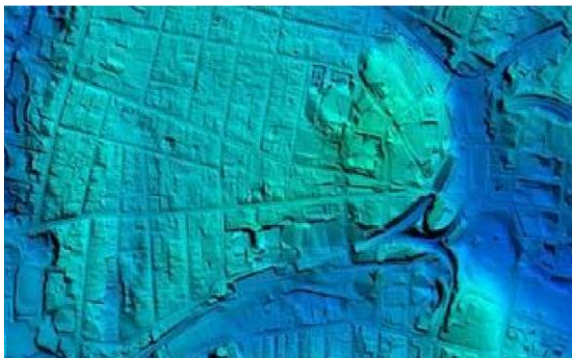

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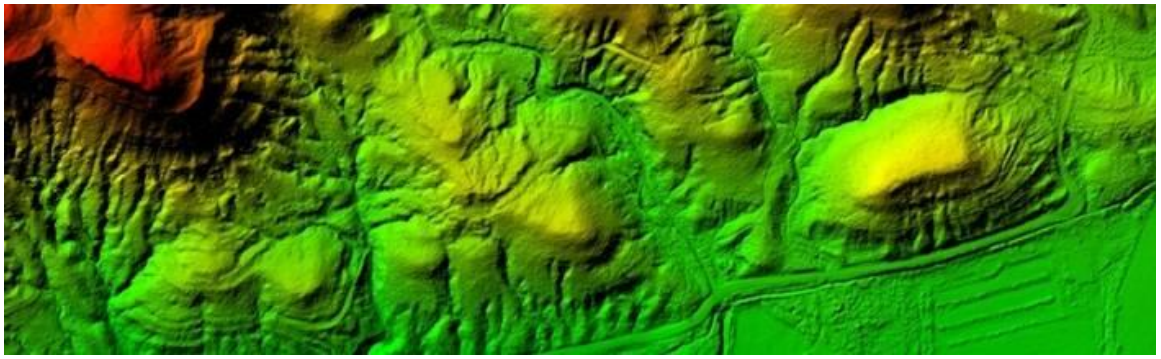

Quality Plan for the Florida Peninsular FDEM 2018 D19 DRRA Project

March 31, 2020

PRODUCED BY:

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Version

Version Number	Date	Description of Modification
1.0	3/11/2019	Initial document
2.0	4/9/2019	Revisions after FL Statewide meeting
2.1	4/16/2019	Revised agriculture canal section
2.2	12/16	Removed 12.5' spec from agricultural canal section, removed 0.3 ft elevation changes in coastal features, removed mention of dry drains, updated dual line drain picture in Connector Placement section to show closed polygons
2.3	3/31/2020	Revisions made to the following sections: Building Classification (p 29), Tidal Collection (p 21), and the addition of Vertical Variance Evaluation (p 23)

Introduction

The *Quality Plan* for the USGS Florida Peninsular Lidar Project will serve as the foundation for Acquisition requirements and Dewberry's QA/QC processes and methodology. It is expected that the *Quality Plan* will be updated throughout the lifecycle of the project as the requirements are modified. The plan includes several sections:

- **Contact Information and Key Staff** lists the key staff and the contact information.
- **Acquisition and Production Partners Contact Information and Key Staff** lists the key staff and the contact information.
- **Introduction** provides an introduction to the project and an overview of the *Quality Plan* structure.
- **Responsibilities of Dewberry Key Personnel** identifies the responsibilities of the Dewberry key personnel.
- **Dewberry's Scope of Work** details Dewberry's scope of work.
- **Communication Plan** documents Dewberry's communication plan.
- **Independent Quality Assurance Acquisition Methodology** describes the methodology Dewberry will use for this project.
- **Independent Quality Assurance Production Methodology** describes the methodology Dewberry will use for this project.
- **Actions Required of USGS, Production Partners, and Acquisition Partners** lists the actions required in order to execute this project.
- **Discussion Items** states the items that need to be discussed with USGS

In addition, there are two appendices.

- Appendix A: Acquisition Delivery Requirements
- Appendix B: Lidar Quality Assurance Plan

Responsibilities of Dewberry Key Personnel

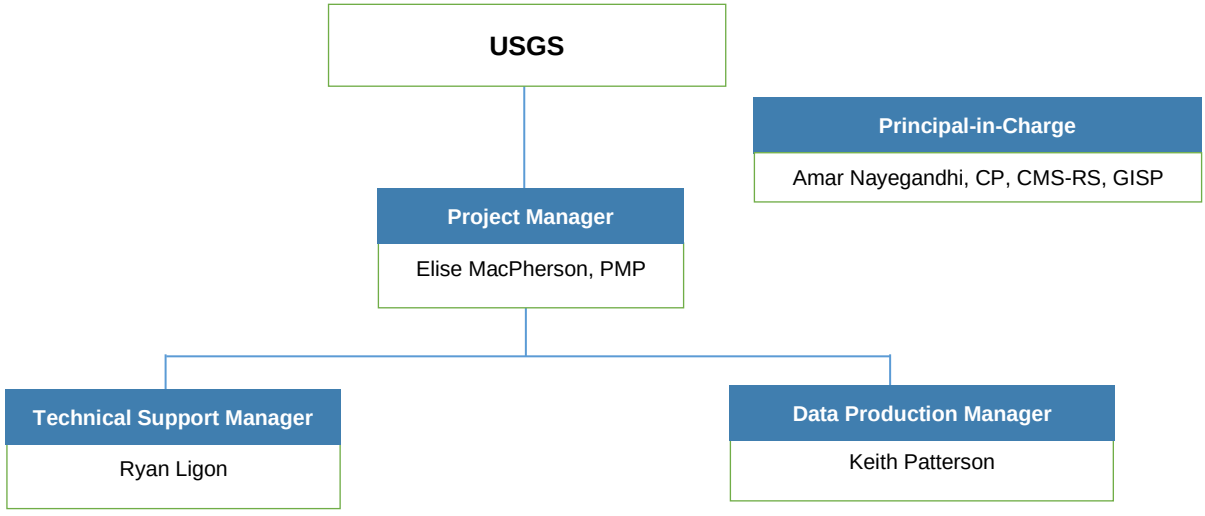

Figure 1 — Organization for USGS QA/QC

Dewberry's key personnel are shown in the organization chart at Figure 1.

- **Elise MacPherson** is Dewberry's Project Manager (PM) for this contract. As such, she is the single point of contact with USGS. Elise MacPherson is responsible for all client liaisons, to include coordination with the acquisition partners, production partners, and for technical, schedule and financial management of the contract. She is overall responsible for execution of this *Quality Plan*.
- **Amar Nayegandhi** is Dewberry's Principal-in-Charge (PIC) for this contract. As such, he is responsible for ensuring that Elise MacPherson receives the priority resources necessary to succeed.
- **Ryan Ligon** is the Technical Support Manager. Ryan is responsible for helping Elise MacPherson in execution of this *Quality Plan*, in review of the acquisition and production partners Lidar and derivative data, and in supervision of Dewberry's quality assurance team.
- **Keith Patterson** is Dewberry's Production Manager for this project. Keith will manage Dewberry production of Lidar and derivative data and supervise the data produced by the production partners.

Dewberry's Scope of Work

Each of the following tasks is required under the award as described in Attachment A – Consultant Scope of Work

1. **Lidar and Digital Elevation Model QA/QC**
   a. Review statewide work plan and confirm that delivered data product meet USGS project requirements and USGS QL1 specifications for Lidar and DEM, spatial quality control, horizontal accuracy and vertical accuracy.
   b. Review and evaluate hydro-flattening methodology and implementation.
   c. Sample Lidar and DEM data to ensure that acquired elevation data matches known elevations such as sea level, water bodies, local high and low points, survey landmarks, etc.
   d. For DEM: no null values, valid min and max stats, elevation matches Lidar.

2. **Deliverables**
   a. QA/QC work plans for topographic data sets.
   b. Documentation of sampling and evaluation methodology.
   c. Biweekly reports by delivery block.
   d. Final QA/QC report for Lidar datasets, which documents all identified errors/deficiencies with such datasets and how they were addressed.

Communication Plan

Elise MacPherson (Dewberry) will coordinate directly with USGS on all services, including meetings, schedules, deliverables, project issues, conference calls, and correspondence. Elise will coordinate status reports and the project tracking. Teleconferences will be coordinated with the acquisition partners, production partners, and USGS as necessary to resolve issues at the earliest stage. Implementing this practice will:

- Allow for discussion of project related issues
- Mitigate potential scoping issues
- Promote project communication
- Foster team unity and communication
- Coordinate project understanding
- Help identify any production and quality control issues
- Allow management team to be proactive vs. reactive.

Dewberry's partnership approach to communication will closely bond Dewberry's project team and USGS. Together, we will build consensus, discuss the status of projects, technical issues, and perform one or more quality audits throughout the project in support of all services and products. Good communication is invaluable, but if that information is not properly disseminated to the appropriate team members, it fails to meet its objectives.

The project tracking spreadsheet will be instrumental in allowing all to review the current status of tiles received from the production subcontractors, tiles QC'd and accepted or rejected by Dewberry, tiles revised by the production subcontractors, tiles submitted to Dewberry for completion reviews and development of final deliverables, and status of deliveries.

Independent Quality Assurance Acquisition Methodology

The final products from the acquisition partners for the USGS project will be tested by Dewberry against the acceptance criteria listed below. Each acquisition partner will provide 3-5 uncalibrated sample swaths to Dewberry while collection is still in progress. A QA inspection will be performed to verify the sample swaths meet or exceeds the specified project density, verify spatial distribution and intra-swath accuracy passes, ensure sufficient ground coverage beneath vegetation, and no sensor anomalies are present. 3-5 calibrated sample swaths will also be provided to Dewberry after all lifts have been calibrated. A QA inspection will be performed to ensure LAS statistics are correct and horizontal and inter-swath accuracy passes. Products not passing the measure of acceptability will be returned to the acquisition partners for review and repair or replacement prior to sending the full swath delivery. Dewberry will perform a comprehensive quality evaluation of the full swath delivery. All checks mentioned above will be performed on the full swath delivery and any issues present may be sent back to the acquisition partner to correct. Results of all tests will be documented. These criteria represent guidelines and variances and/or exceptions may be required with approval of USGS by mutual consent and documentation to explain any changes to the acceptance criteria.

Independent Quality Assurance Production Methodology

The final products from the production partners for the USGS project will be tested by Dewberry against the acceptance criteria listed below. In general each individual deliverable product will be tested against these characteristics to ensure they met or exceeded the following criteria prior to acceptance by USGS. QA inspection will be performed at specified map scales for the Lidar reviews except as necessary to make measurements or inspect anomalies. Products not passing the measure of acceptability will be returned to the production partners for correction. Results of all tests will be documented. These criteria represent guidelines and variances and/or exceptions may be required with approval of USGS by mutual consent and documentation to explain any changes to the acceptance criteria.

In an effort to streamline the quality review and acceptance process, a “One-Pass” review cycle applies to this project. This review cycle is designed to alleviate the production bottleneck that can be caused with iterative cycles of product rejection to resolve minor discrepancies in the deliverables. This approach is a direct result of lessons learned on projects with a similar scope.

The goal of this review process is to ensure that the final accepted database passes through rigorous review cycles designed to identify critical failures. The work flow process for the One Pass Review Cycle is as follows:

- Dewberry will perform a comprehensive quality evaluation of the initial data delivery. This evaluation will identify all failures, discrepancies and systematic errors as defined by the acceptance criteria.
- The Dewberry and USGS teams will review the results together and determine the edit calls that warrant return to the contractor for correction. All valid edit calls will be fixed. USGS has the final authority as to whether or not a feature shall be corrected.
- It is expected that the contractor will address all One Pass discrepancies regardless of the overall % of feature acceptance for features. If there are discrepancies, those will need to be reviewed one at a time to build a team consensus. Simply marking the database with numerous calls stating “Not an Error” or something similar will likely not be acceptable to Dewberry or USGS.

- Upon redelivery, Dewberry will perform a second review validating that the original edit calls were addressed and that no new errors have been introduced during this process.
- Upon finalization of the review process, Dewberry will create a report to accompany the edit calls database that documents the review process and any issues identified with the data. This is submitted to the USGS along with the edit calls database as the deliverable for the review process.

Actions Required of USGS, Production Partners, and Acquisition Partners

This section details the actions required of USGS and acquisition partners for this project.

1. USGS should provide the following to Dewberry:
    a. Any specific changes from the RFP that relate to deliverables or acceptability of products.
2. The production partners should provide the following to Dewberry:
    a. The production partners schedules for planned delivery of their products to Dewberry.
3. The acquisition partners should provide the following to Dewberry:
    a. The acquisition partners schedules for planned delivery of their products to Dewberry.

Discussion Items

This section requires specific resolutions for the items listed below. Resolutions will need to be discussed and agreed upon between USGS and Dewberry and reflect how data should be treated during production and QC.

- **Breakline GDB** – Verification is needed on which feature classes should remain in the breakline GDB that was provided by the stakeholders.
    - **Dewberry will supply the final version of the GDB to data providers**.

Appendix A- Acquisition Delivery Requirements

Each acquisition partner will provide Lidar data acquisition and deliver fully processed QL1 Lidar data as dictated by the USGS TO specifications, to Dewberry for final QA/QC and delivery to USGS

The data is to be acquired during the December 1, 2018 – April 1, 2019 timeframe weather and ground conditions permitting. The acquisition is to be tidally coordinated from the coast inland covering the river/inlet areas connecting to the Atlantic. The data acquisition will be planned to acquire at a minimum of 8 points per square meter and an average density of 10 points per square meter, assessed against first returns only.

