Nueces County, TX - Lidar Terrain Data "Cleanliness" Analysis

Background

URS Corporation performed an independent comprehensive accuracy analysis of the bare-earth lidar in accordance with the Federal Emergency Management Agency's (FEMA) *Guidelines and Specifications for Flood Hazard Mapping Partners* (Appendix A: Guidance for Aerial Mapping and Surveying). The guidelines call for comparing 20 ground-surveyed quality control points in each of five separate land cover classifications against the reported elevations for those same points locations in the lidar bare-earth data.

The results of the accuracy testing indicated that the lidar data met or were better than the prescribed vertical accuracy criteria as indicated in the following excerpt from the accuracy assessment report that was prepared for this project:

Vertical Accuracy at 95 Percent Confidence Level				
Land Cover Category	**Points**	**Fundamental Vertical Accuracy (feet)**	**Consolidated Vertical Accuracy (feet)**	**Supplemental Vertical Accuracy (feet)**
Consolidated				
Open Terrain	19	0.65		
Weeds/Crops				
Scrub				
Forest				
Built Up				

An assessment of the vertical accuracy alone does not yield a complete picture with regard to the usability of this data for its intended purpose. It is very possible for a given set of lidar data to meet the accuracy requirements, yet still contain artifacts (non-ground points) in the bare-earth surface, or a lack of ground points in some areas, that may render the data, in whole or in part, unsuitable for certain applications.

Based on the extremely large volume and density of elevation points generated for a typical lidar project, it simply not time efficient, cost effective, or technically practical to produce a perfectly clean (artifact-free) bare-earth terrain surface. The purpose of this report is to provide a qualitative analysis of the "cleanliness" of the bare-earth terrain surface for use in supporting coastal and riverine analysis, modeling, and mapping efforts.

The lidar data for this project was acquired and processed to a bare-earth terrain surface by Spectrum Mapping, a member of MAPVI, Mapping Alliance Partnership for FEMA Region IV, for the Nueces County & Incorporated Communities, Texas project.

This independent qualitative assessment report, prepared by URS, is based on examination of the entire lidar data set, rather than a random sampling of tiles.

Quality Assurance (QA) Process Overview

Software - The main software programs used by URS in performing the bare-earth data cleanliness review are as follows:

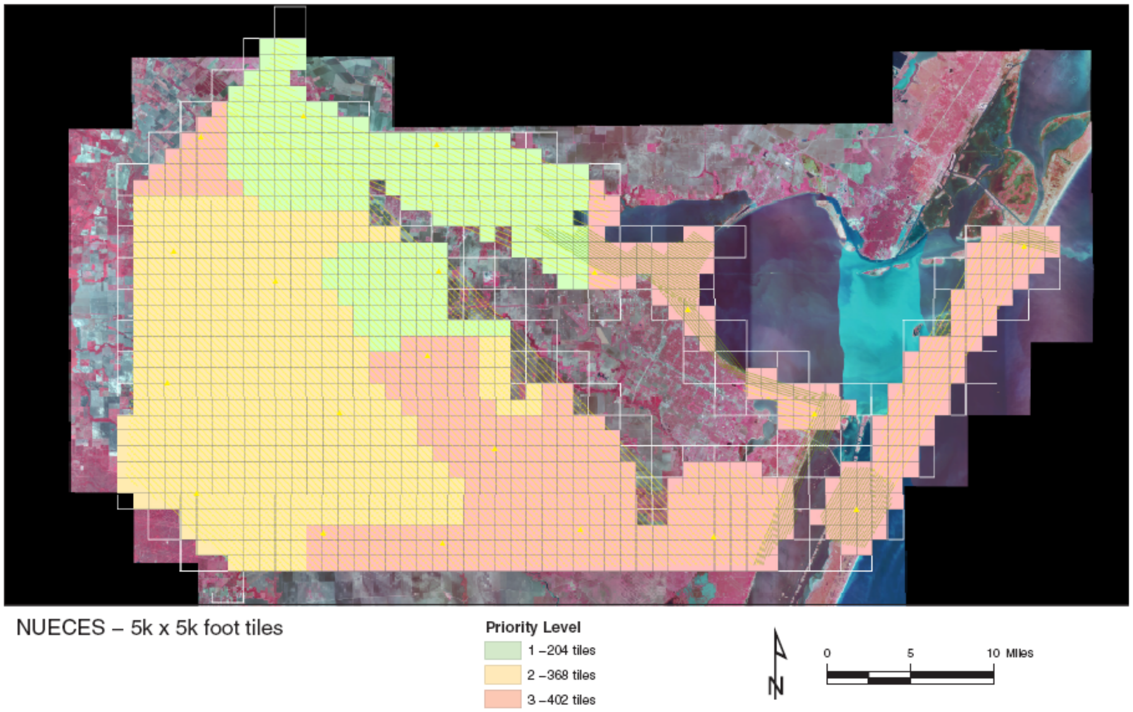
- *GeoCue* - a geospatial data/process management system especially suited to managing large lidar data sets
- *TerraModeler* - used for analysis and visualization
- *TerraScan* - runs inside of MicroStation; used for point classification and points file generation

