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Lidar Quality Assurance and Quality Control Report for Colleton and Charleston Counties, South Carolina

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National Oceanic and Atmospheric Administration (NOAA)
Coastal Services Center

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Executive Summary

Lidar data for Colleton and Charleston Counties, South Carolina, were collected in winter 2006–2007 and reviewed for accuracy and quality by the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center. The data were collected with a nominal point spacing of approximately 1.4 meters or better and have a fundamental vertical accuracy of 16 centimeters (cm) (bare earth) and a consolidated vertical accuracy of 19 cm (all land cover types). Qualitative aspects of the data such as flight line match and feature/vegetation classification were reviewed, and the data met, and in most cases exceeded, quality specifications and expectations.

Accuracy testing by the NOAA Coastal Services Center indicates that the lidar data meet the accuracy specified in the statement of work.

- Using Federal Geographic Data Committee (FGDC), Federal Emergency Management Agency (FEMA), National Digital Elevation Program (NDEP), and American Society for Photogrammetry and Remote Sensing (ASPRS) methodology: **Tested 16 cm vertical accuracy at 95% confidence level in open terrain.**
- Using NDEP and ASPRS methodology: **Tested 19 cm vertical accuracy at 95% confidence level in all land cover categories combined.**
- Using FGDC and FEMA methodology: **Tested 19 cm vertical accuracy at 95% confidence level in all land cover categories combined.**

Table of Contents

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Introduction

This report consists of two separate sections. The first is the vertical accuracy assessment of the lidar data for Colleton and Charleston Counties, South Carolina, and the second is the qualitative assessment of the lidar and the accompanying digital elevation models (DEMs). The data were collected by Photo Science in the winter of 2006–2007 for the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center and the South Carolina Department of Natural Resources. The data were processed to classify points as bare earth, water (surface), or unclassified (e.g., vegetation, houses). The bare earth elevations, along with breaklines, were used to create a DEM that will support, among other applications, Federal Emergency Management Administration (FEMA) flood mapping activities within the State of South Carolina. The point data were reviewed to make certain that they met the accuracy specified in the statement of work (Appendix A), were free of questionable artifacts, and provided a usable data set for multiple types of projects, including flood mapping. The point collection included three sub-collection areas: Inland Colleton County (Figure 1, green), Coastal Colleton County (purple), and Charleston County (teal). Data collection information is contained in the acquisition reports (Appendix B).

