow on the Ouachita River



6. Development of Depth Coefficient and Exponent. The process presented for the velocity variable determination was the same for the depth. The depth variables are presented in Table 3. The comparisons are shown in Table 4.

Table 3. Depth Coefficient and Exponent

Reach	Original Model Coefficient	Original Model Exponent	Flood Model Coefficient	Flood Model Exponent
1	7.17	0.05	$4.994*10^{-6}$	1.37
2	7.17	0.05	$4.994*10^{-6}$	1.37
3	7.17	0.05	$4.994*10^{-6}$	1.37
4	8	0.05	$4.994*10^{-6}$	1.37
5	12	0.018	$4.994*10^{-6}$	1.37
6	12	0.018	$4.994*10^{-6}$	1.37
7	15.03	0.011	$4.994*10^{-6}$	1.37
8	15.03	0.011	$4.994*10^{-6}$	1.37

Table 4. Evaluation of Depth Coefficient and Exponent

Stage	Average Depth (ft)	Flow (cfs)	Depth Calculated using Original Variables (ft)	Depth Calculated using Flood-Flow Variables (ft)
65	3.25	17,250	11.7	3.25
75	12.62	43,364	12.2	12.62

CLOSING

We appreciate the opportunity to work with you on this matter. If you have questions or comments pertaining to this letter, please contact us by telephone at (615) 373-8532, by FAX at (615) 373-8512, or by e-mail at jmcorn@aquaeter.com or mcorn@aquaeter.com.

Regards,

John Michael Corn, P.E.
Project Manager

Michael R. Corn, P.E. (LA), BCEE
President

cc: Rachel Johnson,
Steve Kuhlman, SJKuhlma@gapac.com
Paul Marotta, Ph.D., P.E. (AR), BCEE

CERTIFICATION

Paul J. Marotta, Ph.D., P.E. (AR) BCEE

Michael R. Corn, P.E. (LA), BCEE

ATTACHMENT 1

METADATA AND DATA LIBRARY FOR GIS

abspts	0	
absx	0	
absy	0	
absz	0	
demname	10.2.gda.4357299	
FID	30459	
freetext	FELSENTHAL DAM, AR-LA	FROM 24K CONTOURS - H2O ENFORCED
hdatum	27	-92 0 0.0000 33 0 0.00005
horizres_m	-100	
i_date	0	
lrlat	33	
lrlon	-92.125	
meta_p_are	0.015648	
meta_p_per	0.500374	
pdevice	UNKNOWN	
pmethod	5	
psite	MCMC	
quaddate	20110401	
quadname	felsenthal_dam_AR	
resolution	10	
rmse	1	
rmsepts	28	
rmsex	0	
rmsey	0	
rmsez	1	
s_date	1976	
Shape	Polygon	
ullat	33.125	
ullon	-92	
utmzone	15	
vdatum	29	
xshift	-0.000133	
yshift	0.000125	
zmax	42.42	
zmean	23.461	
zmin	17.14	
zshift	-0.067	
zsigma	5.37035	
zstep	0.01	
zunit	1	

National Elevation Dataset (NED) Data Dictionary

Last updated: January 16, 2016

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NED 1/3 Arc-second, 1 Arc-second, and 2 Arc-second Data Dictionary

Source Identification

DEMNAME
QUADNAME

DEMNAME

Data Name (text)

For projects used to produce the NED prior to March 31, 2014, this field indicates the name of the source DEM file.

For projects used to produce the NED after April 1, 2014, DEMNAME is the name of the original project that was adapted for incorporation into the 1/3, 1 and 2 arc-second NED layers. The format of this field will most commonly be three parts separated by underscores: PRIMARYSTATE, BRIEF-PROJECT-DESCRIPTION, YEAR.

QUADNAME

Quadrangle Name (text)

For DEMs derived from standard USGS paper map series, this is the name of the corresponding USGS quadrangle. This information may also be present in the first 40 characters of the FREETEXT field.

For new high resolution DEM source data, this field may be used in other ways.

Example QUADNAME = oak_island_MN

For DEMs introduced into the NED after April 1, 2014 this field will not be populated. Any values already in this field for DEMs used to produce the NED prior to March 31, 2014 are preserved.

Source Production

PSITE
PMETHOD
PDEVICE
FREETEXT
RESOLUTION
HORIZ_M
S_DATE
I_DATE

PSITE

Production Site (text)

The site or party who created the source DEM for DEMs used to produce the NED prior to March 31, 2014.

Valid codes are:

UNKNOWN	Unknown
CONT	Contractor
MCMC	Mid-Continent Mapping Center
RMMC	Rocky Mountain Mapping Center
EMC	Eastern Mapping Center
WMC	Western Mapping Center
MAC	Mapping Applications Center
FS	Forest Service
USFS	Forest Service
BLM	Bureau of Land Management
NGTO	National Geospatial Technical Operations Center
AB	Alberta Sustainable Resource Development: Edmonton, Alberta, Canada
GDB	Center for Topographic Information, Geomatics Canada
NS	Nova Scotia Geomatics Center
NTDB	Center for Topographic Information Geomatics Canada: Ottawa, Ontario, Canada or Landscape Analysis - Canadian Forest Service: Sault Ste. Marie, Ontario, Canada
ON	Water Resources Information Program: Ottawa, Ontario, Canada
RS	Center for Topographic Information Geomatics Canada: Ottawa, Ontario, Canada
Z	Direction generale de l'information geographique, MRNF, Quebec, Canada
YT	Yukon Environment Information Management and Technology
BC	Base Mapping and Geomatic Services: Victoria, British Columbia, Canada
MULT	Multiple Canadian government agencies

For DEMs introduced into the NED after April 1, 2014 this field will be populated with the value UNKNOWN. Any values already in this field for DEMs used to produce the NED prior to March 31, 2014 are preserved.