QA Process Overview - The following systematic approach was followed for performing the cleanliness review and analysis:

- Uploaded data to the GeoCue data warehouse (enhanced data management)
    - Lidar—the data were cut into uniform tiles measuring 5000 feet x 5000 feet
    - Imagery—NAIP orthophotography was used to facilitate the data review
- Performed coverage/gap check to ensure proper coverage of the project area
    - Created a large post grid (~30 meters) from the bare-earth points, which was used to identify any holes or gaps in the data coverage—no irregularities were identified
- Performed tile-by-tile analysis
    - Using TerraScan, checked for gross errors in profile mode (noise, high and low points)
    - Reviewed each tile for anomalies; problem areas were identified with a polygon, comment, and screenshot as needed for clarification and illustration—note the NAIP ortho imagery was used when necessary to aid in making final determinations with regards to:
        - Buildings left in the bare-earth points file
        - Vegetation left in the bare-earth points file
        - Water points left in the bare-earth points file
        - Proper definition of roads
        - Bridges and large box culverts removed from the bare-earth points file
        - Areas that may have been "shaved off" or "over-smoothed" during the auto-filtering process
- Prepared and sent the error reports to MAPVI
- Reviewed revisions and comments from MAPVI
- Prepared and submitted final report to MAPVI

Tile Layout

The entire project area measured 873 square miles, which was divided into 974 tiles, measuring 5,000 feet x 5,000 feet. In order to maintain a continuous work flow of processing and quality control checks, the project area was separated and prioritized into three groups, as indicated on the following tile layout:



Review and Analysis

The review and analysis of the entire lidar data set for Nueces County indicated anomalies or minor errors that were sorted into four general categories:

1. Bridge deck points left in the bare-earth point file
2. Shaved surfaces—ground points inadvertently removed
3. Vegetation left in the bare-earth point file
4. Water points left in the bare-earth point file

Examples of these error types are illustrated in figures 1-4, on the following pages.