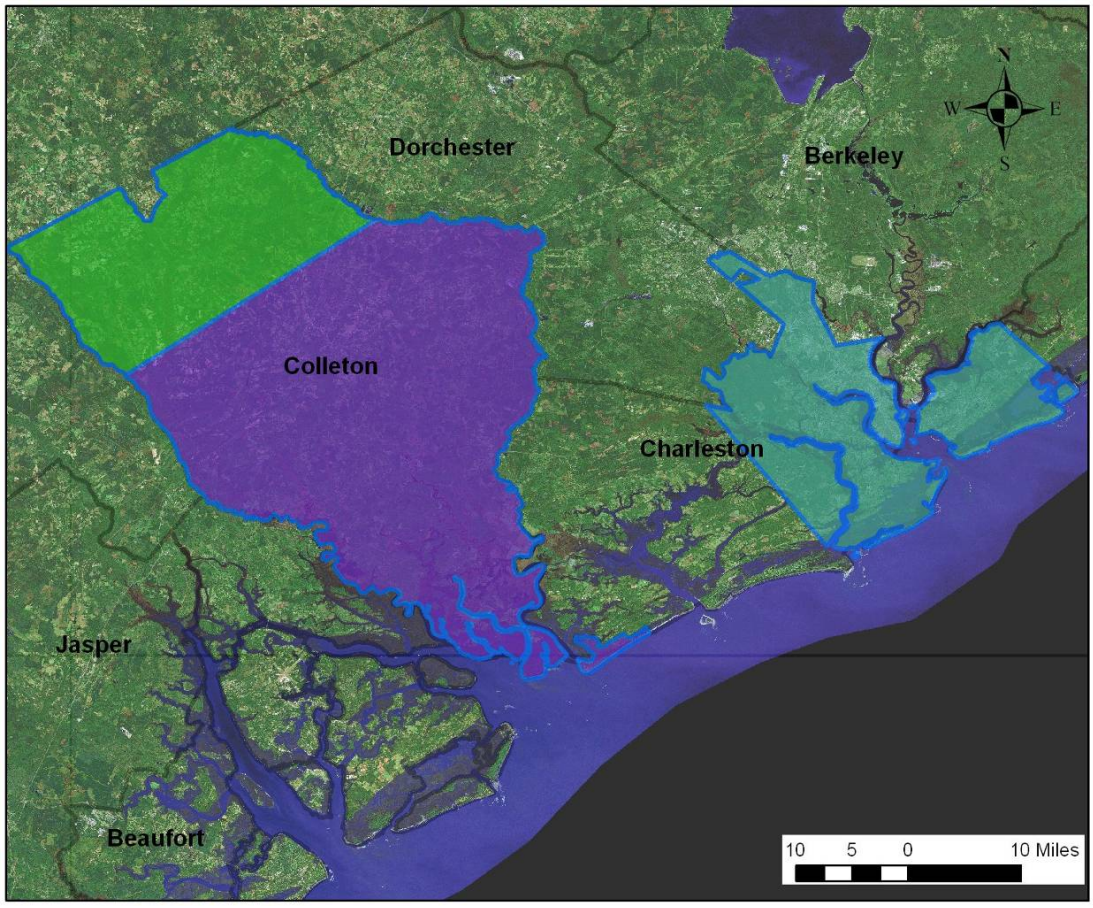

Figure 1. Data Collection Area

Vertical Accuracy Assessment Report

Background: Data Standards

Data standards for topographic data have become more stringent in response to the increased-resolution data sets being generated by private industry, advances in technology, and the data's widespread application and use. Four primary documents have helped define the process of measuring, reporting, and defining the accuracy of Colleton and Charleston Counties lidar elevation data. *Guidelines for Digital Elevation Data* (NDEP, 2004), "ASPRS Guidelines: Vertical Accuracy Reporting for Lidar Data" (ASPRS, 2004), and "National Standard for Spatial Data Accuracy" (FGDC, 1998) provide guidance and formulas for determining elevation data accuracy. "Guidance for Aerial Mapping and Surveying" by the Federal Emergency Management Agency (FEMA, 2003) draws on these other data-standard documents and includes a definition of what types of data are needed for some specific flood-mapping applications.

The specific requirements for the data being reviewed are provided below (Table 1). These requirements are meant to define how well the actual terrain was measured in 1) open areas and 2) obscured or vegetated areas. Several measures, $Accuracy_z$, and the Consolidated and Supplemental Accuracies are used to assess these two important aspects.

$Accuracy_z$ is the 95% confidence level of the data (i.e., 95% of the data meets or exceeds the specified vertical $Accuracy_z$) and relates to the data accuracy in areas without trees; thus, this is an overall measure of the quality of the data collection process and adjustment for flight parameters. The fundamental vertical accuracy (FVA) statistic is the same thing as $Accuracy_z$; it is a FEMA-specific term. These measures are calculated using the root mean square error (RMSE) of the data points and are dependent on the data errors being normally distributed; the formula (RMSE x 1.96) follows guidance provided by the FGDC (1998). For this data set, the goal was to achieve a 15 centimeter (cm) RMSE or $Accuracy_z$ of 29.4 cm, which is a tighter accuracy specification than the FEMA specification (FVA of 36.3 cm).