PMETHOD

Production Method (short integer)

The method used to compile or capture the source DEM. For more information regarding PMETHODS see Digital Elevation Models (USGS, 1993).

Valid codes are:

0	Unknown
1	Electronic Image Correlation (specifically GPM II)
2	Manual Profiling
3	DLG2DEM
4	DCASS
5	LT4X
6	Complex polynomial interpolation, such as ANUDEM
7	Lidar
8	Photogrammetric mass points and break lines
9	Digital camera correlation
10	Ifsar
11	Other remote sensing technique

12 Topobathy

PDEVICE

Production Device (text)

The name of the instrument used to compile the source DEM. This field is of significance primarily to DEMs produced by manual profiling (PMETHOD = 2)

The current list of identified instruments is:

Wild A-7	Wild Autograph A7 - Mechanical Stereoplotter
Wild AG-1	Wild AG1 - Analytical Stereoplotter
OMI AS11A	OMI AS11A - Mechanical Stereoplotter
Wild B-8	Wild Aviograph B8 - Mechanical Stereoplotter
Wild BC-1	Wild BC1 - Analytical Stereoplotter
Wild BC-2	Wild BC2 - Analytical Stereoplotter
Zeiss C-8	Zeiss Stereoplanigraph C8 - Stereoplotter
Zeiss C100	Zeiss C100 Planicomp - Analytical Stereoplotter
GPM	Gestalt Photo Mapper II (GPM II)
KELSH	Kelsh - Optical Stereoplotter
Kern	PG-2 Kern PG-2 - Mechanical Stereoplotter
Wild	PPO-8 Wild PPO-8 Orthophoto Equipment (Used with Wild A8)
Santoni IIC	Santoni IIC - Analytical Stereoplotter
Galileo IIId	Galileo-Santoni Stereosimplex IIId
Jena Topocart B	Zeiss Jena Topocart B
Matra Traster	Matra Optique Traster - Photogrammetric Workstation
Helava US-2	Helava US-2 - Analytical Stereoplotter
CP100	Unknown, but appears to be a stereoplotter
CTOG	Contour to Grid Conversion
DCASS	Digital Cartographic Software System (USGS Software)
DLG	Digital Line Graph
LT4X	Either LT4X or LTPlus software
GDM COTS	DEM made by GeoDigital Mapping, Inc.
GTR COTS	DEM made by GTRSystems, Inc.
LT2000	Windows version of LT4X by Titan Systems, Inc.
SRTM	Shuttle Radar Topographic Mission
Unknown	Unknown
ADS40	Leica ADS40 Digital Camera

For DEMs introduced into the NED after April 1, 2014 this field will no longer be populated. Any values already in this field for DEMs used to produce the NED prior to March 31, 2014 are preserved.

FREETEXT

Free Text Description (text)

For DEMs derived from standard USGS paper map series, this field is first 136 bytes of the source DEM file, including the quadrangle name, free format text, and process field. This field may contain additional information, though there are no standards for the use of the free text field.

Example: NORTH CHINOOK RESERVOIR, MT -VDYA 1-09 9/06/75 WILD A-7 60000 4 -10915 0.0000 4845 0.00002

The contents of the FREETEXT field vary greatly from one DEM to the next, and in some cases are more confusing than helpful.

For DEMs introduced into the NED after April 1, 2014 this field will no longer be populated. Any values already in this field for DEMs used to produce the NED prior to March 31, 2014 are preserved.

RESOLUTION

Source Resolution (short integer)

This code indicates the planimetric (x, y) spacing of elevation postings within the source DEM. Note that all source data are resampled to a common resolution during NED production.

For DEMs used to produce the NED prior to March 31, 2014 valid values are:

0	Unknown
1	1 arc-second (Alaska, Canada, Mexico)
2	2 arc-seconds (1:100k series)
3	3 arc-seconds (1:250k series)
5	5 meters (non-standard data)
10	10 meters (7.5-minute series)
30	30 meters (7.5-minute series)
13	1/3 arc-second (non-standard data)
19	1/9 arc-second (non-standard data)

For DEMs introduced into the NED after April 1, 2014 the actual resolution of the original high-resolution source DEM will be populated in the HORIZRES_M field, and the RESOLUTION field will be populated with:

100	High-resolution source

HORIZRES_M

Horizontal Resolution of Source DEM (floating point)

The horizontal resolution (x, y) of the original DEM which was used to produce the NED, expressed in meters. Regardless of the source DEM horizontal units, this field is expressed in the common unit meters for more meaningful comparisons and simplified queries.