Bridge Deck Points

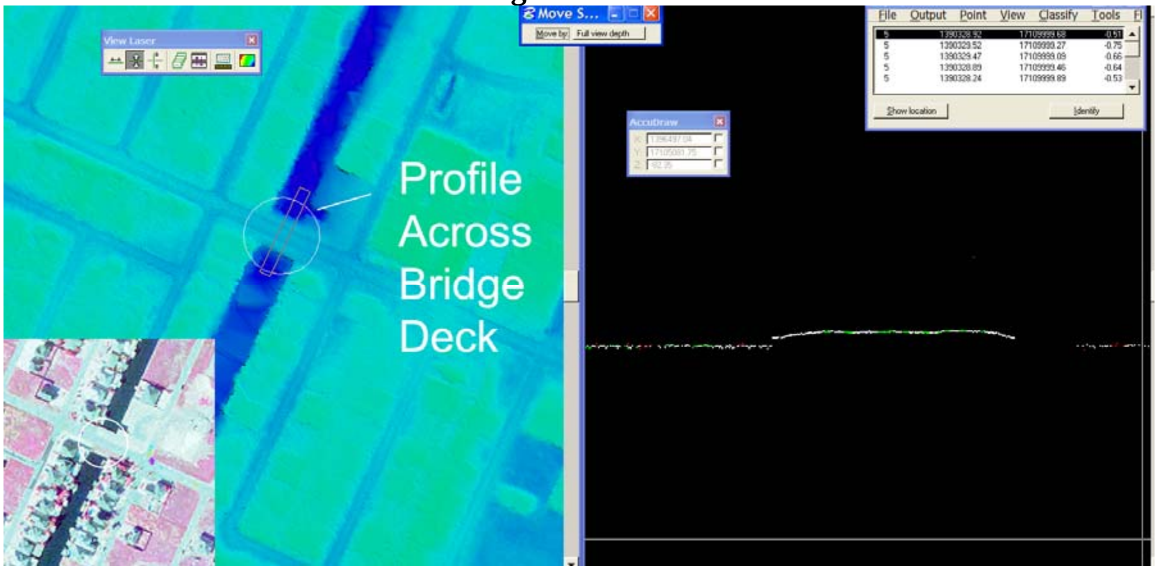


Figure 1

Figure 1 illustrates points on a bridge deck that were not removed from the bare-earth file (circled area). While this condition is not normally a concern for coastal modeling, it does present a problem for riverine modeling, as it would become an impediment to the natural stream flow. The image on the right shows a profile slice with the bridge points classified as ground points (note the profile location is indicated by the rectangle within the circled area on the left image).

Pavement points over large box culverts were not removed from the bare-earth data. The culverts and embankments were defined in the lidar to supplement the field survey for the riverine analysis. MAPVI uses the embankment data in conjunction with the field survey to determine the maximum headwater that can be generated during hydraulic analysis for culvert calculations.

Shaved Areas

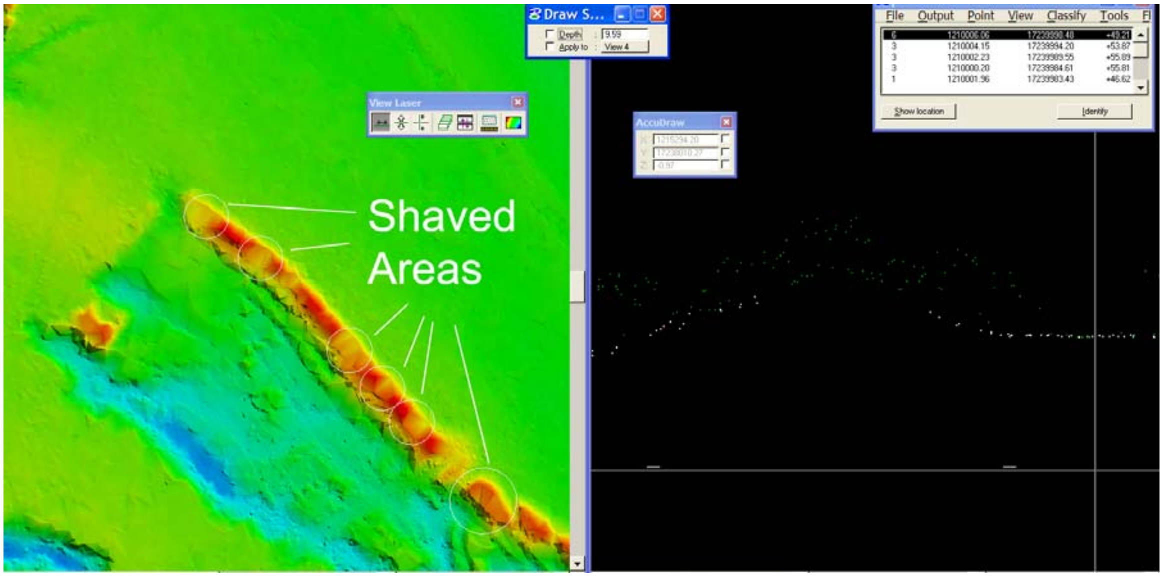


Figure 2

Figure 2 illustrates a “shaved surface” area, where ground points were inadvertently removed from the bare-earth file. This typically happens during the automated filtering, if the parameters are set too tight for terrain conditions. In this case, the tops of some of the dredged piles were shaved off. Corrections were made by the lidar vendor for errors of this type.