The supplemental and consolidated vertical accuracy is a 95^{th} percentile confidence statistic. In this case, the values provide a measure of how well the lidar penetrated the tree or shrub canopy, and how well the vegetation, structures, and other non-ground features have been removed (processed), while still providing enough information about the ground surface in their vicinity to accurately portray the terrain. These "obscured" data are not normally distributed, since there are many different types of vegetation/features, and therefore the calculation of the value is done graphically. FEMA guidance (FEMA, 2003) suggests that for coastal areas (relatively flat) the supplemental vertical accuracy (SVA) and consolidated vertical accuracy (CVA) values be 36.3 cm or better. These are suggested values and, while not dictating the acceptance of the data, provide some additional guidance for their use.

Table 1. NOAA Coastal Services Center and FEMA Accuracy Requirements from Statement of Work

Vertical Accuracy Criteria	NOAA/FEMA Measures of Acceptability
$RMSE_z$ = National Standard for Spatial Data Accuracy (FGDC, 1998) vertical accuracy statistic at 68% confidence level	15 cm in open terrain only
$Accuracy_z$ = National Standard for Spatial Data Accuracy (FGDC, 1998) vertical accuracy statistic at the 95% confidence level = $RMSE_z$ x 1.9600	29.4 cm (15 cm $RMSE_z$ x 1.9600) in open terrain only
Fundamental vertical accuracy (FVA) in open terrain only = 95% confidence level	36.3 cm (18.5 cm $RMSE_z$ x 1.9600) for open terrain only
Supplemental vertical accuracy (SVA) in individual land cover categories = 95% confidence level	36.3 cm (based on 95th percentile per category; this is a target value only, not mandatory)
Consolidated vertical accuracy (CVA) in all land cover categories combined = 95% confidence level	36.3 cm (based on combined 95th percentile)

There are ongoing discussions on whether the values for non–bare earth points (e.g., forest, scrub-shrub) should be calculated using RMSE x 1.96 or the 95th-percentile-confidence-level techniques. FEMA and National Standard for Spatial Data Accuracy (FGDC, 1998) guidance specify that RMSE x 1.96 should be used; ASPRS and NDEP guidance specify that the 95th percentile should be used. We provide values using both techniques for future reference; however, the acceptability measures in Table 1 are being used as the criteria for the validation of the data set.

Ground Control Point Collection

Ground control points (GCPs) were collected to measure the difference between ground elevations and lidar elevations. The points were collected by personnel from the NOAA Coastal Services Center and National Geodetic Survey during the summer of 2007. Documentation of the point collection is provided in Appendix B. Two separate types of point collection techniques were used depending on site conditions. Global Positioning System (GPS) points were collected using the Virtual Reference System (VRS) in areas with acceptable cell phone reception and overhead cover. VRS is a technique similar to Real Time Kinematic (RTK), except that it uses cell phone corrections from the nearby Continuously Operating Reference Stations. Areas that were not within cell phone range or were under tree cover were collected using a total station. The total station was typically set up on a known benchmark and a VRS–GPS established point used as a back-sight and GCP.

The calculated RMSE of the GPS points were typically less than 5 millimeters (Appendix C). The accuracy of the points collected with the total station is estimated to be approximately 2 or 3 centimeters and is associated primarily with operator error. The process did, however, include an averaging technique using multiple measurements per point to minimize operator error. In general, the surveyed points are judged to have accuracies that are approximately five times better than the target RMSE of the lidar collection (15 cm).

There were 23 “test sites” where points representing the target land covers were collected (Figure 2), and most were in locations near benchmarks so that cross-checks could be made to pre-existing data. The surveyed points were grouped into one of five different land cover categories, and photographs of each point were taken to provide information on its specific land cover aspects. The five land cover categories are 1) bare earth, 2) urban, 3) forest, 4) scrub/shrub, and 5) weeds and crops. These groups were used to compute errors across the spectrum of different land covers.