The project area consists of approximately 34,873 square miles as depicted on the map below.

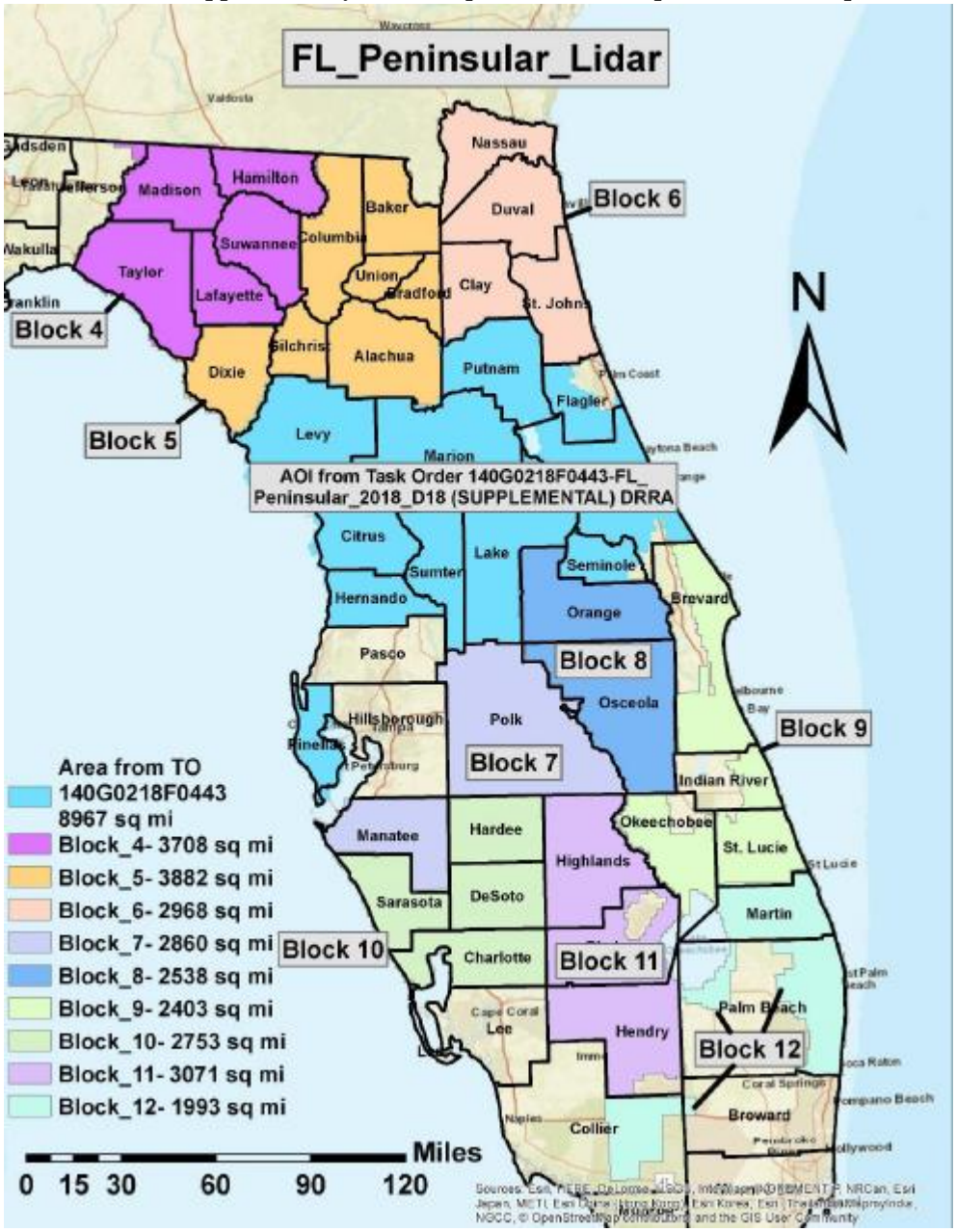

Figure 2-Map of project area

The acquisition partners will ensure that the flight plans and delivered data covers all land identified by the final project boundary as well as a buffer of 500 meters, and a minimum of 2 swaths past the boundary edge.

Deliverables

The acquisition partners were provided a Statement of Work (SOW) outlining deliverables and schedule in great detail. Table 1 below lists the deliverables Dewberry requires from the acquisition partners.

TABLE 1
Final Deliverables

Deliverable	Format
Derived Products	
LAS Swaths	Calibrated LAS 1.4 swaths point record format 6. Swaths should not be delivered larger than 30 GB.
Terrascan Trajectories	.TRJ binary format.
Collected Data	
GNSS/IMU processing files	Binary raw POS files (.000, .raw), Binary and ASCII SBET (.out/.sol, .txt), and all PosPac or Inertial explorer project files/folders.
Raw GPS Base Station Data	System binary format or RINEX
Flight Logs	Scans of written logs or electronic formats such as CSV, excel, word, etc.
Metadata	
Acquisition Report	Microsoft Word (.doc/.docx)
Lidar calibration and intensity files	Vendor utilized formats (.ini, .csv, .tbl, .res, etc)
Calibration and instrument settings by lift	Text or table format
Flightline Index	ESRI Shapefile
Ground Survey Report	Microsoft Word (.doc/.docx)
Static Control Shapefile	ESRI Shapefile
Calibration Control Shapefile	ESRI Shapefile
Tide Charts (if applicable)	Text or table format

Acquisition Checklist	Microsoft Word (.doc/.docx)

Appendix B – Lidar Quality Assurance Plan

Dewberry will perform an independent evaluation of the Lidar data delivered to USGS. As per the scope of work the data provider was required to produce Lidar data to meet USGS QL1 specifications as defined by the Lidar Base Specification Version 1.3 along with the ASPRS guidelines and standards for accuracy. The tables below outline the requirements as defined by these documents along with the approach Dewberry will utilize in the validation of the data.

Dewberry will initially perform a macro level review of the Lidar data to determine which products have been delivered, Table 2, and identify if any systematic or severe issues are present in the Lidar data. The macro review includes the validation of the acquisition parameters as described in Table 3 along with a 1:10,000 scale manual review of the classified ground data. The macro level review will identify issues related to the classification of the ground only. In the event that systematic or severe errors are identified in the ground classification. The tiles for detailed review will be selected based on the macro review identifying areas that require additional analysis. Unless there is a systematic issue with the Lidar data the entire delivery will be reviewed and all features requiring edits will be marked with either a point or polygon feature to delineate where the revision is expected.

Required Deliverables

Table 2 provides an outline for the deliverables expected as part of this project based on the Scope of Work.

Table 2 - Required Deliverables for USGS Specification Compliance

Parameter	Requirement
Pilot Delivery	A ten tile pilot from an area Dewberry specified shall be delivered to ensure the data and quality is consistent among all blocks
Project Delivery	Project deliverables should be delivered in USGS' provided folder structure template. All deliverables should be organized in the correct folders.
Classified Point Cloud	a. Fully compliant to LAS v1.4 specifications b. Correct projection defined in header c. Classified to 1 – Processed but unclassified 2 – Bare-earth ground 6 - Buildings 7 – Low Noise 9 – Water 17 – Bridge Deck Points 18 – High Noise 20 - Ignored ground (breakline proximity) 21 – Snow (if present and identifiable) 22 – Temporal exclusion (typically non-favored data in intertidal zones, use as necessary) d. Overlap (Overage) and Withheld points are set to the Overlap and Withheld bits e. GPS times are recorded in Adjusted GPS Time with precision sufficient to allow unique timestamps for each pulse. f. Intensity values normalized to 16-bit g. Tiled to USGS tile scheme
Building Classification	Only tops of buildings are classified using class 6. Sides of buildings are not included in this classification. In the automated process some areas such as screened in pool enclosures may also be assigned the building classification if the density of points on the screen is sufficiently detailed. All buildings with a minimum threshold of 300 square feet should be classified.
Swaths	Swaths should be classified to Class 0-Default
Hydro-Flattened DEM	Dewberry will review the DEM products in detail to ensure no artifacts or classification errors are present. The review will ensure that all bare earth DEM products meet the USGS v1.3 guidelines and are suitable for ingestion into the NED.

	1. DEM will be created with a grid spacing of 2.5 feet 2. 32-bit floating point raster format in ERDAS .img 3. All files must have the correct Georeferencing 4. Tiles shall not have any edge artifacts or mismatches. 5. Void areas will be coded as NoDATA 6. Depressions and Sinks are not to be filled
Intensity Imagery	Dewberry will review the intensity imagery to ensure it matches the project tile scheme are created from the first return Lidar. 1. File format will be GeoTIFF format 2. Image shall be 8-bit, 256 color gray scale 3. Images shall be tiled to match the Classified LAS and DEM files
Breaklines	Breakline GDB containing all required feature classes and each feature class attributed correctly
Extents	The 'shapefile' deliverable folder should have all shapefiles listed below and the shapefiles should be in the correct Coordinate Reference System: a. Delivery diagram shapefile (shapefile of all delivery blocks for full AOI) b. Full boundary c. Full tile grid d. County tile grid e. County LAS extents.
Flight Line Index	Swath polys must show exact coverage and extents of each swath. At a minimum, the attribute table must contain the flight line ID, mission
Product metadata	FGDC compliant, XML format should align with the template provided by USGS. a. Classified point data b. Bare-earth DEM c. Breaklines d. Intensity Imagery
Collection Report	Detailing the acquisition and flight logs.
Survey Data	a. Survey report detailing all ground control used in the acquisition and processing of the Lidar including control points used to calibrate and process the Lidar and checkpoints used to validate the accuracy of the Lidar b. Excel spreadsheet of control points and checkpoints with fields listing point ID, easting, northing, and orthometric height c. Photos of control points and checkpoints d. Control point shapefile and checkpoint shapefile with fields listing point ID, easting, northing, and orthometric height
Processing Report	Detailing calibration, classification, and product generation procedures including those used for breakline and DEM production.
Accuracy assessment	Accuracy assessment report for the final Lidar deliverable. The minimum number of checkpoints required for this project is 583 NVA (Non-Vegetated) and 397 VVA (Vegetated) points.

Acquisition Parameters

Table 3 outlines the acquisition parameters that are required to be met under the scope of work. The validation approach provides details on how Dewberry will perform the independent validation of the requirements.

Table 3 - Acquisition Parameters for to be validated during the independent Quality Assurance

Parameter	Requirement	Validation Approach
Nominal Pulse Spacing	Nominal Pulse Spacing (NPS) shall be no greater than 0.35 meters (QL1); assessment to be made against single swath, first return data located within the geometrically usable center portion (typically ~90%) of each swath.	Dewberry will calculate the NPS of each swath using a proprietary tool. The output of the script will be recorded and documented in the project report. The values will be reported as the NPS for single swaths and an ANPS for the final classified LAS in tile format.

Signal Returns	The laser system shall be configured to collect multiple echoes per pulse, with a minimum of a first return and a last return and at least one additional intermediate return. All returns captured during acquisition shall be delivered. Return number shall be recorded.	Dewberry will validate that system returns have been captured through the use of a custom python script that verifies the header information stored in the LAS file. The results of this validation will be documented in our project report.
GPS Times	Shall be recorded as Adjusted GPS Time, at a precision sufficient to allow unique timestamps for each return. Adjusted GPS Time is defined to be Standard (or satellite) GPS time minus $1*10^9$. See the LAS Specification for more detail	Dewberry will validate that adjusted GPS time as been recorded by running a custom python script that validates the header information. For this validation we will verify the GPS time as well as the global encoder bit which must be set properly for other software to recognize the time as adjusted GPS time.
Signal Strength	The signal strength (intensity) of each return pulse shall be recorded.	Dewberry will validate that the intensity of each pulse has been recorded properly through the use of an automated script. The results of this script will be documented in the project report.
Spatial Distribution	The spatial distribution of geometrically usable points is expected to be uniform and free from clustering. In order to ensure uniform densities throughout the data set: (a) A regular grid, with cell size equal to the design 2*NPS will be laid over the data, (b) At least 90% of the cells in the grid shall contain at least 1 Lidar point.(c) Clustering will be tested against the 1st return only data of points located in the geometrically usable center part (typically 95%) of each swath.(d) Acceptable data voids identified elsewhere in this task order are excluded.	Dewberry will validate the spatial distribution of the points using a QT modeler script that divides the swath into a grid that is 2* the NPS (0.7 meters) and calculates the number of Lidar returns in each cell. This creates a raster with the point counts for each cell as well as a value for the percentage of cells with at least one point. The graphical output along with the percentage will be documented in the project report.
Overlap	Flight line overlap is at the contractor's discretion, but is cautioned to be vigorous to ensure there are no data gaps between the usable portions of the swaths and to ensure the nominal pulse density (NPD) can be achieved. Collections in high relief terrain are expected to require greater overlap. Any data with gaps between the geometrically usable portions of the swaths will be rejected.	Dewberry will validate the overlap of the swath data to ensure sufficient coverage with no voids between swaths. This will be completed using GeoCue and TerraScan software. The output of the review will be included in the project report.
Data Voids	Data Voids [areas => $4(NPS^2)$, measured using 1^{st}-returns only] within a single swath are not acceptable, except: (a) where caused by water bodies. (b) Where caused by areas of low near infra-red (NIR) reflectivity such as asphalt or composition roofing. (c) where appropriately filled-in by another swath	Dewberry will validate the overlap of the swath data to ensure sufficient coverage with no voids between swaths. This will be completed using GeoCue and TerraScan software. The output of the review will be included in the project report.