This is a new field in the spatial metadata shapefiles for DEMs used to produce the NED after April 1, 2014. For DEMs used to produce the NED prior to March 31, 2014, this field will be populated with -100.

S_DATE

Data Source Date (short integer)

For DEMs derived from standard USGS paper map series, this field is data element 21 in the source DEM Type A record, the date of original photography from which the DEM was compiled (Digital Elevation Models (USGS, 1993). This information was not provided with some standard DEMs with a native resolution of 30 meters.

In the case of high resolution source data, this field reflects the year that the base elevation data was collected, as in the case of LIDAR derived DEMs. For projects whose collection spanned more than one calendar year, this is the earliest acquisition year.

Format: YYYY

I_DATE

Data Inspection Date (short integer)

For DEMs derived from standard USGS paper map series, this field is data element 22 in the source DEMs Type A record: DEM Edit System (DES) inspection date (Digital Elevation Models, USGS, 1993). This information was not provided with some standard DEMs.

Format is either YYYY or YYMM

This field not used for newer, high-resolution data sources.

For DEMs introduced into the NED after April 1, 2014 this field be populated with -100. Any values already in this field for DEMs used to produce the NED prior to March 31, 2014 are preserved.

Source Planimetric Descriptors

HDATUM
LRLAT
LRLON
ULLAT
ULLON
UTMZONE
XSHIFT
YSHIFT

HDATUM

Horizontal Datum (short integer)

Valid values:

0	Unknown
27	North American Datum of 1927 (NAD 27)
83	North American Datum of 1983 (NAD 83)
72	World Geodetic System of 1972 (WGS 72)
84	World Geodetic System of 1984 (WGS 84)
99	Other

LRLAT, LRLON, ULLAT, ULLON

Coordinates defining the minimum bounding box of the source DEM (floating point)
Units: decimal degrees. Coordinate System: NAD 83.

For DEMs derived from standard USGS paper map series, this field is derived from corner coordinates indicated in data element 11 of the DEMs Type A record (Digital Elevation Models USGS, 1993).

LRLAT Southern extent in latitude
LRLON Eastern extent in longitude
ULLAT Northern extent in latitude
ULLON Western extent in longitude

UTMZONE

Source UTM or State Plane Zone (short integer)

The projection zone of the source DEM.

If two digits, a UTM zone.

If four digits, a State Plane zone.

A value of zero in this field indicates that the source DEM is cast in geographic (lat/lon) coordinates.

For DEMs introduced into the NED after April 1, 2014 this field will be populated with -100. Any values already in this field for DEMs used to produce the NED prior to March 31, 2014 are preserved.

XSHIFT, YSHIFT

Horizontal Shift (floating point)
Units: decimal degrees

The positional shifts in longitude and latitude, respectively, applied to each posting in the source DEM to convert from NAD27 coordinates to NAD83 coordinates. These values will be zero if the source DEM's HDATUM field value is 83, 84 or 72. (WGS84 is nearly identical to NAD83, and WGS72 is sufficiently similar that no shift was deemed necessary). The shift values were obtained from NGS's NADCON software, and were calculated at the nominal center of each quadrangle.

New high-resolution DEMs introduced into the NED after April 1, 2014 generally have a horizontal datum of NAD83 and this field will be populated with -100. Any values already in this field for DEMs used to produce the NED prior to March 31, 2014 are preserved.

Source Elevation Descriptors

VDATUM
ZUNIT
ZSTEP
ZSHIFT

VDATUM

Vertical Datum (short integer)

This code represents the vertical datum of source DEM.

Valid values are:

0	Unknown
1	Local Mean Sea Level
29	National Geodetic Vertical Datum of 1929 (NGVD 29)
88	North American Vertical Datum of 1988 (NAVD 88)
99	Other

ZUNIT

Elevation Unit (short integer)

This code represents the unit of elevation values in source DEM.

Valid values:

0	International Feet
1	Meters
2	U.S. Survey Feet
3	Decimal degrees
4	Centimeters
5	Inches
99	Other

ZSTEP

Elevation Resolution (floating point)
For DEMs derived from standard USGS paper map series, this field, together with ZUNIT, defines vertical resolution of the source DEM. Typical values are 1 and 0.1, though others are possible.

Example: ZSTEP = 0.1 This indicates that the source DEM records elevations to the nearest tenth of a meter.

A value of 0 is used when this field does not apply, as in the case of source data with floating point precision.

New high-resolution DEMs introduced into the NED after April 1, 2014 all have floating point precision, and this field will be populated with -100. Any values already in this field for DEMs used to produce the NED prior to March 31, 2014 are preserved.

ZSHIFT

Elevation Shift (floating point)
The elevation shift, in meters, applied to each posting within the source DEM to convert to NAVD88 values. The shift values were obtained from NGS's VERTCON software, and were calculated at the nominal center of each quadrangle.

New high-resolution DEMs introduced into the NED after April 1, 2014 all have a vertical datum of NAVD88, therefore this field will be populated with -100. Any values already in this field for DEMs used to produce the NED prior to March 31, 2014 are preserved.

Source Elevation Summary Statistics

ZMIN
ZMAX
ZMEAN
ZSIGMA

Discussion: The summary statistics shown in these fields usually describe the entire source DEM, even when only some portion of the source DEM is used in NED, or when the source DEM is represented by more than one polygon within the metadata. These data are presented in common units (meters) and in a common vertical datum (NAVD88) to allow for more meaningful graphical displays and simplified queries.