Vegetation Points

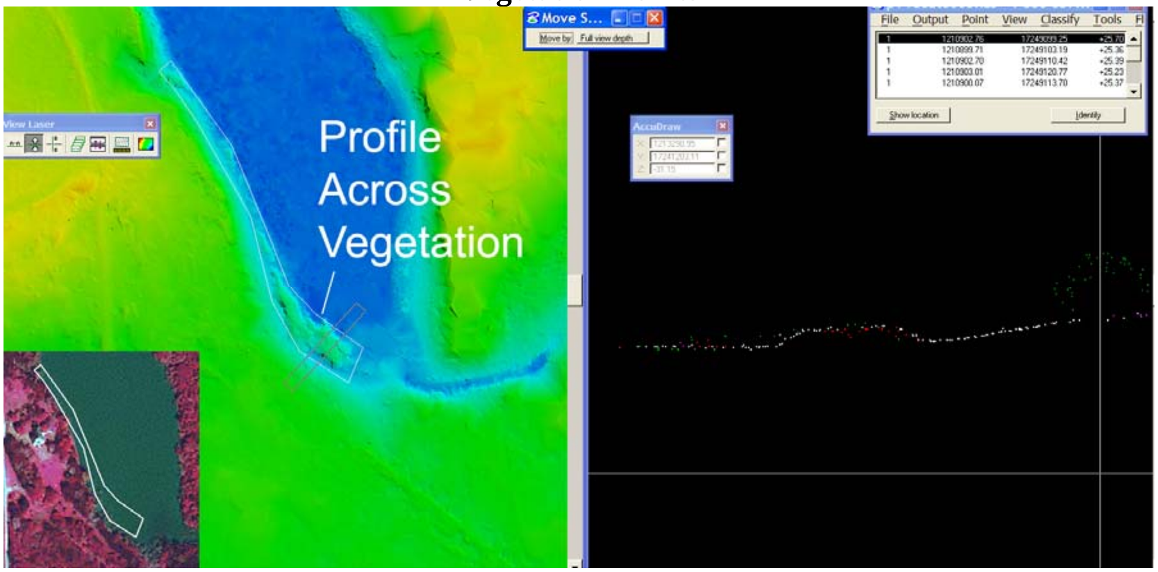


Figure 3

Figure 3 illustrates low-vegetation points that were not removed from the bare-earth file. The rectangle in the left image shows where an illustrative profile was taken. The profile points are displayed in the image on the right. These conditions were corrected by the lidar vendor.

Water Points

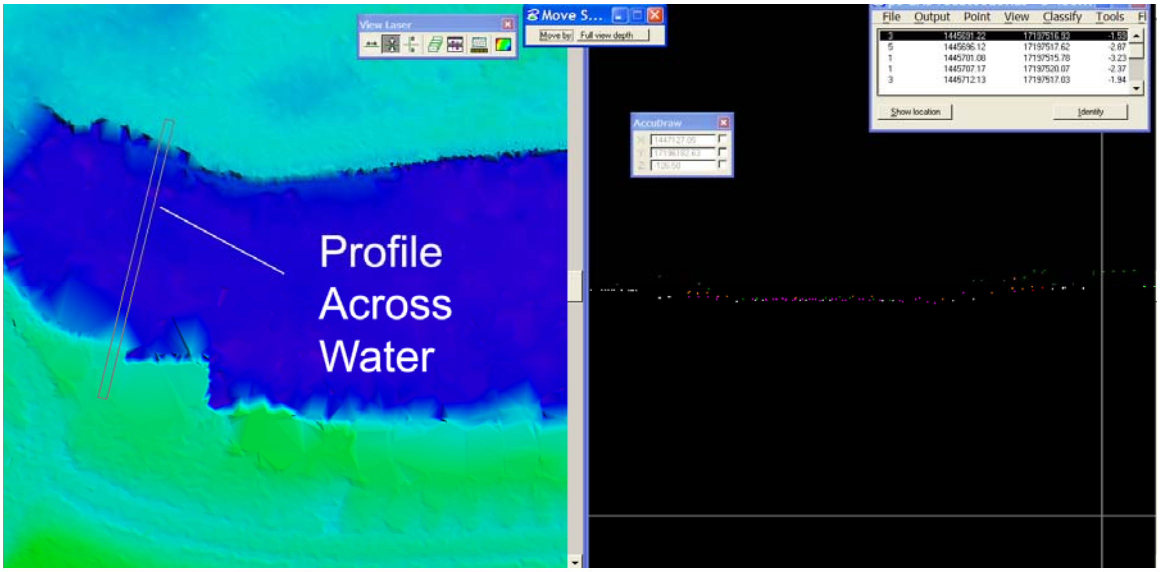


Figure 4

Figure 4 illustrates water points that were not removed from the bare-earth points file. MAPVI has generated a shoreline based on the lidar data, which they will use to remove the water points from the lidar-derived, bare-earth surface prior to performing any coastal modeling. It is MAPVI's intention to leave the water points falling within closed water bodies (lakes and ponds) in the bare-earth data set.