Ground Conditions	Snow free; No unusual flooding or inundation, except in cases where the goal of the collection is to map the inundation. Data shall be acquired to minimize the effects of variable water elevations within the project area. Contractor shall seek approval to acquire Lidar data prior to 72 hours following a rain event of 0.5 inches or greater within the project area. Lidar data shall not be acquired during high water events and/or recent rain events which may affect the resultant digital elevation model. If weather conditions and/or hydrologic conditions do not meet specified requirements, Contractor must receive customer approval before flying. All approvals shall be vetted through official correspondence or email and shall include the USGS contracting point of contact.	Dewberry will verify that ground conditions were suitable and will validate the weather as it existed during collection.
Vegetation Requirements	Leaf-off is preferred, however as numerous factors will affect vegetative condition at the time of any collection, the USGS National Geospatial Program (NGP) only requires that penetration to the ground must be adequate to produce an accurate and reliable bare-earth surface suitable for incorporation into the 1/9 (3-meter) NED	Dewberry will verify that the vegetation conditions were accepted based on the project plan and report submitted by the acquisition partners.
Tidal	Tidally impacted waters within the AOI are to be acquired at or below NAVD88/ 0 feet. It is possible that some tide windows will be too short for NAVD88/ 0 feet in some areas, especially in the northeast section of Florida. In those cases, predicted MLLW +/- 2 hours exclusive of neap, unless exempted from this requirement during technical negotiations. Tidal requirements shall be applicable to a distance of 1 mile off the coastal boundary for streams/rivers/inlets going inland. Tide coordination information from the state of Florida may be provided to the contractor. At minimum, it is recommended five (5) tide stations be monitored. (01) 8720030 – Fernandina Beach (02) 8721604 – Trident Pier (03) 8722670 – Lake Worth Pier (04) 8726384 – Port Manatee (05) 8727520 – Cedar Key (06) 8724580 - Key West (Optional) (07) 8725110 – Naples (Optional) (08) 8726724 - Clearwater Beach (Optional) (09) 8728690 - Apalachicola (Optional)	The acquisition partners will provide a Tide Chart in text or table format. Dewberry will review the tide chart and the times flown for tidally coordinated areas to confirm the swaths were acquired when the tidally impacted waters were at optimal low tide

Accuracy Assessment

Table 4 shows the accuracy requirements as stated in the scope of work. Dewberry will perform and independent validation of all accuracy requirements.

Table 4 - Accuracy Requirements for USGS Lidar		
Description	**Accuracy Requirement**	**Validation Approach**
Non-Vegetated Vertical Accuracy	≤10 cm RMSEz / ≤19.6cm at the 95% Confidence Level (Lidar/DEM)	The validation will be performed using TerraScan/TerraModeler for the Lidar validations and ArcGIS for the DEM validations. This will enable our analysts to quickly determine the differences between the Lidar and checkpoints. The values are then input into a worksheet designed by Dewberry to quickly calculate all of the accuracy statistics. This validation will occur at: 1. At the completion of the project on the final classified Lidar tiles and the DEM products. These results will be reported in the final project report along with other descriptive statistics.
Vegetated Vertical Accuracy	≤30 cm at the 95th Percentile (Lidar/DEM)	The validation will be performed using TerraScan/TerraModeler for the Lidar validations and ArcGIS for the DEM validations. This will enable our analysts to quickly determine the differences between the Lidar and checkpoints. The values are then input into a worksheet designed by Dewberry to quickly calculate all of the accuracy statistics. This validation will occur at: 1. At the completion of the pilot any points falling within the area will be calculated. These values will be reported in the pilot deliverables. 2. At the completion of the project on the final classified Lidar tiles and the DEM products. These results will be reported in the final project report along with other descriptive statistics.
Relative Accuracy (between swaths)	≤8 cm RMSE	Dewberry has designed a process to validate the relative accuracy between swaths that provides both a graphical representation of the relative accuracy in the form of DZ orthos as well as an actual RMSE value. The DZ orthos are generated in GeoCue and allows our analysts to quickly review 100% of the overlapping areas for anomalies in the relative accuracy. Once this is completed we run the Lidar through a series of automated processes which are designed to identify areas that are free from vegetation and with minimal slope. These areas are then extracted and the difference values are exported for each cell. The final values are then processed in excel to determine the RMSE. The relative accuracy will be reported to USGS in the final report.
Relative Accuracy (within a single swath)	≤6 cm RMSE	Dewberry has designed a process to validate the relative accuracy within swaths that provides both a graphical representation of the relative accuracy in the form of a difference raster as well as an actual RMSE value. The difference raster is generated in QT Modeler allows our analysts to quickly review 100% of the Lidar swaths for anomalies in the relative accuracy within the swath. Once this is completed we run the Lidar through a series of automated processes which are designed to identify areas that are free from vegetation and with minimal slope. These areas are then extracted and the difference values are exported for each cell. The final values are then processed in excel to determine the RMSE. The relative accuracy within a swath will be reported to USGS in the final report.

Lidar Qualitative Assessment

Dewberry will review the Lidar to meet the task order requirements based on the USGS/NGP Lidar Base Specification v1.3 and the requirements outlined in the SOW. The Lidar data shall initially undergo an initial review at 1:2,400 to verify any major anomalies or issues with the classification. Table 5 outlines the project requirements along with a brief overview of our approach to validating compliance.

Table 5 - Lidar Processing Requirements for USGS Lidar	
Requirement	**Validation Approach**
LAS Version 1.4	Dewberry will perform an evaluation of all LAS deliverables to ensure they are fully compliant with LAS v1.4 requirements. This is conducted using a custom python script that validates all LAS headers and records.

Table 5 - Lidar Processing Requirements for USGS Lidar	
Requirement	**Validation Approach**
Point Record Format 6-10	Dewberry will perform an evaluation of all LAS deliverables to ensure the correct point record format has been set. This is conducted using a custom python script that validates all LAS headers and records.
Overlap (Overage) Bit/Withheld Bit	Dewberry will perform an evaluation of all LAS deliverables to ensure the correct bits have been set. This is conducted using a custom python script that validates all LAS headers and records. Additional verification will come from a visual review of the point cloud data to ensure that points with this bit set are displaying properly in TerraScan, LP360, and ArcGIS software.
Georeferencing Information in OGC WKT Format	Dewberry will verify the header information of all LAS files to ensure they are fully compliant with the WKT requirement in LAS v1.4. Dewberry will verify that the correct projection has been set.
Adjusted GPS Time (correct global encoder bit)	Dewberry will perform an evaluation of all LAS deliverables to ensure the correct GPS time has been set along with the correct global encoder bit. This is conducted using a custom python script that validates all LAS headers and records. An additional validation step will be to convert the adjusted GPS time to Julian dates to ensure it aligns with the project.
Full Swaths	All swaths will be loaded into GeoCue and their extents will be reviewed to ensure full coverage of the project area.
Raw Point Cloud Data Classification (Class 0 - Withheld bit and overlap bit assigned)	Dewberry will perform an evaluation of all LAS deliverables to ensure they are fully compliant with LAS v1.4 requirements. This is conducted using a custom python script that validates all LAS headers and records.
Classified Point Cloud Data Classification (Class 1, 2, 7, 9, 10, 17, 18 - Withheld bit and Overlap bit assigned)	The classified LAS will undergo a full compliance validation at a macro level (1:10,000) and micro level only where issues in the DEM or macro review have been identified. This will validate that all files are classified accurately and consistently with the USGS requirements. An overview of the review along with the final results will be provided in the final project report.

Dewberry Specified Pilot Area

A pilot shall be completed by each production partner for an area Dewberry specifies. The pilot delivery should include classified LAS, breaklines, and hydro-flattened DEMs. The pilot delivery is to ensure the data is seamless between counties and delivery blocks and that the data is being produced to meet client expectations.

Difference Rasters

Dewberry will provide project wide difference grids (deltaZ plots) of data for the two Florida Peninsular task orders as well as previous USGS and SWFWMD task orders to ensure correct data calibration. The task orders include the counties of Hillsborough, Pasco, Palm Beach, Levy, Collier, Everglades, and Florida Southeast. The different grids will be floating points rasters. The vertical difference along a tie-edge will not exceed the Non-Vegetated Vertical Accuracy (NVA) in consolidated terrains or the Vegetated. If offsets greater than the 10 cm the FL Peninsular data might be shifted to minimize the offset between current and previous datasets. The elevation of accepted data from previous task orders shall not be adjusted.

Hydro-flattening and Breakline Assessment

Dewberry will provide an attributed breakline GDB template to the production partners. The Breakline GDB includes all required feature classes and the fields in the attribute table that will need to be filled prior to delivery. Dewberry will review the breaklines required for hydro-flattening using manual and semi-automated approaches where applicable. Breaklines will undergo an automated review process to verify the following items:

- Completeness – Visual review against intensity imagery and Lidar surface to ensure all features have been collected based on the requirements.
- Data Reviewer Checks- A series of automated checks used to ensure the data meets the defined level of quality
- Monotonicity – Automated process to ensure all streams are consistently collected with elevations progressing in a downhill fashion from the start of the feature to the end.
- Connectivity – Automated process to validate that any intersections between hydrographic features have a consistent X, Y, and Z.
- Vertical Variance – Semi-Automated process that compares the breakline vertex elevations to the surrounding Lidar surface. This process ensures that all breaklines are at or below the surrounding terrain with no excessive digging or floating.

Table 6 outlines the breaklines that will be compiled for this project:

Table 6 - Hydrographic & Breakline Requirements

Feature	Collected	Capture Rules and Validation
WATERBODY	Yes	Water bodies greater than 2 acres shall be captured as closed polygons with the water feature to the right. The compiler shall take care to ensure that the z-value remains consistent for all vertices placed on the water body. Breaklines must be 0.10 foot below the elevations of the immediately surrounding terrain. Under no circumstances should a feature be elevated above the surrounding Lidar points. Acceptable variance in the negative direction will be defined for each project individually. An Island within a Closed Water Body Feature that is 1 acre in size or greater will also have a "donut polygon" compiled. This includes rocky outcroppings. These instructions are only for docks or piers that follow the coastline or water's edge, not for docks or piers that extend perpendicular from the land into the water. If it can be reasonably determined where the edge of water most probably falls, beneath the dock or pier, then the edge of water will be collected at the elevation of the water where it can be directly measured. If there is a clearly-indicated headwall or bulkhead adjacent to the dock or pier and it is evident that the waterline is most probably adjacent to the headwall or bulkhead, then the water line will follow the headwall or bulkhead at the elevation of the water where it can be directly measured. If there is no clear indication of the location of the water's edge beneath the dock or pier, then the edge of water will follow the outer edge of the dock or pier as it is adjacent to the water, at the measured elevation of the water.
HYDROGRAPHICFEATURE Dual Line Drains	Yes	The HYDROGRAPHICFEATURE feature class will contain the wet- drain features drains and single line drains as polylines. Dual line drain features should be captured showing dual line (one on each side of the feature). Average width shall be greater than 8 feet to show as a double line. Each vertex placed should maintain vertical integrity. Generally both banks shall be collected to show consistent downhill flow. There are exceptions to this rule where a small branch or offshoot of the stream or river is present. The banks of the stream must be captured at the same elevation to ensure flatness of the water feature.

		Breaklines must be 0.10 foot below the elevations of the immediately surrounding terrain. Under no circumstances should a feature be elevated above the surrounding Lidar points. Acceptable variance in the negative direction will be defined for each project individually. These instructions are only for docks or piers that follow the coastline or water's edge, not for docks or piers that extend perpendicular from the land into the water. If it can be reasonably determined where the edge of water most probably falls, beneath the dock or pier, then the edge of water will be collected at the elevation of the water where it can be directly measured. If there is a clearly-indicated headwall or bulkhead adjacent to the dock or pier and it is evident that the waterline is most probably adjacent to the headwall or bulkhead, then the water line will follow the headwall or bulkhead at the elevation of the water where it can be directly measured. If there is no clear indication of the location of the water's edge beneath the dock or pier, then the edge of water will follow the outer edge of the dock or pier as it is adjacent to the water, at the measured elevation of the water. Every effort should be made to avoid breaking a stream or river into segments. Dual line features shall break at road crossings (culverts). In areas where a bridge is present the dual line feature shall continue through the bridge. An Island within a Closed Water Body Feature that is 1 acre in size or greater will also have a "donut polygon" compiled. This includes rocky outcroppings unless otherwise agreed upon between CRCOG/Sanborn.
HYDROGRAPHICFEATURE Single Line Drains	Yes	The HYDROGRAPHICFEATURE feature class will contain the dual line drains and single line drains as polylines. Single line drain features should be captured showing single line in the center of the feature. Average width shall be less than 8 feet and greater than 0.5 miles in length for single line drains. Single line drains should only be collected when the drain is apparent in the Lidar data (i.e the drain contains water). Single line drains should not be collected when the drain is obscured by vegetation and the Lidar does not penetrate. However, when the bottom or banks are obscured for more than 50 linear feet preventing laser points from penetrating to the ground, a soft feature breakline will be collected at the best interpretation of the compiler. (see SoftFeature section). For dry "U" or "V" shaped drains, when the laser points adequately define the shape of the drain, no breaklines are required. However, when the laser points do not define the shape, or in areas obscured by vegetation, the centerline, at minimum should be collected by the best estimate of the compiler. These instructions are only for docks or piers that follow the coastline or water's edge, not for docks or piers that extend perpendicular from the land into the water. If it can be reasonably determined where the edge of water most probably falls, beneath the dock or pier, then the edge of water will be collected at the elevation of the water where it can be directly measured. If there is a clearly-indicated headwall or bulkhead adjacent to the dock or pier and it is evident that the waterline is most probably adjacent to the headwall or bulkhead, then the water line will follow the headwall or bulkhead at the elevation of the water where it can be directly measured. If there is no clear indication of the location of the water's edge beneath the dock or pier, then the edge of water will follow the outer edge of the dock or pier as it is adjacent to the water, at the measured elevation of the water. Every effort should be made to avoid breaking a stream or river into segments.