ZMIN, ZMAX

Minimum and Maximum Elevation of Source DEM (floating point)

The minimum and maximum elevation values of the source DEM before any filtering or reprojection, but after conversion to meters and to NAVD88. For DEMs derived from standard USGS maps, subtracting ZSHIFT and converting to the DEM's original units results in the min and max values reported in data element 12 of the DEM's Type A record (Digital Elevation Models, USGS, 1993).

ZMEAN

Mean Elevation of Elevations in Source DEM (floating point)

The mean elevation value of the source DEM before any filtering or reprojection, but after conversion to meters and to NAVD88

ZSIGMA

Standard Deviation of Elevations in Source DEM (floating point)

The standard deviation of the elevations of the source DEM, before any filtering or reprojection, but after conversion to meters.

Source Accuracy Statistics

ABSX
ABSY
ABSZ
ABSPTS
RMSE
RMSEX
RMSEY

RMSEZ
RMSEPTS
VA_UNIT

ABSX, ABSY, ABSZ

Absolute Accuracy (short integers)
Absolute accuracy in X, Y, Z.

This field applies only to standard production USGS DEMs and echos data element 2 of the source DEM's Type C record,(Digital Elevation Models, USGS, 1993). See Standards for Digital Elevation Models for more information. This field is populated with zero if not available.

For DEMs introduced into the NED after April 1, 2014 this field will be populated with -100. Any values already in this field for DEMs used to produce the NED prior to March 31, 2014 are preserved.

ABSPTS

Sample Size (short integer)

This field applies only to standard production USGS DEMs and echoes data element 3 of the source DEM's Type C (sample size record) (Digital Elevation Models, USGS, 1993).

For DEMs introduced into the NED after April 1, 2014 this field will be populated with -100. Any values already in this field for DEMs used to produce the NED prior to March 31, 2014 are preserved.

RMSE

Availability of Relative Accuracy Statistics (short integer)

This field applies only to standard production USGS DEMs and echoes data element 4 of the source DEM's Type C (relative accuracy statistics) (Digital Elevation Models, USGS, 1993).

Valid codes:

1	Available
0	Not available

For DEMs introduced into the NED after April 1, 2014 this field will be populated with -100. Any values already in this field for DEMs used to produce the NED prior to March 31, 2014 are preserved.

RMSEX, RMSEY, RMSEZ

Relative Accuracy (short integer)
This field applies only to standard production USGS DEMs and echoes data element 5 of the source DEM's Type C (relative accuracy in X, Y, Z (Digital Elevation Models, USGS, 1993).This field is zero if not available.

For DEMs introduced into the NED after April 1, 2014 this field will be populated with -100. Any values already in this field for DEMs used to produce the NED prior to March 31, 2014 are preserved.

RMSEPTS

Sample Size (short integer)

This field applies only to standard production USGS DEMs and echoes data element 6 of the source DEM's Type C (sample size) (Digital Elevation Models, USGS, 1993).

For DEMs introduced into the NED after April 1, 2014 this field will populated with -100. Any values already in this field for DEMs used to produce the NED prior to March 31, 2014 are preserved.

NED Production Timestamps

QUADDATE

QUADDATE

Date the data were used to produce the NED (long integer)

The date on which the source DEM was first processed into NED. This field is particularly useful in the identification of recently updated areas.

Format: YYYYMMDD

NED1/9 Arc-second Data Dictionary

Source Identification

PROJ_NAME
DEMNAME

PROJ_NAME

Project name (text)

This field is the name of the original project that was adapted for incorporation into the NED 1/9 arc-second layer. The format of this field will most commonly be three parts separated by underscores: PRIMARYSTATE, BRIEF-PROJECT-DESCRIPTION, YEAR.

DEMNAME

Data Name (text)
The name of the final elevation dataset processed into a common coordinate system and units according to NED 1/9 arc-second specifications.

For DEMs introduced into the NED after April 1, 2014 this field will no longer be populated. Any values already in this field for DEMs used to produce the NED prior to March 31, 2014 are preserved.

Source Production

RESOLUTION
HORIZRES_M
PMETHOD
S_DATE
FREETEXT

RESOLUTION

Resolution (short integer)

The planimetric (x, y), spacing of elevation postings of the final pre-processed datasets. Source LiDAR datasets resolution varies but is typically less than 3 meters. During NED 1/9 arc-second processing, source datasets are resampled to a common resolution (e.g. 1/9 arc-second or about 3 meters).

For DEMs used to produce the NED prior to March 31, 2014 valid values are:

19 1/9 arc-second (non-standard data)

For DEMs introduced into the NED after April 1, 2014 the actual source resolution is used in NED processing. The source resolution of the source data in meters of the original high-resolution source DEM will be populated in the HORIZRES_M field, and the RESOLUTION field will be populated with:

100 High-resolution source

HORIZRES_M

Horizontal Resolution of Source DEM (floating point)

The horizontal resolution (x, y) of the original DEM which was used to produce the NED, expressed in meters. Regardless of the source DEM horizontal units, this field is expressed in the common unit meters for more meaningful comparisons and simplified queries.