The five different land cover types did not always occur within each test site, and at some sites more than one point per land cover type was collected (Figure 3). A total of 166 points were collected, with 47 points in open terrain, 36 points in weeds and crops, 24 points in scrub/shrub, 35 points in forest, and 24 points in built-up or urban land covers.

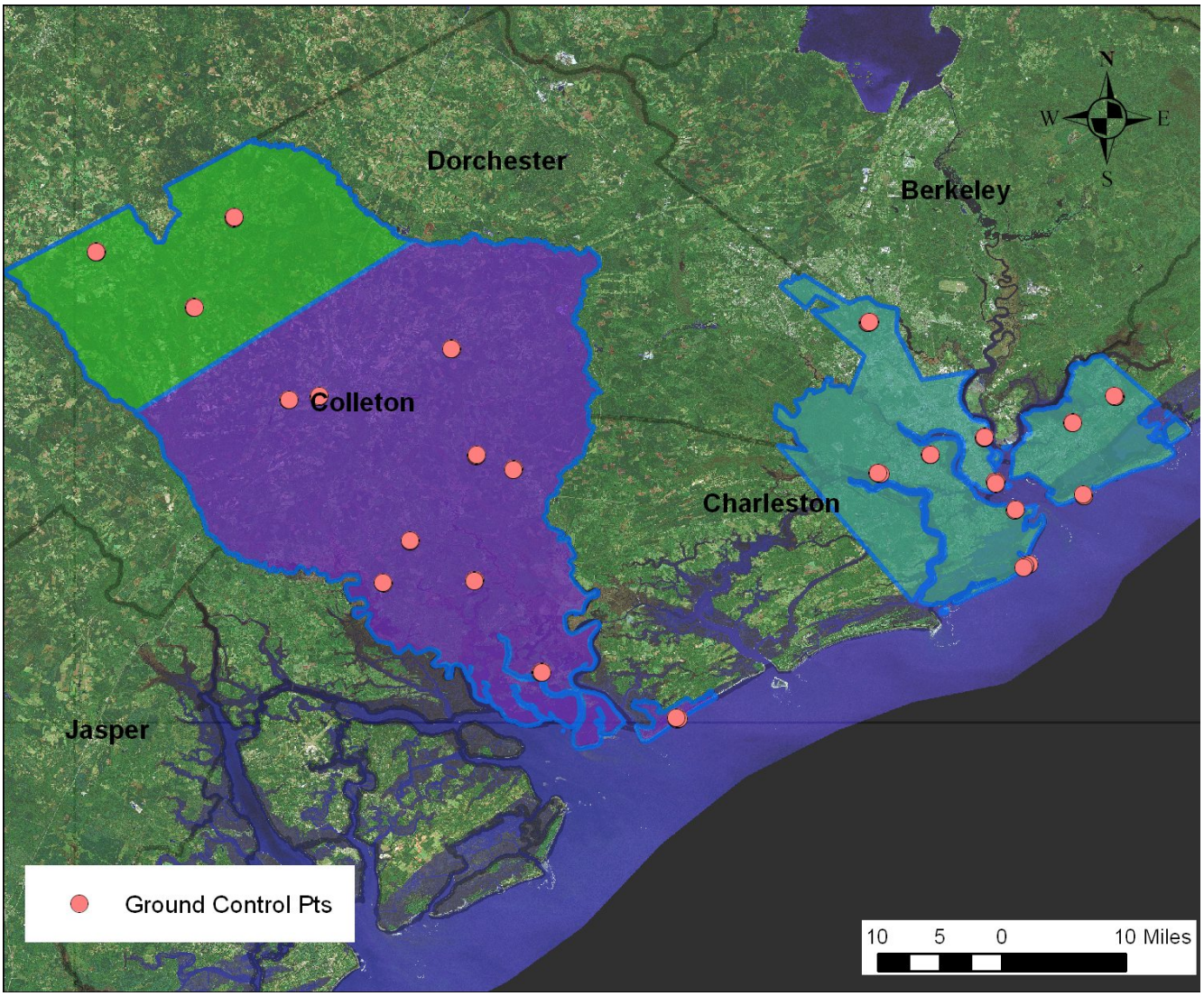

Figure 2. Location of Sample Sites in Colleton and Charleston Counties

Figure 3. Example of Point Collection (Green Points) at a Test Site

Vertical Accuracy Tests

To test the vertical accuracy of the lidar data, the NOAA Coastal Services Center first generated a digital terrain model (DTM) by creating a triangulated irregular network (TIN) surface of the bare earth classified points. This DTM was then used to assign each surveyed point a lidar-generated elevation. The difference between the surveyed and lidar elevation was taken as the error. From these errors and land cover groupings, the various statistics were computed ($Accuracy_z$, FVA, SVA, CVA) using the guidance documents. All resolved and fixed solution GPS points were used along with all collected total station points; no points were removed from the survey data set (point data are available in Appendix D).

Results

The critical pass or fail results are highlighted (bolded text) in Table 2; all the values are in centimeters. The values were consistent using both measures of accuracy, RMSE x 1.96 and 95^{th} percentile, such that use of either technique to report the accuracy of the data is probably within the resolution of the techniques to gather survey data (~3 cm). The results meet and exceed all the specifications in the statement of work (SOW; Appendix A).

Table 2. Ground Control Point Values