		Dry- drain features shall break at road crossings (culverts). In areas where a bridge is present the dual line feature shall continue through the bridge. An Island within a Closed Water Body Feature that is 1 acre in size or greater will also have a "donut polygon" compiled. This includes rocky outcroppings.
COASTALFEATURE	Yes	Within each COASTALFEATURE, the water surface shall be flat and level for each different water-surface elevation. Discontinuities in the collection and elevation of the shoreline will be based on the individual flight lines and will be minimized as much as possible. Vertical discontinuities within a water body resulting from tidal variations during the collection are considered normal and shall be retained in the final DEM. Horizontal discontinuities along the shoreline of a water body resulting from tidal variations during the collection are considered normal and shall be retained in the final DEM. Long tidal water bodies that also exhibit downhill flow (such as a fjord) can present unusual challenges; data producers are to exercise their best professional judgment in determining the appropriate approach solution to meet the overall goal of hydro-flattening as described in this section. For projects located in coastal areas, cooperating partners may impose additional requirements for tidal coordination. An Island within a Closed Water Body Feature that is 1 acre in size or greater will also have a "donut polygon" compiled. This includes rocky outcroppings
BRIDGESADDLEBREAKLINES	Yes	In areas where the DEM produces a saddle under the bridge additional breaklines shall be collected to support the generation of the DEM. These breaklines shall be placed perpendicular to the bridge at the top and bottom of the embankment (at minimum). Vertices are to be placed in areas where the density of the ground points is sufficient to model the surface. One vertex should be placed on either side of the bridge and the elevations derived from the Lidar surface.
ISLAND	Yes	Permanent islands that are greater than 1 acre in area will be collected on all hydrographic features. Island elevations will be set 0.1' above the surrounding water elevations.
CONNECTOR	Yes	A CONNECTOR will be collected where a hydrographic feature is collected on either side of the road. The connector must snap to the adjoining hydrological features.
SOFTFEATURE	Yes	SOFTFEATURE breakline contains a domain for linear hydrographic features and roads. This feature class is intended to be used for those areas in which gaps of 50 feet or greater in the laser point distribution do not permit identify these features and do not support the terrain. Breaklines in this feature class are at the discretion and best interpretation of the compiler. These are to be three-dimension breaklines of varying elevation or a single elevation as best determined by the compiler, the Lidar surface, or a combination of both.
HYDROGRAPHIC_DLD	Yes	USGS request. Polygon feature class that is identical to the dual line hydrographic feature class.

Tidal Collection

Regions that are subject to tidal fluctuations will be flown so the data will display minimal changes as much as possible. Breaklines will be collected at the land/water interface, following USGS guidelines. Due to the extensive coastline terrain in Florida, when needed, the breaklines will be broken when a significant elevation change is evident in the data.

Data Reviewer Checks

Prior to delivery to Dewberry a series of Data Reviewer checks should be run on all feature classes. Data Reviewer is an extension of ArcGIS. The automated checks will identify possible anomalies or issues within the breakline GDB that will need to be corrected.

- Perform “unnecessary polygon boundaries check” on all polygons feature classes. This Data Reviewer check returns border geometries for polygons that share a common boundary and identical attribution.
- Perform “find dangles check” on all line features. There must be a topology in the GDB with this feature class for the tool to work. This tool is found under “Polyline Checks.”
- Perform “duplicate geometry check” on all features. Data Reviewer check returns geometries from features in Feature Class 1 that are co-located with geometries in Feature Class 2. This tool is found under “Duplicate Geometry Checks.”
- Perform “geometry on geometry check”. This tool is found under “Feature on Feature Checks.” This Data Reviewer check returns relationship specific geometries for features in Feature Class 1 that have a user-defined relationship to features in Feature Class 2. This check should be performed using the spatial relationships: “Crosses”, “Contains”, “Overlap” and “Intersect”
- Perform “polygon overlap/gap is sliver check”. Maximum Polygon Area is not required. This tool is found under “Feature on Feature Checks.”
- Perform "multipart line check." This tool is found under “Default Checks.” This tool will identify multipart features and is used on line features.
- If the feature class is 3d, meaning it has elevation, and each feature should be at a single elevation, perform “adjacent vertex elevation change check." Elevation Difference Tolerance=.001 feet/meter. This check will return features whose vertices are not all identical. This tool is found under “Z Value Checks.”
- If the feature class is 3d, meaning it has elevation, perform “different Z-Value at intersection check.” Elevation Difference Tolerance= .01 feet/meter Minimum, 600 feet/meter Maximum, Touches). This tool is found under “Z Value Checks.” Please note that polygon feature classes will need to be converted to lines for this check.
- Perform “evaluate z-values check.” Operation is less than or equal to 0.001 feet/meters. This tool checks for features that do not have the correct elevation applied are at the default of 0 ft in elevation.

Breakline Feature Class Attribution

Each feature class in the breakline GDB should be attributed accordingly

1. HYDROGRAPHICFEATURE
    - DATESTAMP_DT- Date the data was delivered in MM/DD/YYYY format
    - HYDROTYPE- Single line drains should be attributed as Centerline of Conveyance, dual line drains should be attributed as Toe of Slope
    - Shape_Length- Length in feet
2. SOFTFEATURE
    - DATESTAMP_DT- Date the data was delivered in MM/DD/YYYY format
    - dSOFTTYPE- The statement “Softfeature defining spillway, weir, or dam” should be attributed for each soft feature
    - Shape_Length- Length in feet
3. ISLANDS
    - DATESTAMP_DT- Date the data was delivered in MM/DD/YYYY format
    - Shape_Length- Length in feet
4. CONNECTOR
    - Shape_Length- Length in feet
5. WATERBODY
    - WATERBODY_ELEVATION_MS-Elevation of the waterbody
    - DATESTAMP_DT- Date the data was delivered in MM/DD/YYYY format
    - Shape_Length- Length in feet
    - Shape_Area- Area in acres

6. COASTALFEATURE
    - DATESTAMP_DT- Date the data was delivered in MM/DD/YYYY format
    - Shape_Length- Length in feet
    - Shape_Area- Area in acres
7. HYDROGRAPHICFEATURE_DLD (polygon dual line drains)
    - Shape_Length- Length in feet
    - Shape_Area

Task Order Edge Matching Review

All counties within the project must seamlessly edge-match or butt match. The counties will be reviewed for any discontinuities, including but not limited to inconsistency in the modeling of ground features, noticeable texture or grounding differences between blocks, hard edges or seamlines along block boundaries, disconnects in breaklined features-either horizontal placement issues or vertical/elevation discrepancies, etc. Any discontinuities or inconsistencies will be marked for corrections. Dewberry will provide neighboring data when possible to ensure the data butt matches.

Temporal Differences

Monotonicity should be enforced if temporal differences are present in hydro features. This may causes areas to be excessively digging in the bare earth DEM. Large temporal differences that cause breaklines to be buried should be outlined in a shapefile and provided to Dewberry for delivery to the end clients. If the data producer is concerned about an individual feature please reach out to the Dewberry team for verification of the approach on that feature to ensure consistency.

Conflating Waterbodies

After waterbodies are conflated a two foot buffer around the waterbodies should be used to determine if any ground points within the buffer are lower than the assigned elevation of the waterbody to reduce the chance of sinks around waterbodies which would negatively impact the bare earth DEM. If any ground points are lower than the waterbody elevation within the two foot buffer, the waterbody's elevation should be adjusted to be 0.1 foot lower than the lowest elevation in the buffer zone.

Vertical Variance Evaluation

Vertical variance is the process Dewberry uses to compare final breakline elevation to the surrounding lidar elevations in order to review the breakline elevations for incorrect horizontal placement (which typically manifests as excessive digging in the vertical variance results) or incorrect vertical elevations (which could be digging or floating). Dewberry uses the term excessive because the actual threshold of acceptable vs. not acceptable is very dependent on environmental factors and characteristics of the dataset, including but not limited to where the breakline is located, what feature is represented by the breakline (vertical structures such as dams will often show high vertical variance results), how well the lidar is modeling the feature, water levels at the time of acquisition, varying water levels in other portions of the AOI (affects downstream flow and monotonicity), and land cover of the area in question (vegetated banks will result in more interpolation in the lidar and often lead to high vertical variance results). Because so many environmental factors and dataset characteristics must be reviewed, Dewberry does not set a numeric threshold for digging. It should be noted that while some floating false positives may exist due to vertical structures, such as dams, the enforcement of monotonicity and water flatness does not normally result in floating features, so all floating vertices are reviewed, and a threshold is not necessary for floating.

Instead, Dewberry considers features to be excessively digging if they create anomalous sinks in the bare earth surface or if they create an erroneous build-up of contours. The minimum appropriate contour interval suitable for the dataset should be utilized (which would be 1 ft for FL Peninsular) and then a build-up of 4-5 stacked contours would be considered an erroneous build-up. Legitimately low features, such as quarries, would be excluded from the contour stack rule along with any features which are purposely buried when maintaining monotonicity or water flatness due to temporally different water levels present in different project swaths.

Examples of anomalous sinks and erroneous contour stacking are shown below. These are just examples of excessively digging to demonstrate the process and types of issues which would need to be corrected.

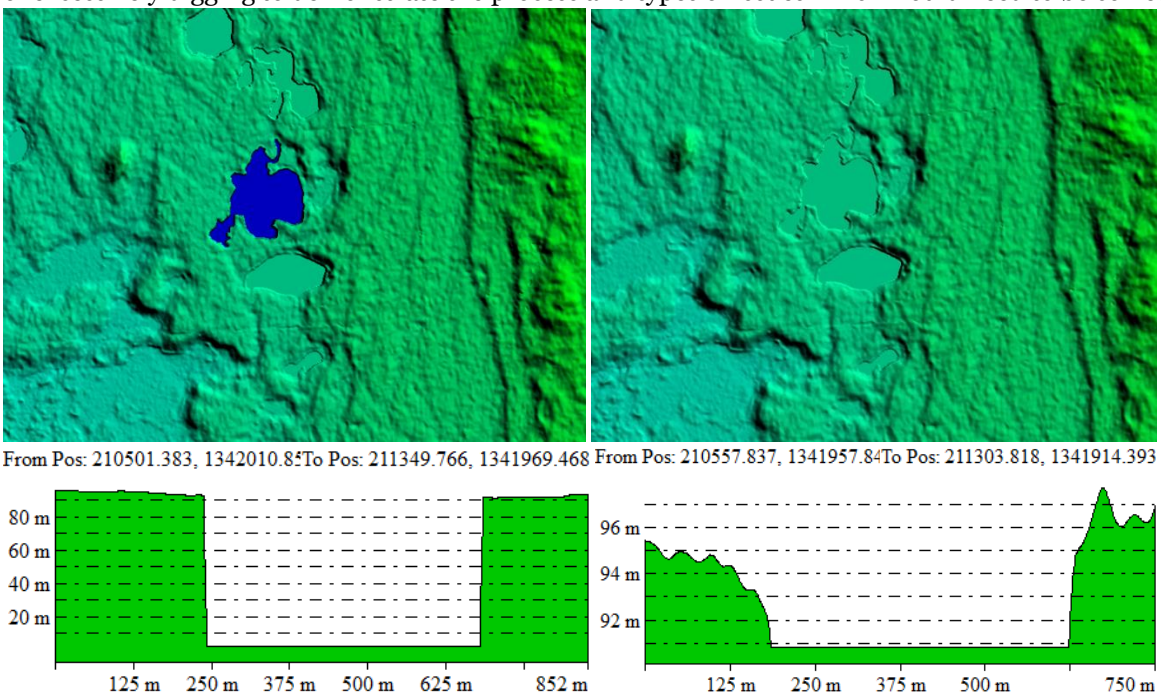

Figure 3-The DEM on the left shows a waterbody that is excessively digging because it has created an anomalous sink in the DEM. This feature is over 60 meters below the surrounding terrain and has extremely sheer sides, as shown in the accompanying profile. The DEM on the right is the same feature, after corrections. The corrected feature is only approximately 2 meters below the surrounding terrain and no longer has deep, sheer sides, shown in the accompanying profile. These screenshots are from QL5 data, where the minimum contour interval is 20 feet so 2 meters below the surrounding terrain is well within tolerance.