This is a new field in the spatial metadata shapefiles for DEMs used to produce the NED after April 1, 2014. For DEMs used to produce the NED prior to March 31, 2014, this field will not be populated.

PMETHOD

Production Method (short integer)

The method used to collect the original source elevation data. Valid codes are:

7 Lidar
10 Ifsar
11 Other remote sensing technique
12 Topobathy

S_DATE

Data Source Date (short integer)

The year the source elevation data were collected. If acquisition of a project spanned two or more calendar years, the earliest acquisition year is indicated in this field.

FREETEXT

Free Text Description (text)

There are no standards for the use of the free text field. This field may contain additional information to further describe the source project or clarify other metadata fields.

For DEMs introduced into the NED after April 1, 2014 this field will no longer be populated. Any values already in this field for DEMs used to produce the NED prior to March 31, 2014 are preserved.

Output Production

ZUNIT

ZUNIT

Elevation Unit (short integer)

This field describes the elevation units of the output 1/9 arc-second NED data. During the NED 1/9 arc-second processing, the source data vertical units are converted to a consistent elevation unit.

Valid value:

1	Meters

Source Accuracy Statistics

S_FVA
S_CVA
S_NVA
S_VVA
VA_UNIT
RMSEZ
RMSE_FVA
RMSE_SVA
RMSE_CVA

S_FVA

Source DEM Fundamental Vertical Accuracy (FVA) (floating point)

This is the tested FVA of the source resolution DEM. FVA, or $Accuracy_z$, is based only on points in clear and open terrain. The fundamental accuracy is the value by which vertical accuracy can be equitably assessed and compared among datasets. The S_FVA is calculated at the 95-percent confidence level as a function of vertical Root Mean Square Error (RMSE) i.e., $Accuracy_z = RMSE_z \times 1.96$.

S_FVA is expressed in the units reported in the VA_UNIT field.

Valid values:

-1	Not available
Other Values	Actual Calculated RMSE value

S_CVA

Source DEM Consolidated Vertical Accuracy (CVA) (floating point)

This is the tested CVA of the source resolution DEM. CVA is based on check points in all land cover categories combined. Error distribution for points in vegetated areas does not have a normal distribution. Therefore S_CVA is reported as the 95^{th} percentile.

S_CVA is expressed in the units reported in the VA_UNIT field.

Valid values:

-1	Not available
Other Values	Actual Calculated RMSE value

S_NVA

Non-vegetated Vertical Accuracy (floating point)

This field is reserved for future use.

Current valid value: -1

S_VVA

Vegetated Vertical Accuracy (floating point)

This field is reserved for future use.

Current valid value: -1

VA_UNIT

Vertical Accuracy Unit (short integer)

The units in which the vertical accuracy statistics are reported.

Valid values:

0	International Feet
1	Meters
2	US Survey Feet
3	decimal degrees
4	centimeters
5	inches
99	unknown

RMSEZ, RMSE_FVA, RMSE_SVA, RMSE_CVA

RMSE(z), RMSE(FVA), RMSE(SVA), RMSE(CVA) (double)

Vertical accuracy for source DEMs introduced into the NED after April 1, 2014 are reported in the S_FVA and S_CVA fields above.

Reported RMSE statistics are in meters.

RMSE(z): Root Mean Square Error of the elevation estimates.
RMSE(FVA): RMSE (Fundamental Vertical Accuracy).
RMSE(SVA): RMSE (Supplemental Vertical Accuracy).
RMSE(CVA): RMSE (Consolidated Vertical Accuracy).

RMSE is the square root of the average of the set of squared differences between dataset coordinate values and coordinate values from an independent source of higher accuracy for identical points.

$$RMSE_z = \text{sqrt}[\ \Sigma\ (Z_{\text{data I}} - Z_{\text{check I}})^2/n]$$

where $Z_{\text{data I}}$ is the vertical coordinate of the I_{th} check point in the elevation dataset, $Z_{\text{check I}}$ is the vertical coordinate of the I_{th} check point in the independent reference source of higher accuracy, n is the number of points being checked, and I is an integer from 1 to n.

The Fundamental Vertical Accuracy (FVA) of a dataset must be determined with check points located only in open terrain, where there is a very high probability that the sensor will have detected

the ground surface. The fundamental accuracy is the value by which vertical accuracy can be equitably assessed and compared among datasets. The FVA is calculated at the 95-percent Confidence Level as a function of vertical RMSE, i.e., $Accuracy_z = RMSE_z \times 1.9600$.

In addition to the fundamental accuracy, supplemental or consolidated accuracy values maybe calculated for other ground cover categories or for combinations of ground cover categories. Because elevation errors often vary with the height and density of ground cover, a normal distribution of error cannot be assumed and, therefore, RMSE cannot be used to calculate accuracy values. Consequently a nonparametric testing method (95th Percentile) is employed for supplemental and consolidated accuracy tests. The SVA or CVA are calculated at the 95^{th} percentile for each supplemental land cover category or combination of categories.

Valid values:

0	Not available
Other Values	Actual Calculated RMSE value

For DEMs introduced into the NED after April 1, 2014 theses RMSE fields will be populated with -100. Instead, accuracy statistics for these DEMs will be provided in the S_FVA and S_CVA fields or in the S_NVA and S_VVA fields above. Any values already in the RMSE fields for DEMs used to produce the NED prior to March 31, 2014 are preserved.