Additional Errors

In addition to the four common errors cited above, URS also identified two additional types of errors, which are illustrated in Figures 5 and 6:

Elevation Steps

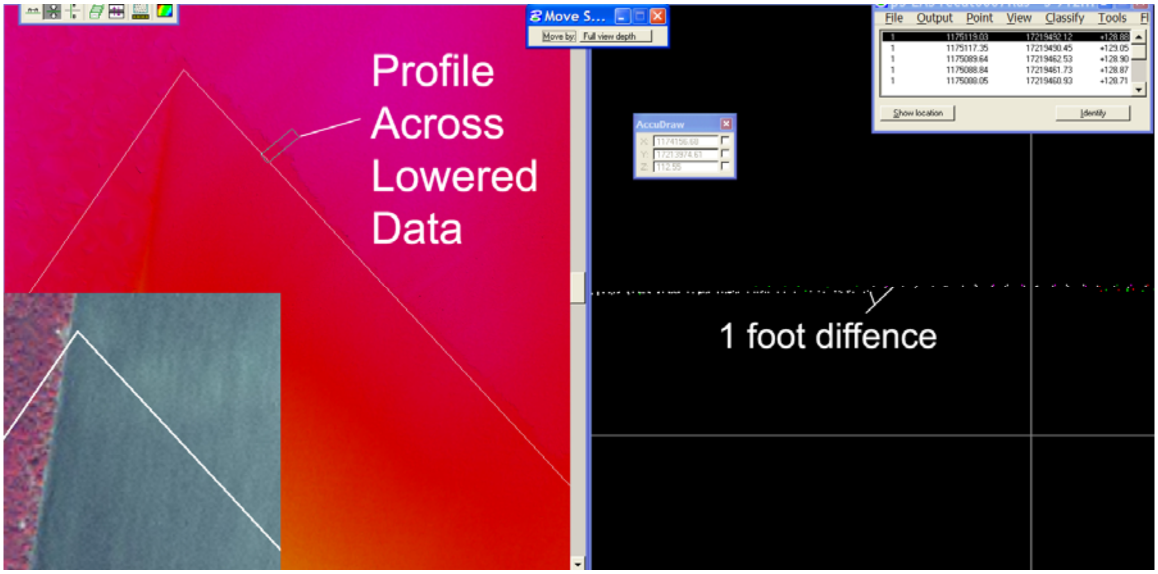


Figure 5

Figure 5 illustrates an area where there is an evident elevation step between data points acquired from two different flight lines. This condition is often caused by improper application of the airborne GPS antenna offset value during the preprocessing of the data. The lidar vendor "feathered" the step in this area, reducing the vertical "step" difference to approximately 0.5 foot.