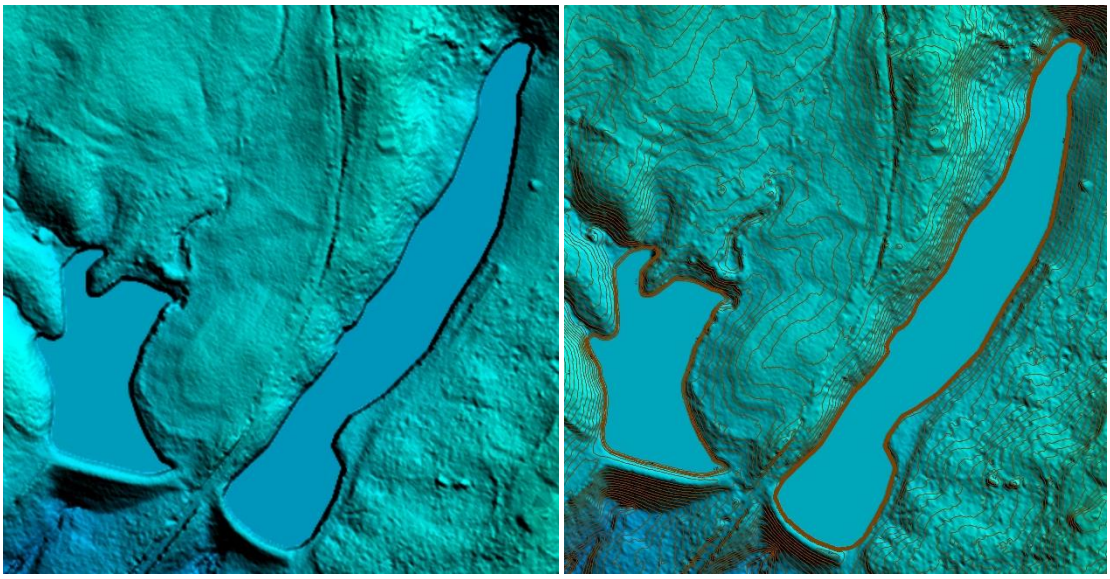

Figure 4- The left image shows two water body features in a hydro-flattened DEM. The right image shows the same features with 2-foot contours (brown) overlaid. The build-up of eight stacked contours around these features (the brown lines around the water body polygons) when the surrounding terrain is not that steep indicates that both features are excessively digging and the breakline elevations should be raised. Additionally, there is heavy shadowing in the hillshade around the shoreline of these features and the shorelines are rather sheer. Heavy shadowing in hillshades combined with sheer shorelines that seem unnatural can be further indicators that breaklines may be excessively digging.

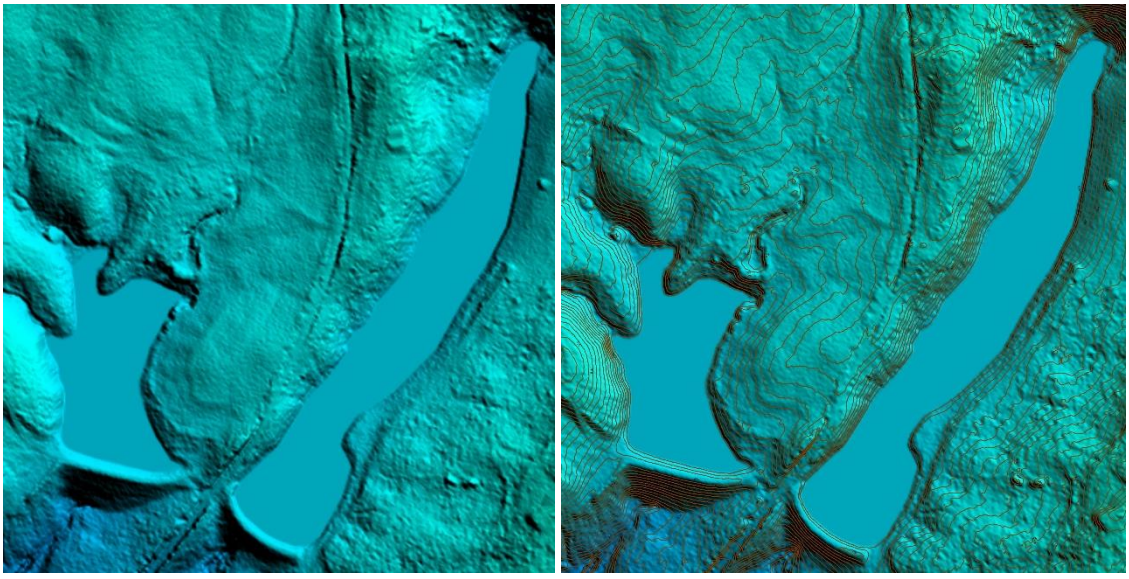

Figure 5- These images show the same features as Figure 2 after corrections have been applied. There is no longer a build-up of stacked contours around these features; only two contours represent each feature. Additionally, heavy shadowing and sheer or steep shorelines are no longer present in the hillshade or DEM.

Reporting and Metadata Assessment

The production partners should use the most recent metadata templates provided by USGS to complete the FL Peninsular metadata. Metadata will be delivered per county and one final set of metadata included in the final delivery. Dewberry will review all required reports and metadata delivered for the project to ensure compliance with the standards defined in the SOW. Table 7 provides an overview of the required products and review that will be conducted.

Table 7 - Additional Required Products

Product	Validation Methods
Metadata	Dewberry will validate metadata for all required deliverables. Some metadata is in the form of XML files while others are as reports or additional files. A breakdown of the deliverables that Dewberry will review is as follows: Product metadata (FGDC compliant, XML format metadata). One file for each (**XML Deliverable**): • Classified LAS • DEM • Intensity Imagery • Breakline

Classification Examples

Bridges vs Culverts

A culvert is defined as a tunnel carrying a stream or open drain under a road or railroad. Bridge features in coastal or tidal areas may have culvert characteristics. These features should be classified as bridges if the features are in coastal or tidal areas and not carrying a stream or drain. Breaklines should not break where bridges are located.

The images below show bridges with culvert characteristics in coastal south Florida.

Figure 6 – An example of a feature with culvert characteristics that should be classified as a bridge.

Figure 7 – An example of a feature with culvert characteristics that should be classified as a bridge

Vegetation

Dense areas of low-lying vegetation are prevalent throughout Florida. In these areas the lidar sense may not have been able to penetrate through the vegetation fully and the initial ground macro may classify some of the points within the low-lying vegetation to ground. To avoid having large areas of interpolation if the vegetation was fully removed from the ground a specific threshold that is yet to be decided will be used to determine what is to be considered as actual ground. Profiles should be drawn in these areas to determine if the vegetation classified as ground is greater than the specified threshold. Vegetation less than that threshold can remain in the ground unless causing obvious visual artifacts, like spikes.

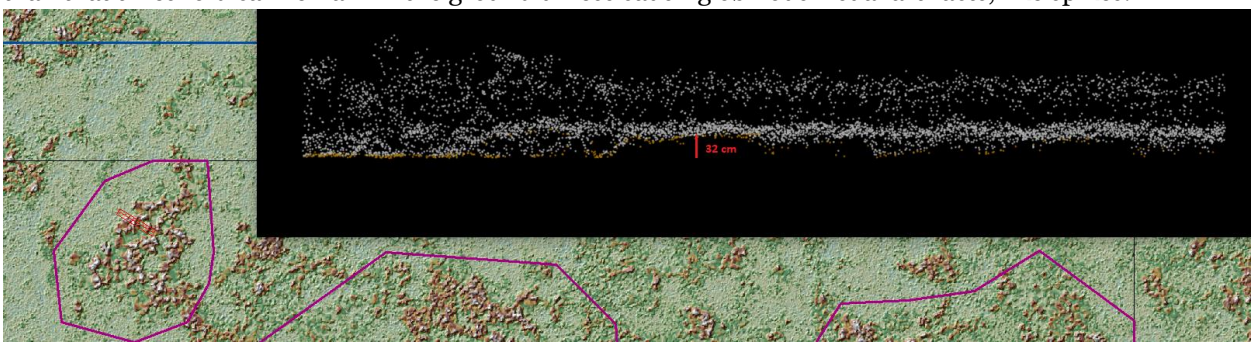

Figure 8- The image above shows a profile drawn in an area of dense vegetation. The vegetation was measured and determined to exceed the 30 cm threshold. This vegetation should be reclassified from Class 2- Ground (orange points) to Class 1- Unclassified (white points).

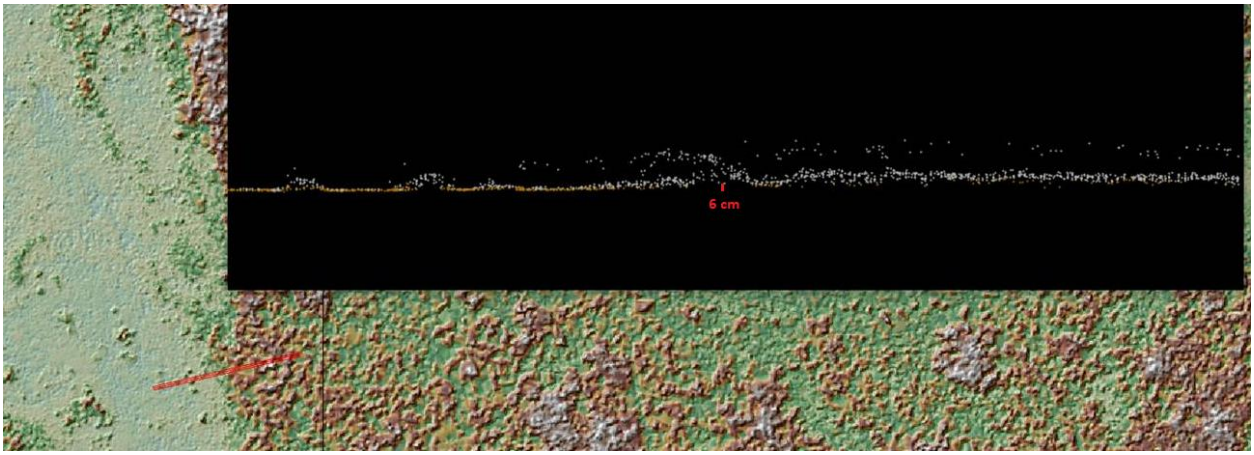

Figure 9- The image above shows a profile drawn in an area of dense vegetation. The vegetation was measured and determined to be below the 30 cm threshold. The low-lying vegetation can remain in the ground class to maintain DEM integrity.

Shrub Bogs

In areas of shrub bog the initial ground macro might not fully classify the actual ground surface causing large areas of interpolation caused from sparse ground. Profiles should be drawn in areas of interpolation in the DEM to determine whether there are Class 1 –Unclassified Points that can be classified to Class 2- Ground Points for the DEM to be fully modeled.

Figure 10-Aerial imagery of a shurb bog

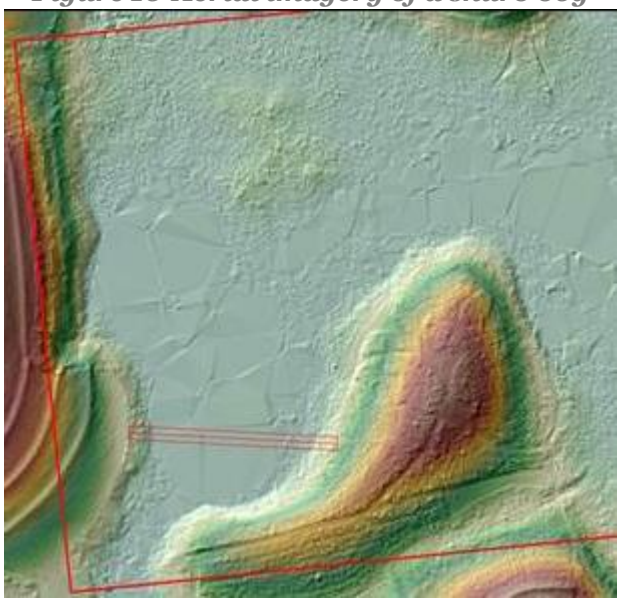

Figure 11-Area of interpolation in a bare earth DEM caused to sparse ground where a shrub bog is located.

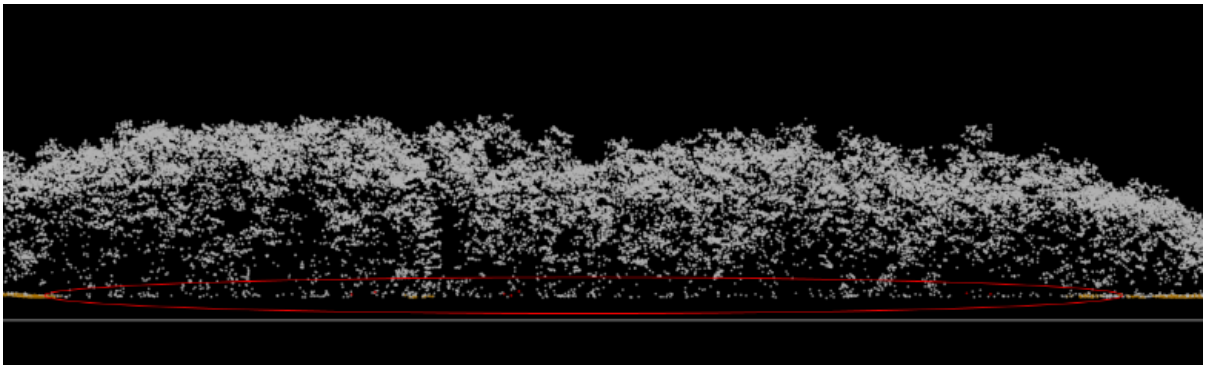

Figure 12-Profile drawn in the area of interpolation. Class 1- Unclassified (white points) can be reclassified to Class 2- Ground (orange points)

Building Classification

Dewberry has designed an automated process for the classification of buildings. This process searches for planar features that meet the criteria, so only tops of buildings are classified using class 6. Sides of buildings are not included in this classification, as they are often obscured in the point cloud. In the automated process some areas such as screened in pool enclosures may also be assigned the building classification if the density of points on the screen is sufficiently detailed. The automated building algorithm uses a threshold of 300 square feet so that any feature less than this area threshold will remain classified as class 1 (default). The building classification will be reviewed to ensure the building algorithm is working as expected. Modifications may be made to the algorithm to improve the automated process when necessary and if possible.