NED Production Timestamp

QUADDATE

QUADDATE

Date the data were used to produce the NED (long integer)

The date on which the source DEM was first processed into NED. This field is particularly useful in the identification of new NED coverage areas.

Format: YYYYMMDD

NED Original Product (Source) Resolution Data Dictionary

Source Identification

PROJ_NAME

PROJ_NAME

Source Project Name (text)

Project name is the name of the original source DEM project that was adapted for incorporation into the 1/9, 1/3, 1, or 2 arc-second NED layers. The NED Original Product Resolution production process maintains the coordinate reference system and horizontal units of the original project. However, vertical units are converted to meters.

The format of this field will most commonly be three parts separated by underscores: PRIMARYSTATE, BRIEF-PROJECT-DESCRIPTION, YEAR.

Source Production

PMETHOD
S_DATE

PMETHOD

Production Method (short integer)

The acquisition method used to collect the source elevation data (Digital Elevation Models, USGS, 1993).

Valid values are:

7	Lidar
10	Ifsar
11	Other remote sensing technique
12	Topobathy

S_DATE

Data Source Date (short integer)

The year the source elevation data were collected. If acquisition of a project spanned two or more calendar years, the earliest acquisition year is reported in this field.

Output Production

ZUNIT
REFSYS
HORIZRES
HORIZUNIT
FORMAT

HORIZRES_M

ZUNIT

Elevation Unit (short integer)

This field describes the elevation units of the output data. During the NED Original Product Resolution processing, the source data vertical unit is converted to consistent elevation unit, which is meters.

Valid value:

1 Meter

REFSYS

Coordinate Reference System (text)

This field describes the coordinate reference system and projection of the NED Original Product Resolution DEM.

HORIZRES

Horizontal Resolution (floating point)

The horizontal resolution (x, y) of the NED Original Product Resolution DEM. The value is reported in the units recorded in the HORIZUNIT field.

HORIZUNIT

Horizontal Resolution Units (short integer)
The unit in which the horizontal resolution, HORIZRES, is reported.

Valid values:

0 International Feet
1 Meters
2 U.S. Survey Feet
3 Decimal Degrees
4 Centimeters
5 Inches
99 Unknown

FORMAT

Raster File Format (short integer)
The raster file format of the Original Product Resolution DEM.

Valid values:

1 IMG
2 ArcGrid
3 GridFloat
4 Tiff

5 Other

HORIZRES_M

Horizontal Resolution Expressed in Meters (floating point)

The horizontal resolution (x, y) of the Original Product Resolution DEM expressed in meters. This field is provided for easy comparison of and sorting of horizontal resolutions, regardless of the horizontal units of the actual DEM.

Accuracy Statistics

FVA
CVA
NVA
VVA
VA_UNIT

FVA

Fundamental Vertical Accuracy (FVA) (floating point)

This is the tested FVA of the source resolution DEM. FVA, or $Accuracy_z$, is based only on points in clear and open terrain. The fundamental accuracy is the value by which vertical accuracy can be equitably assessed and compared among datasets. The FVA is calculated at the 95-percent confidence level as a function of vertical Root Mean Square Error (RMSE) i.e., $Accuracy_z = RMSE_z \times 1.96$.

FVA is expressed in the units reported in the VA_UNIT field.

Valid values:

-1	Not available
Other Values	Actual Calculated RMSE value

CVA

Consolidated Vertical Accuracy (floating point)

This is the tested CVA of the source resolution DEM. CVA is based on check points in all land cover categories combined. Error distribution for points in vegetated areas do not have a normal distribution. Therefore S_CVA is reported as the 95^{th} percentile.

CVA is expressed in the units reported in the VA_UNIT field.

Valid values:

-1	Not available
Other Values	Actual Calculated RMSE value

NVA

Non-Vegetated Vertical Accuracy (floating point)

This field is reserved for future use.

Current valid value: -1

VVA

Vegetated Vertical Accuracy (floating point)

This field is reserved for future use.

Current valid value: -1

VA_UNIT

Vertical Accuracy Unit (short integer)

The units in which the vertical accuracy values are reported.

Valid values:

0	International Feet
1	Meters
2	U.S. Survey Feet
3	Decimal Degrees
4	Centimeters
5	Inches
99	Unknown

NED Production Timestamp

QUADDATE

QUADDATE

Date the data were released into the NED (long integer)
Quaddate is the date when the Original Product Resolution DEM was processed into the NED.