Land Cover Type	No. of Points	RMSE (cm)	$Accuracy_z$ or FVA (1.96 x RMSE) (cm)	Consolidated Vertical Accuracy, CVA (95^{th} percentile) (cm)	Supplemental Vertical Accuracy, SVA (95^{th} percentile) (cm)
Total Combined (all points)	166	0.094	0.19	**0.19**	
Open Terrain	47	0.081	**0.16**		0.12
Weeds/Crops	36	0.098	0.19		0.18
Scrub/Shrub	24	0.100	0.20		0.18
Forest	35	0.116	0.23		0.26
Built-up/Urban	24	0.071	0.14		0.13

The error values for each land cover type show a fairly normal trend but do contain a few outliers (Figure 4). The overall error is low, which tends to highlight any deviations from the "normal" distribution, a distribution that would more closely approximate a straight line in Figure 4. The mean of the data (Table 3) is essentially at zero, however, which highlights the overall accuracy and high quality of the data.

Skewness (an argument for not using the RMSE x 1.96 methods to determine $Accuracy_z$) is below 1.0 for all classes and as the results highlight, the difference between the two methods is minimal.

Given that the largest error within the 166 points still met the 95% accuracy requirement, it appears that this data set is very consistent throughout the land covers and can be used with confidence in all types of settings. In practical terms, a large fraction of the data is within 10 cm of the surveyed ground elevation (Figure 5), and applications requiring this level of detail can, in most cases, be supported by the data.

There are certain environments where this is less applicable, including heavily vegetated areas or those with a high level of undergrowth, such as coastal hammocks. Additionally, while some marsh areas were sampled (weeds/crops), more ground control points in the various marsh habitats are required to provide statistical measures in this highly vegetation-specific habitat.