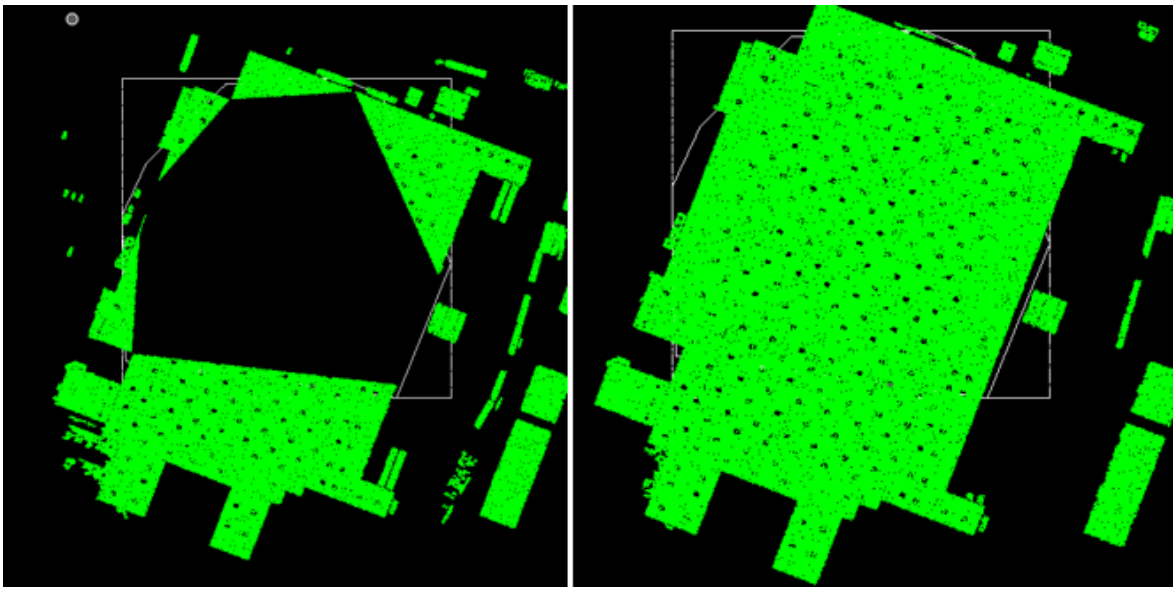

Figure 13-Class 6-Building points shown in green. This before/after picture shows how updates to the building classification macro have improved the accuracy of building classification.

Figure 14- Class 6-Building points shown in red. This before/after picture shows how updates to the building classification macro have improved the accuracy of classification by eliminating trucks from the automated classification.

Water Treatment Facilities

Water treatment facilities causing areas of uniformly depressed ground should not be included in the ground class.

Figure 15- The uniform depressions circled in the image above are located at a water treatment facility and should not remain in the ground class.

Figure 16- Aerial image of the water treatment facility

Collection Examples

Floating Aquatic Vegetation vs Emergent Vegetation

Best judgement should be used when determining whether vegetation in the water is considered floating aquatic vegetation or emergent vegetation. If the vegetation is determined to be floating aquatic vegetation the breakline collectors should include the floating aquatic vegetation in the breaklines as it is assumed there is water underneath. Emergent vegetation is more permanent and should be treated as if it were ground. If it is not possible to determine whether the vegetation is floating aquatic vegetation or rooted vegetation it is best to lean on the side of excluding the vegetation from the breaklines.

The images below show an example of floating aquatic vegetation which should be included in the breaklines.

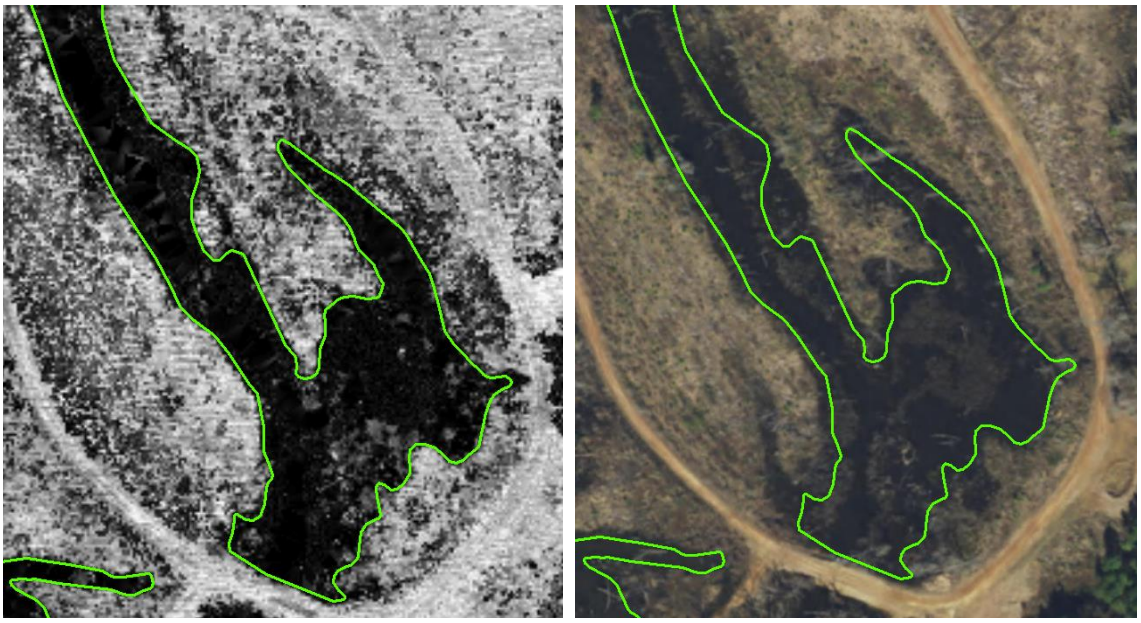

Figure 17- The image on the left shows Floating Aquatic Vegetation in the intensity imagery. The pond was included in the breaklines. The image on the right is what the Floating Aquatic Vegetation looks like in the Basemap imagery.

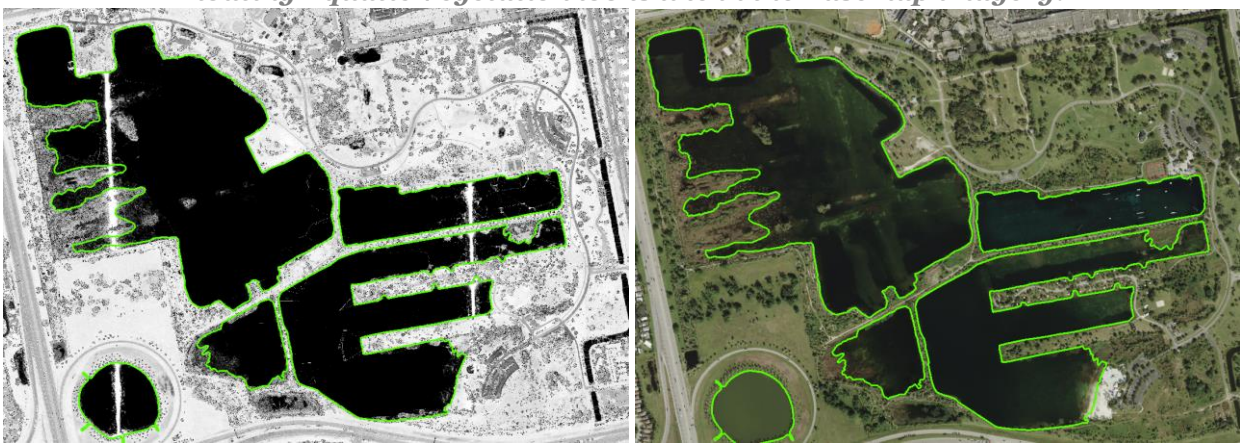

Figure 18- The image on the left shows Floating Aquatic Vegetation in the intensity imagery. The pond was included in the breaklines. The image on the right is what the Floating Aquatic Vegetation looks like in the Basemap imagery.

The images below show an example of emergent vegetation which should be included in the breaklines. The intent is to capture the waterbody as accurately as possible with these areas representing additional challenges to the standard collection.

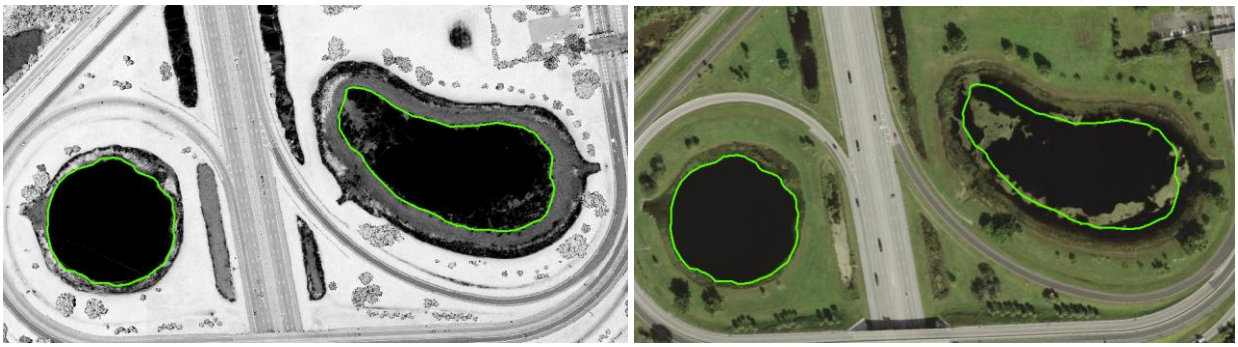

Figure 19- The image on the left shows emergent vegetation in the intensity imagery. The emergent vegetation was excluded from the breaklines. The image on the right is what the emergent vegetation looks like in the Basemap imagery.

Figure 20- The image on the left shows emergent vegetation in the intensity imagery. The emergent vegetation was excluded (incorrectly) from the breaklines. The image on the right is what the emergent vegetation looks like in the Basemap imagery.

Mining Areas

Hydro features located in active mining areas should not be collected as these features changes frequently. Inactive mines are considered permanent features and can be collected as a WATERBODY if the hydro feature is within spec. A shapefile will be provided of active and inactive mines. The shapefile should be included for each block delivery.

Figure 21- Example of an active mining area

SoftFeature Placement

SoftFeature breaklines are typically placed where dams and weirs are located in hydro features or areas in which gaps of 50 feet or greater are present in the lidar data. The lidar points cloud should be used to determine where to place SoftFeatures. Draw LAS profile along the feature to locate the top of the feature before the elevation drops to the bottom of the feature where the elevation becomes constant. The SoftFeature should be placed at the elevation drop at the top of the feature and another SoftFeature should be placed where the elevation becomes constant after the drop. The SoftFeatures must snap to the hydro feature it is within and the vertices' elevation for each SoftFeature needs to be constant.

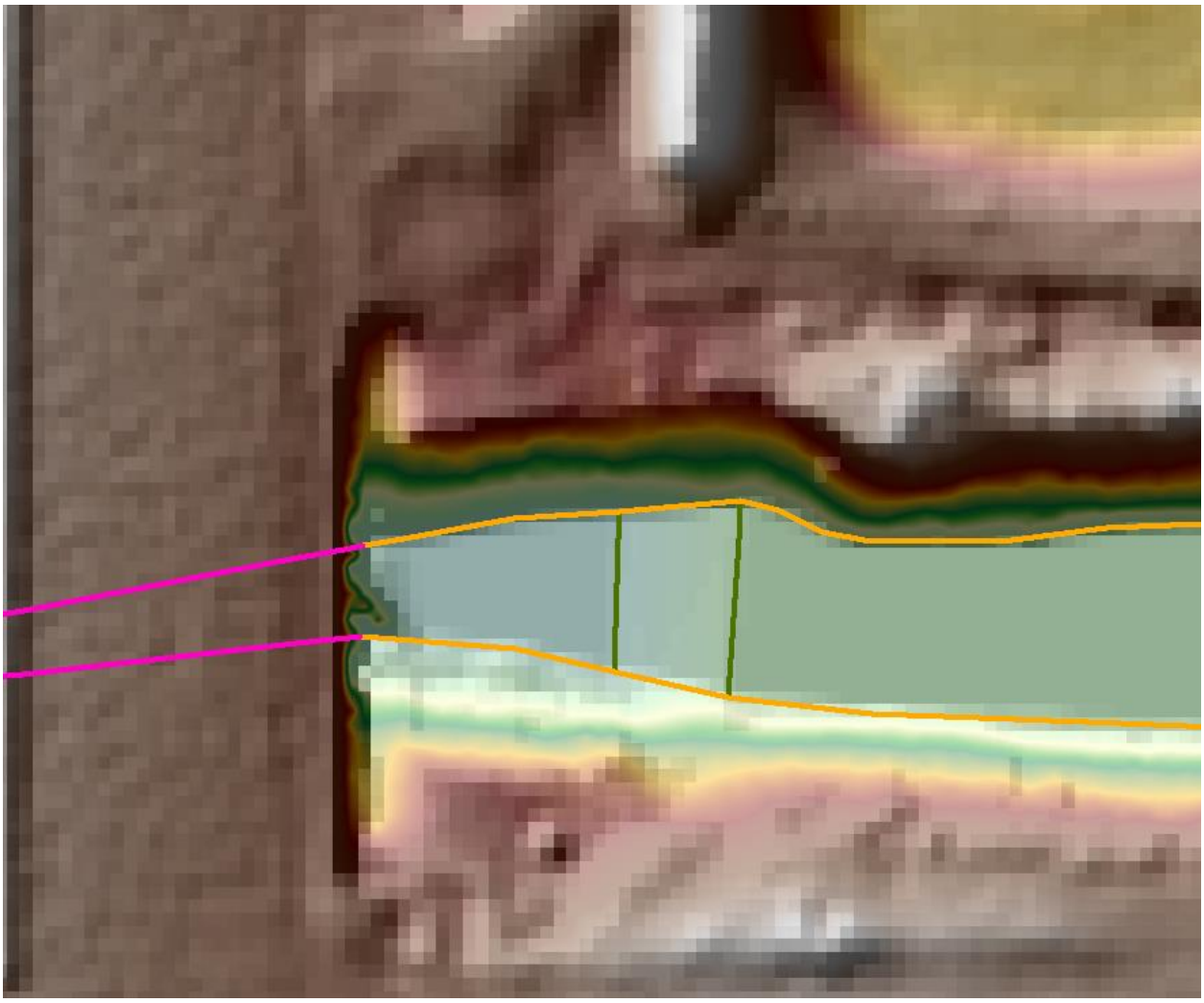

Figure 22- The image above shows the SoftFeatures (green) placed at the top and bottom of a weir and snap to the Dual Line Drain (yellow) overlaid on a bare earth DEM.