Corn Rows

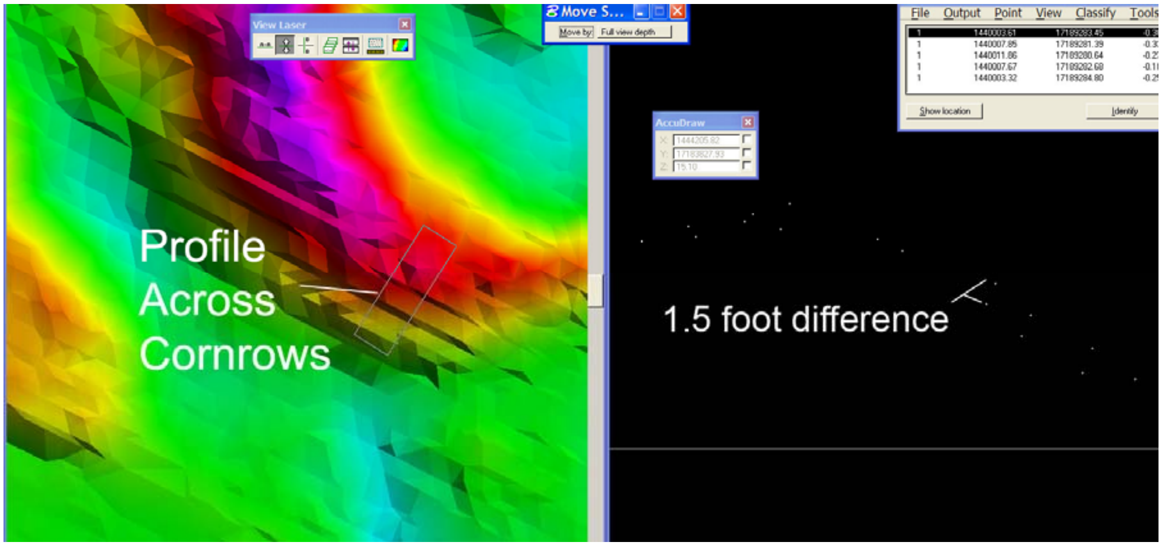


Figure 6

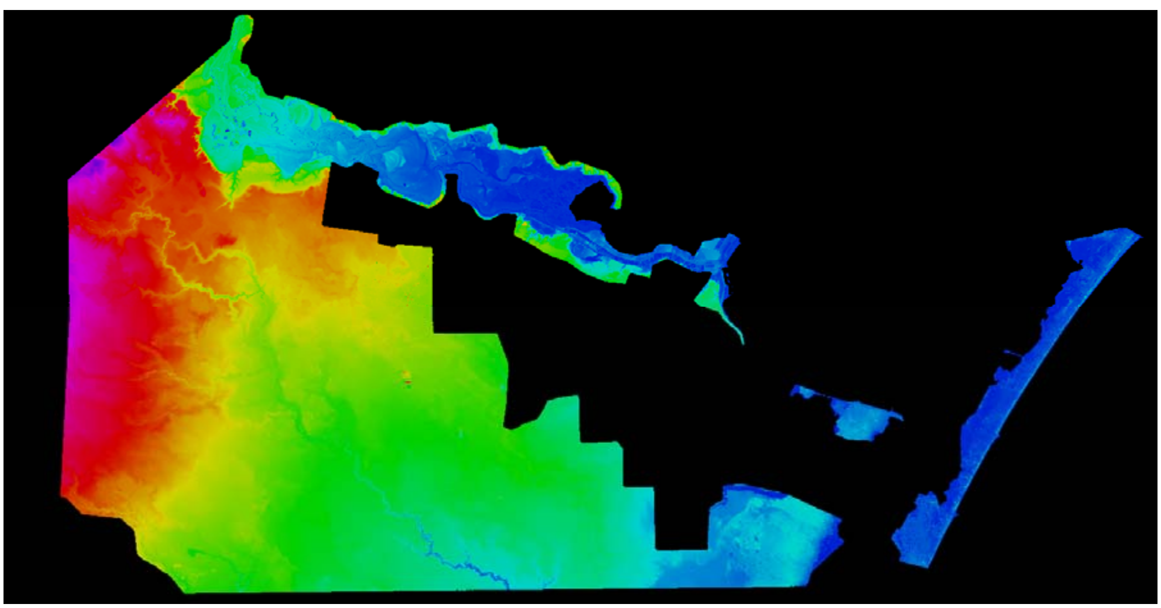
Figure 6 illustrates a problem that is commonly referred to as "corn rows," due to the distinctive furrowing pattern caused by the sensor losing sync during turbulent flight conditions. Basically, the forward rotation of the mirror is at one elevation, and the backswing is at another, causing the high-to-low furrowed effect, which is evidenced most readily in the image on the bottom left. The profile points in the image on the bottom right indicate a vertical difference of approximately 1.5 feet. There is no evidence that the vendor made any attempt to "smooth" vertical steps between the corn rows. It will be up to the engineers performing the coastal modeling to determine whether the corn rows will have a negative impact on the modeling. The corn rowing appears to be contained to spot areas along Mustang Island.

Conclusion
The overall quality of the data is good with respect to both accuracy and “cleanliness.” This data will meet the *National Standard for Spatial Data Accuracy* equivalents to the National Map Accuracy Standard (NMAS) error threshold for 2-foot contour accuracy (see the *Lidar Accuracy Assessment Report—Nueces County, TX*), and is suitable for flood studies. The quality of the data processing, prior to any edits being performed, was better than average.

Because the major emphasis of this project is coastal modeling as opposed to riverine, MAPVI chose not to develop any 3D hydro-enforced breaklines. However, as previously noted, MAPVI has produced a lidar-generated shoreline, which they will use to remove all coastal water points from the bare-earth data prior to performing coastal modeling. It is assumed that MAPVI is going to leave in the bare-earth data the water points that occur within closed water bodies.

Suggestion
For similar, future lidar projects, “obscured area” polygons should be generated for areas where there is an insufficient distribution of ground points to adequately depict the terrain surface.

Cautionary Note
In order to generate 2-foot contours that will meet recognized accuracy standards, this lidar data will need to be supplemented with horizontally and vertically accurate 3D breaklines. Further, any subsequent 3D hydro-enforced breaklines that may be developed for this project, to support modeling in riverine areas, will not necessarily meet the accuracy standards for 3D breaklines required for generating accurate 2-foot contours.



Nueces County, TX

Colorized hillshade produced from a triangulated irregular network (TIN) based on a 30-meter bare-earth grid