Format: YYYYMMDD

The National Map – Elevation, Lidar Point Cloud Project Data Dictionary

Lidar Project Information

project_id
state
vendor
s_date
e_date
entry_date
lr_lat, lr_long, ll_lat, ll_long, ul_lat, ul_long, ur_lat, ur_long
sensor_type
spec
nva_swath
va_unit

project_id

Project Name (text)

The format of this field will most commonly be three parts separated by underscores: PRIMARYSTATE, BRIEF-PROJECT-DESCRIPTION, YEAR.

state

The State(s) the project is in. (text)

Format: Two letter State abbreviations

vendor

The name of the company which collected and processed the data. (text)

s_date

Start date of data collection for the project (date)

e_date

End date of data collection for the project (date)

entry_date

Date the lidar data were released into the *The National Map* (date)

lr_lat, lr_long, ll_lat, ll_long, ul_lat, ul_long, ur_lat, ur_long

Coordinates defining the minimum bounding box of the lidar point cloud project (double) Units: decimal degrees. Coordinate System: NAD 83.

lr_lat, lr_long	Southeastern extent in latitude and longitude
ll_lat, ll_long	Southwestern extent in latitude and longitude
ul_lat, ul_long	Northwestern extent in latitude and longitude
ur_lat, ur_long	Northeastern extent in latitude and longitude

sensor_type

Sensor used in lidar collection for the dataset. (text)

spec

Applicable specification for the dataset. (waiting on domain)

Valid Values:

0	Draft Version 12
1	Draft Version 13
2	USGS Lidar Base Specification 1.0
3	USGS Lidar Base Specification 1.2
4	USGS Lidar Base Specification 2.0
99	Other

nva_swath

Non-vegetated vertical accuracy assessed against a swath. Measured as RMSEz. (waiting on domain)

va_units

Units of NVA RMSEz

Valid Values:

0	International Feet
1	Meters
2	US Survey Feet
3	Decimal Degrees
4	Centimeters
5	Inches
99	unknown

Coordinate Reference System

refsys
horizunit
zunit

refsys

Coordinate Reference System (text)

This field describes the coordinate reference system and projection of the lidar project.

horizunit

HorizontalUnits (long integer)
This field describes the horizontal unit of the lidar point cloud project.

Valid values:

0	International Feet
1	Meters
2	U.S. Survey Feet
3	Decimal Degrees
4	Centimeters
5	Inches
99	Unknown

zunit

Elevation Unit (long integer)

This field describes the vertical unit of the lidar point cloud project.

Valid values:

0	International Feet
1	Meters
2	U.S. Survey Feet
3	Decimal Degrees
4	Centimeters
5	Inches
6	Feet
99	Unknown

Lidar Information

las_type
quality
rptd_nps
rptd_pd
rptd_units
rptd_anps
rptd_anpd

las_type

LAS type (long integer)

This field describes the organization of the LAS files and whether or not the points are classified.

Valid values:

0	Tile unclassified
1	Tile classified
2	Swath unclassified
3	Swath classified
4	Other

quality

Quality Level (long integer)

This field indicates the 3DEP quality level of the tile. For more information regarding 3DEP quality levels, see The 3D Elevation Program Initiative: A Call for Action (USGS, 2014).

Valid values:

1	Quality level 1 (10cm $RMSE_z$, 0.35m nominal pulse spacing)
2	Quality level 2 (10cm $RMSE_z$, 0.7m nominal pulse spacing)
3	Quality level 3 (20cm $RMSE_z$, 1.4m nominal pulse spacing)
99	Other

rptd_nps

Vendor reported nominal pulse spacing (double)
This field describes the reported average point spacing of dataset.

rptd_pd

Vendor reported pulse density (double)
This field describes the reported concentration of points in the dataset.

rptd_units

The units of the vendor reported pulse density and nominal pulse spacing (long integer)

Valid values:

0	International Feet
1	Meters
2	U.S. Survey Feet
3	Decimal Degrees
4	Centimeters
5	Inches
6	Feet
99	Unknown

rptd_anps

Vendor reported aggregate nominal pulse spacing (waiting on domain). This field describes the reported average aggregate pulse spacing of the dataset.

rptd_anpd

Vendor reported aggregate nominal pulse density (waiting on domain). This field describes the reported average aggregate pulse density of the dataset.

The National Map – Elevation, Lidar Point Cloud Tile Data Dictionary

Lidar Tile Information

project_id
tile_name
entity_id
s_date
e_date
entry_date
lr_lat, lr_long, ll_lat, ll_long, ul_lat, ul_long, ur_lat, ur_long

project_id

Project Name (text)

The format of this field will most commonly be three parts separated by underscores: PRIMARYSTATE, BRIEF-PROJECT-DESCRIPTION, YEAR.

tile_name

Tile Name (text)

The .las file name, not including the extension.

entity_id

Project and tile name, separated by an underscore. (text)

s_date

Start date of data collection for the project (date).

Format: YYYYMMDD

e_date

End date of data collection for the project (date).

Format: YYYYMMDD

entry_date

Date tile became available in *The National Map* (date).

Format: YYYYMMDD

lr_lat, lr_long, ll_lat, ll_long, ul_lat, ul_long, ur_lat, ur_long

Coordinates defining the minimum bounding box of the point cloud tile (double)
Units: decimal degrees. Coordinate System: NAD 83.

lr_lat, lr_long	Southeastern extent in latitude and longitude
ll_lat, ll_long	Southwestern extent in latitude and longitude
ul_lat, ul_long	Northwestern extent in latitude and longitude
ur_lat, ur_long	Northeastern extent in latitude and longitude

Coordinate Reference System

refsys
horizunit
zunit

refsys

Coordinate Reference System (text)

This field describes the coordinate reference system and projection of the lidar project.

horizunit

Horizontal Resolution Units (long integer)
This field describes the unit in which the horizontal resolution, HORIZRES, is reported.