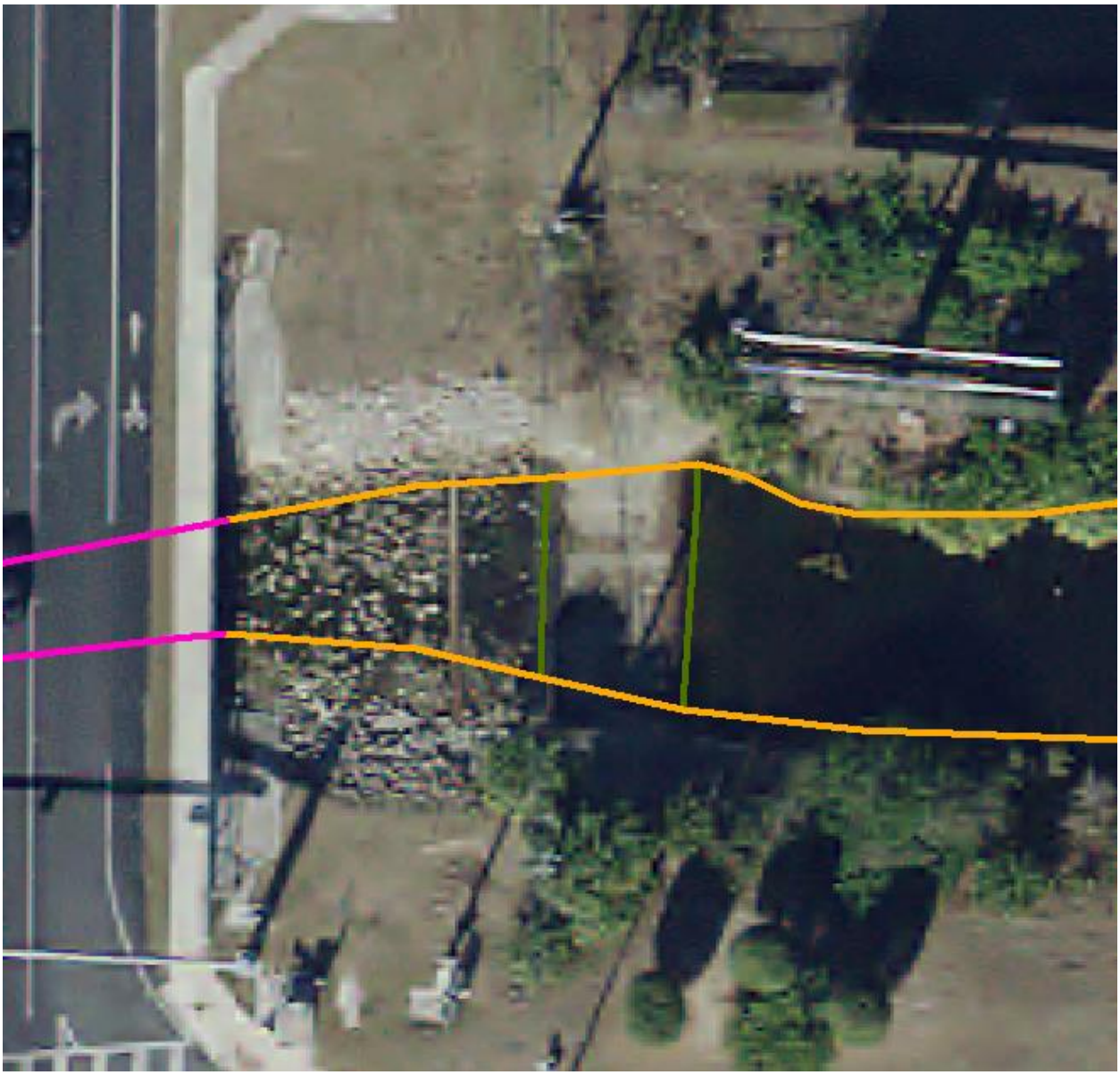

Figure 23- The image above shows the SoftFeatures (green) placed at the top and bottom of a weir and snap to the Dual Line Drain (yellow) overlaid on orthoimagery.

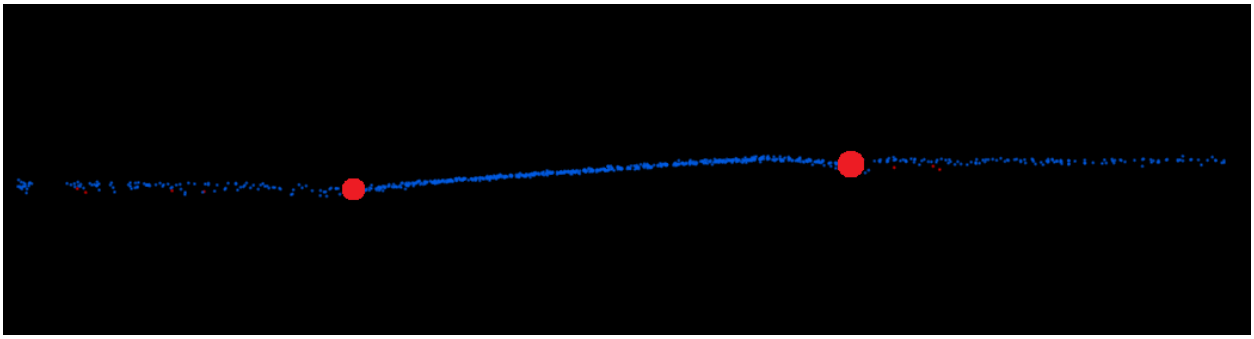

Figure 24- A profile was drawn along the weir to determine where to place the softFeatures. The red circles represent the top and bottom of the weir.

Connector Placement

Connectors should be placed across the culvert feature with the starting vertex and ending vertex snapping to the Hydrographic Feature or each side of the Waterbody or Coastal feature. The vertices should not be placed on the culvert or on interpolation causing raised elevation in the surface but rather on a flat surface.

Figure 25- The image above shows proper placement of a connector (pink) across a culvert. The connector snaps to each end of the single line drain (yellow).

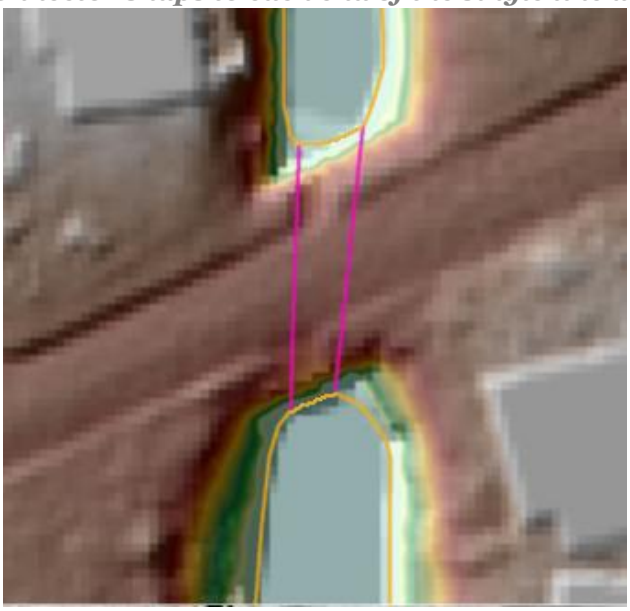

Figure 26- The image above shows proper placement of a connector (pink) across a culvert. The connector snaps to each end of the dual line line drain (yellow).

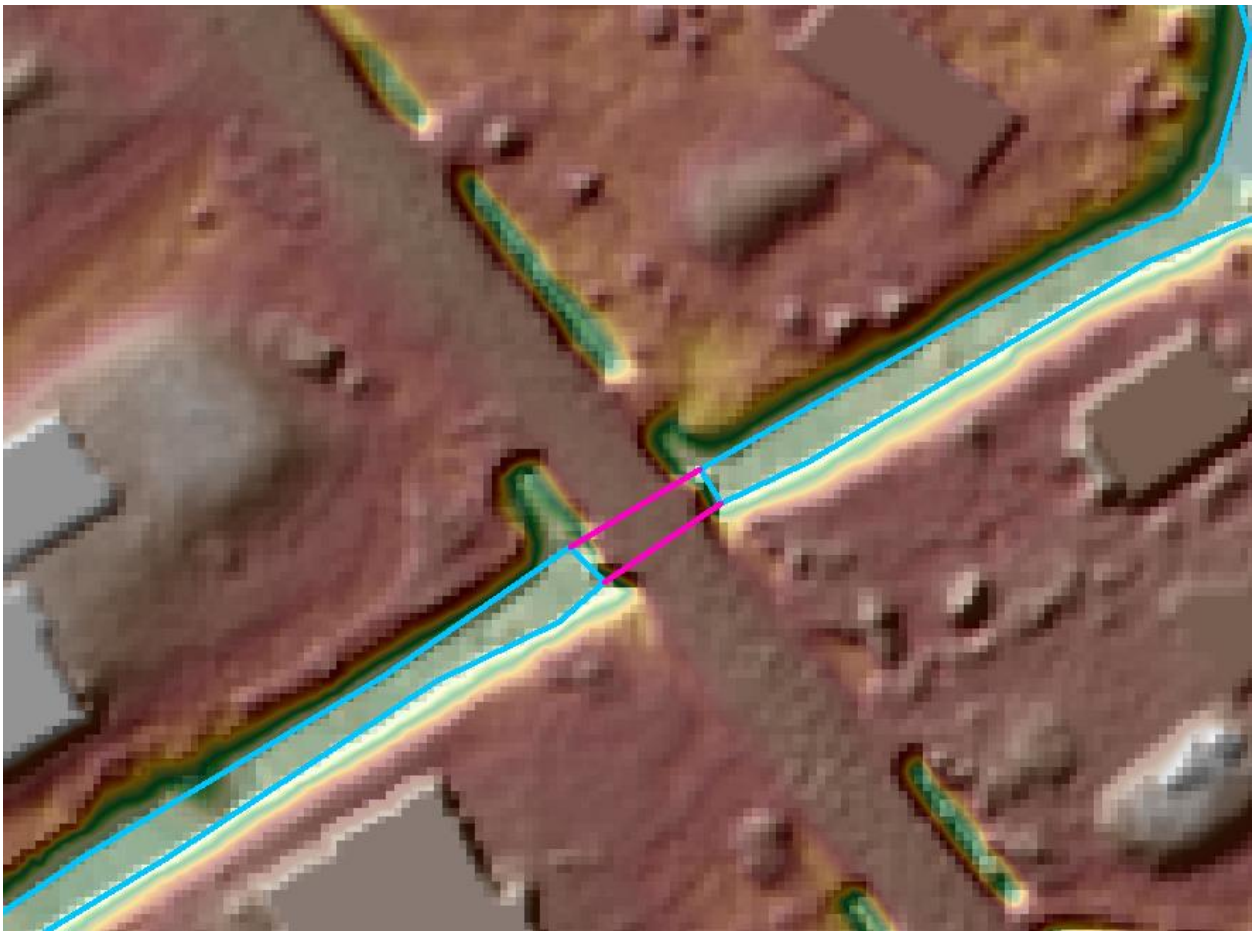

Figure 27- The image above shows proper placement of a connector (pink) across a culvert. The connector snaps to each end of the waterbody (blue).