Valid values:

0	International Feet
1	Meters
2	U.S. Survey Feet
3	Decimal Degrees
4	Centimeters
5	Inches
99	Unknown

zunit

Elevation Unit (integer).

This field describes the vertical units of the lidar tile.

Valid value:

0	International Feet
1	Meters
2	U.S. Survey Feet
3	Decimal Degrees
4	Centimeters
5	Inches
6	Feet
99	Unknown

Lidar Information

las_type
quality
version
rtrnct_1
rtrnct_2
rtrnct_3
rtrnct_4
rtrnct_5
rtrnct_6
rtrnct_7
rtrnct_8
rtrnct_9
rtrnct_10
rtrnct_11
rtrnct_12
rtrnct_13
rtrnct_14
rtrnct_15
point_ct

las_type

LAS file type (integer).

This field describes if the LAS file has been classified, and whether it is delivered as a tile or swath.

Valid values:

0	Tile unclassified
1	Tile classified
2	Swath unclassified
3	Swath classified
4	Other

quality

Quality Level (integer)

This field indicates the 3DEP quality level of the tile.For more information regarding 3DEP quality levels, see The 3D Elevation Program Initiative: A Call for Action (USGS, 2014).

Valid values:

1	Quality level 1 (10cm $RMSE_z$, 0.35m nominal pulse spacing)
2	Quality level 2 (10cm $RMSE_z$, 0.7m nominal pulse spacing)
3	Quality level 3 (20cm $RMSE_z$, 1.4m nominal pulse spacing)
99	Other

version

The LAS file format version of the tile (double)

rtnct_1

Number of first return points in the .las file. (integer).

rtnct_2

The number of second return points in the .las file. (integer)

rtnct_3

The number of third return points in the .las file. (integer)

rtnct_4

The number of fourth return points in the .las file. (integer)

rtnct_5

The number of fifth return points in the .las file. (integer)

rtnct_6

The number of sixth return points in the .las file. (integer)

rtnct_7

The number of seventh return points in the .las file. (integer)

rtnct_8

The number of eighth return points in the .las file. (integer)

rtnct_9

The number of ninth return points in the .las file. (integer)

rtnct_10

The number of tenth return points in the .las file. (integer)

rtnct_11

The number of eleventh return points in the .las file. (integer)

rtnct_12

The number of twelfth return points in the .las file. (integer)

rtnct_13

The number of thirteenth return points in the .las file. (integer)

rtnct_14

The number of fourteenth return points in the .las file. (integer)

rtnct_15

The number of fifteenth return points in the .las file. (integer)

point_ct

The total number of points in the .las file. (integer)

References Cited

U.S. Geological Survey, 1993, Digital Elevation Models; U.S. Geological Survey Data Users Guide 5, i-53 p., accessed January 20, 2015 at *http://pubs.er.usgs.gov/publication/70038376*.

U.S.Geological Survey, 2014, The 3D Elevation Program Initiative – A Call for Action, i-36p., accessed January 20, 2015 at *http://pubs.er.usgs.gov/publication/cir139.*

Appendix A

Correspondence between selected NED metadata items and USGS DEM Type A records.

Refer to Data User's Guide 5, Appendix A, for complete descriptions of the A record data elements referenced below.

FREETEXT The FREETEXT field is a literal copy of Data Element 1: The first 140 bytes of the A record. By USGS definition, only bytes 41 through 80 are free format text, but this restriction is not commonly observed.

PSITE This is a literal copy of data element 2, the Mapping Center origin code. If this field is blank, the code "UNKNOWN" is assigned to PSITE.

ZONE This is a literal copy of data element 6.

ZUNIT This field is derived from data element 9, but does not use the same values. Data element 9 is coded as 1 = feet, 2 = meters. ZUNIT, however, is coded as 0 = feet, 1 = meters.

LRLAT, LRLON, ULLAT, ULLON These fields are derived from data element 11.

RESOLUTION This field is derived from data element 15, which indicates the *x*, *y*, and *z* resolutions of the source DEM. In the case of Alaska data, where x and y resolutions differ, the y resolution is taken to be the resolution of the DEM. Further, RESOLUTION is indicated in the DEM's native units (meters or decimal seconds). Nonstandard DEM's may be assigned RESOLUTION values in a different manner.

ZSTEP This is a literal copy of the *z* resolution component of data element 15.

S_DATE This is a literal copy of data element 21, or 0 if data element 21 is absent.

I_DATE This is a literal copy of data element 22, or 0 if data element 22 is absent.

HDATUM This field is derived from data element 27, but uses different values. Data element 27 specifies unique codes for the Old Hawaii Datum and the Puerto Rico Datum, both of which are designated as 27 in HDATUM.

VDATUM This field is derived from data element 26, but uses different values. A value of 0 is assigned to VDATUM if no vertical datum information is present.

ATTACHMENT 2

PICTURES OF RIVER IN FLOOD

Picture of Coffee Creek Looking Toward Outfall at Mossy Lake During Non-Flood.

Picture from Mossy Lake Outfall Looking at Ouachita River in Flood

Picture of Houses in Fish Camp Area near Coffee Creek Confluence with the Ouachita River