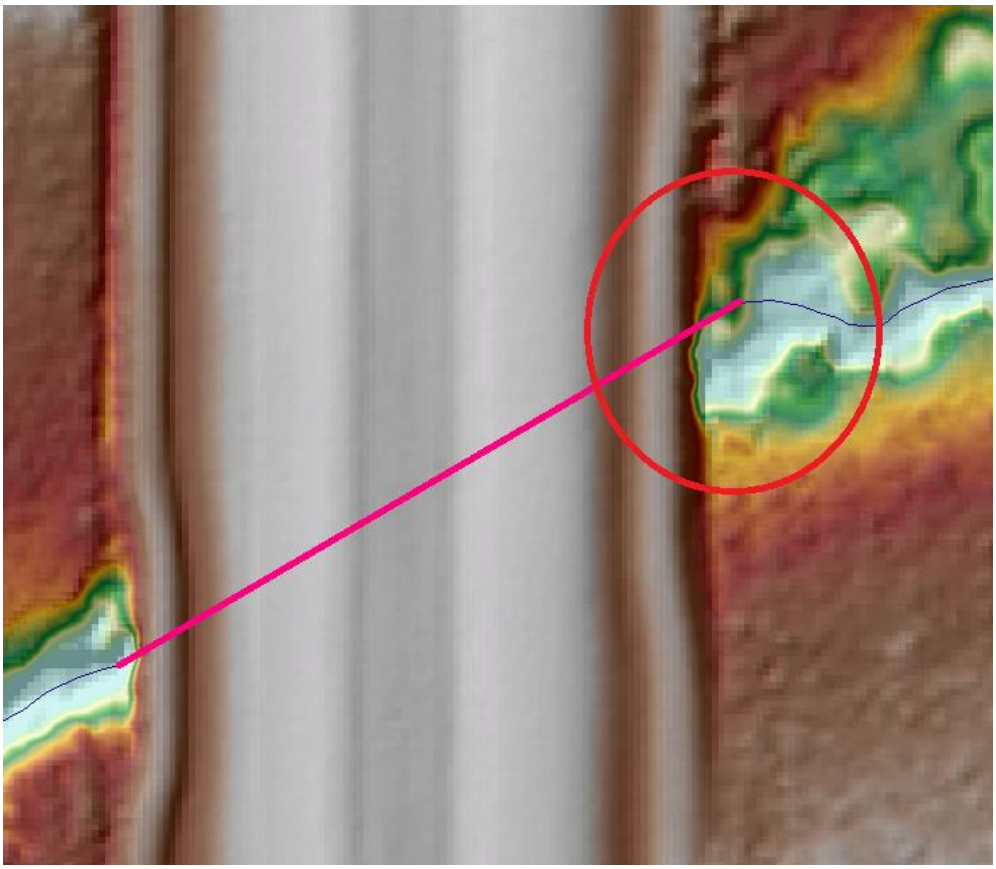

Figure 28- The image above shows incorrect placement of a connector (pink). The vertex circled in red was placed on an elevated bank. The starting vertex and ending vertex for a connector should be placed on a flat surface.

Single Line Drain Placement and QC

Single line drains should be collected if the average width is less than 8 feet and is greater than 0.5 miles in length. Single line drains should only be collected when the drain is apparent in the Lidar data. Single line drains should not be collected when the drain is obscured by vegetation and the Lidar does not penetrate. However, when the bottom or banks are obscured for more than 50 linear feet preventing laser points from penetrating to the ground, a soft feature breakline will be collected at the best interpretation of the compiler. Single line drains should be placed in the center of the feature and should not be digging into the surrounding elevated terrain. Single line drains should be collected in the direction of the downhill flow to ensure the features maintain monotonicity.

A QC check should be performed to ensure the features are monotonic and collected in the correct direction. A visual review should be performed to ensure single line drains are in the center of the drain and no dangles are present in the dataset. An additional QC check should be performed intersecting single line drains to ESRI Roads shapefile to identify if any single line drains were placed across culverts incorrectly instead of connectors.

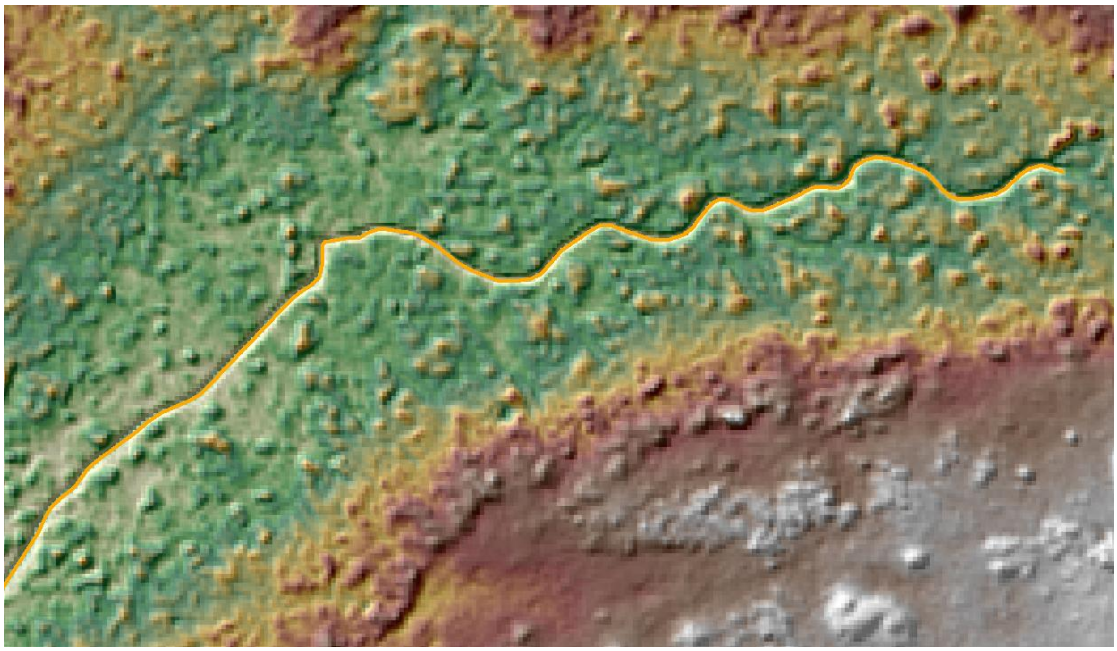

Figure 25- The image above shows correctly placed single line drains

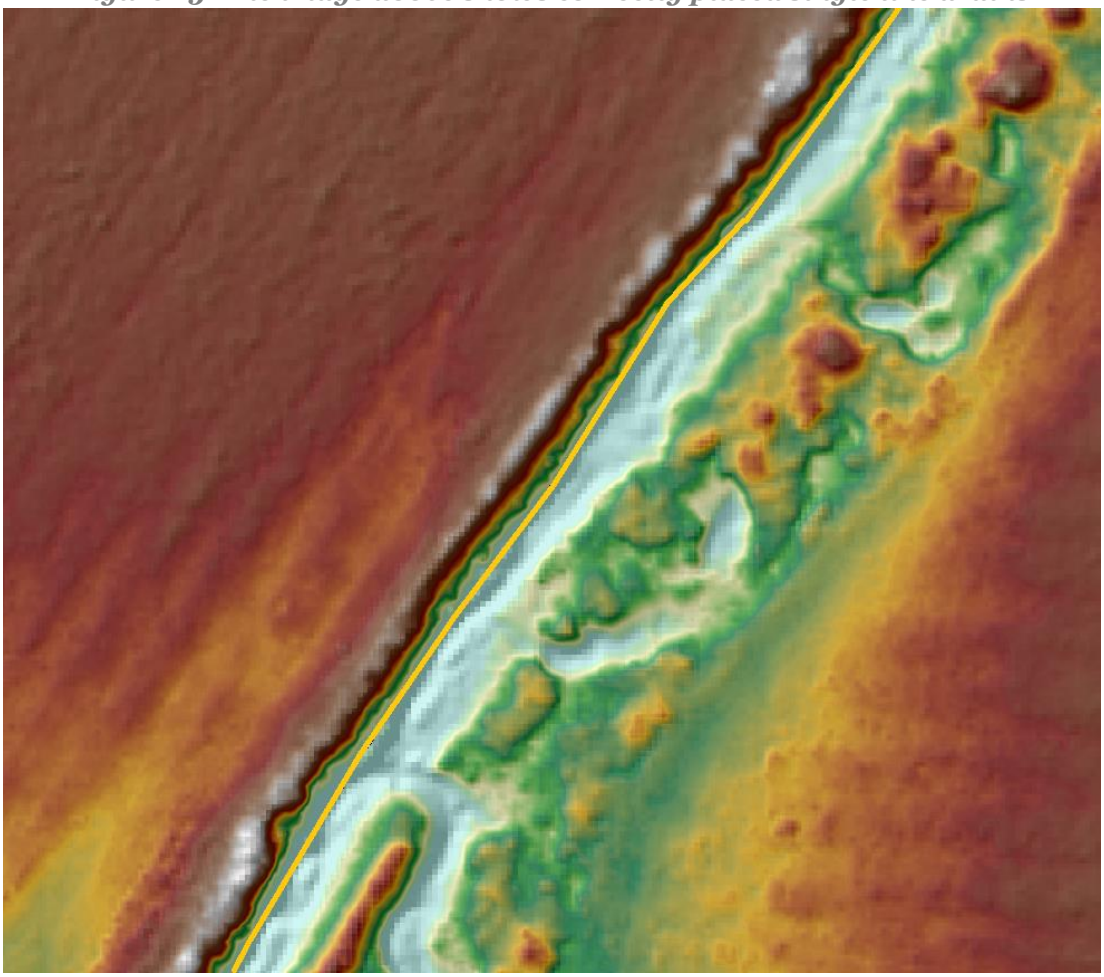

Figure 29- The image above shows incorrectly placed single line drains. The single line drains are not placed in the center of the drain.

Agriculture Canals

Canals in agricultural areas should be collected as a continuous single line drain and should continue through small breaks in the surface that may be culverts or other features without the requirement of a connector. Features should be broken with connectors at main roads if present. The single line drains located in these areas will be enforced into the final DEMs and should be monotonic. The primary means of conveyance through the agricultural areas should be collected as a dual line feature.

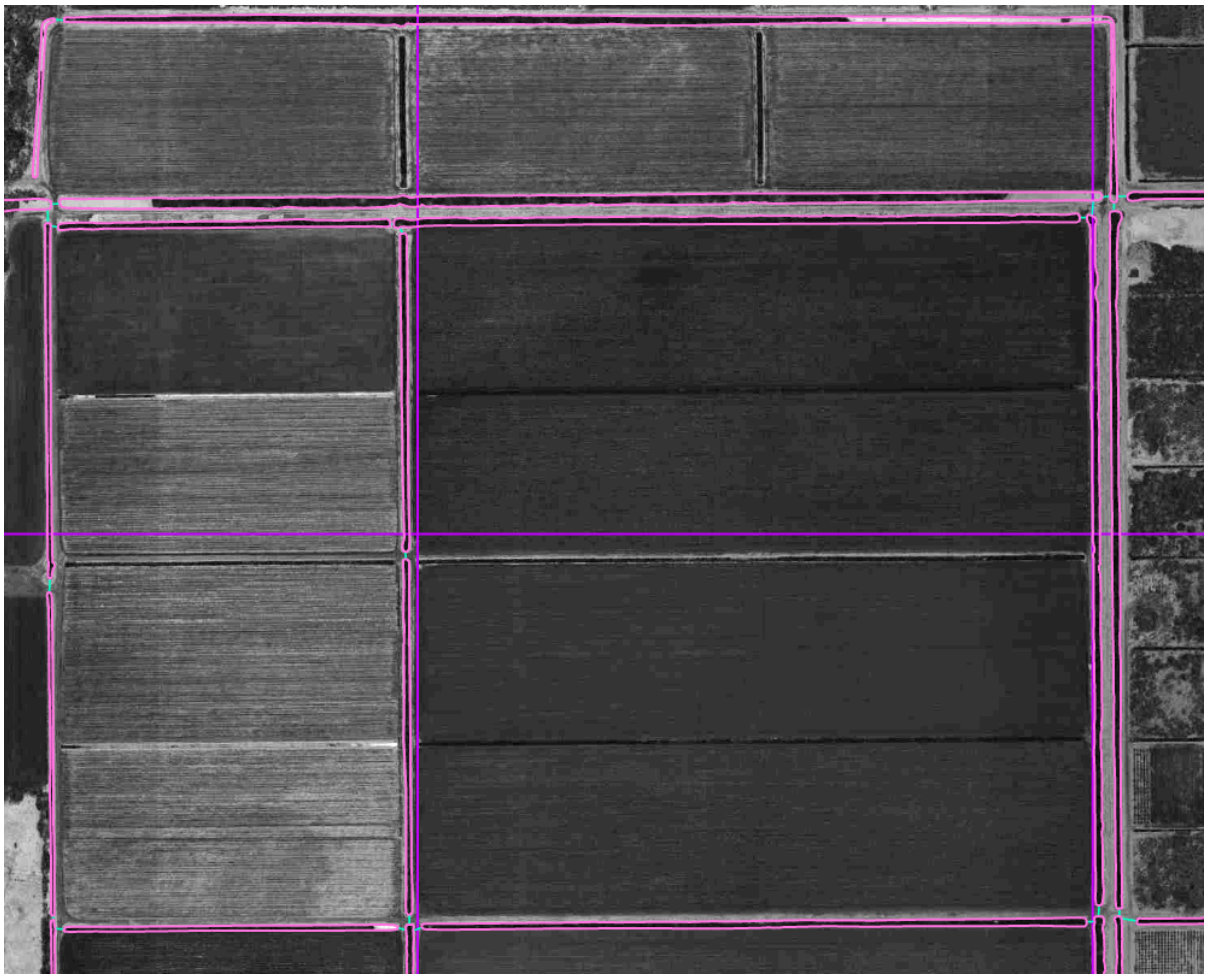

Figure 30- These features can be collected as a single line feature with a centerline. Centerlines can continue through small breaks in the surface that may be culverts or other features without the requirement of a connector. Features should be broken with connectors at main roads. THIS ONLY APPLIES TO AGRICULTURAL AREAS.