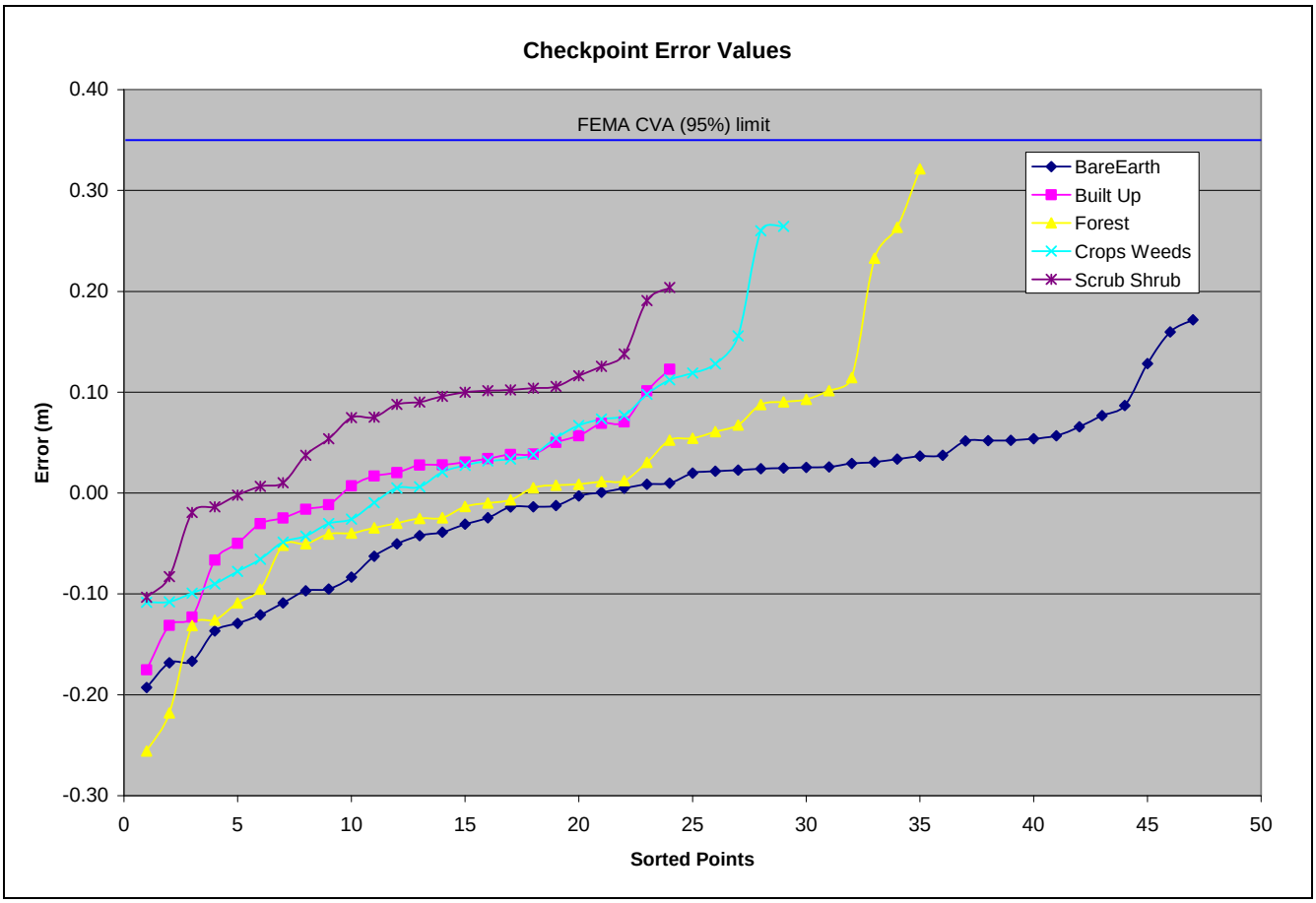

Figure 4. Sorted Check-Point Values

Table 3. Point Statistics

100 Percent of Totals	RMSE (m)	Mean (m)	Median (m)	Skew	Std Dev (m)	# of Points	Max (m)	Min (m)
Total	0.094	0.01	0.02	0.14	0.09	166	0.321	-0.256
Open Terrain	0.081	-0.01	0.01	-0.34	0.08	47	0.172	-0.193
Weeds/Crop	0.098	0.02	0.02	0.62	0.10	36	0.264	-0.139
Scrub	0.100	0.07	0.09	-0.51	0.08	24	0.204	-0.103
Forest	0.116	0.01	0.01	0.42	0.12	35	0.321	-0.256
Built-up	0.071	0.00	0.02	-0.90	0.07	24	0.123	-0.175

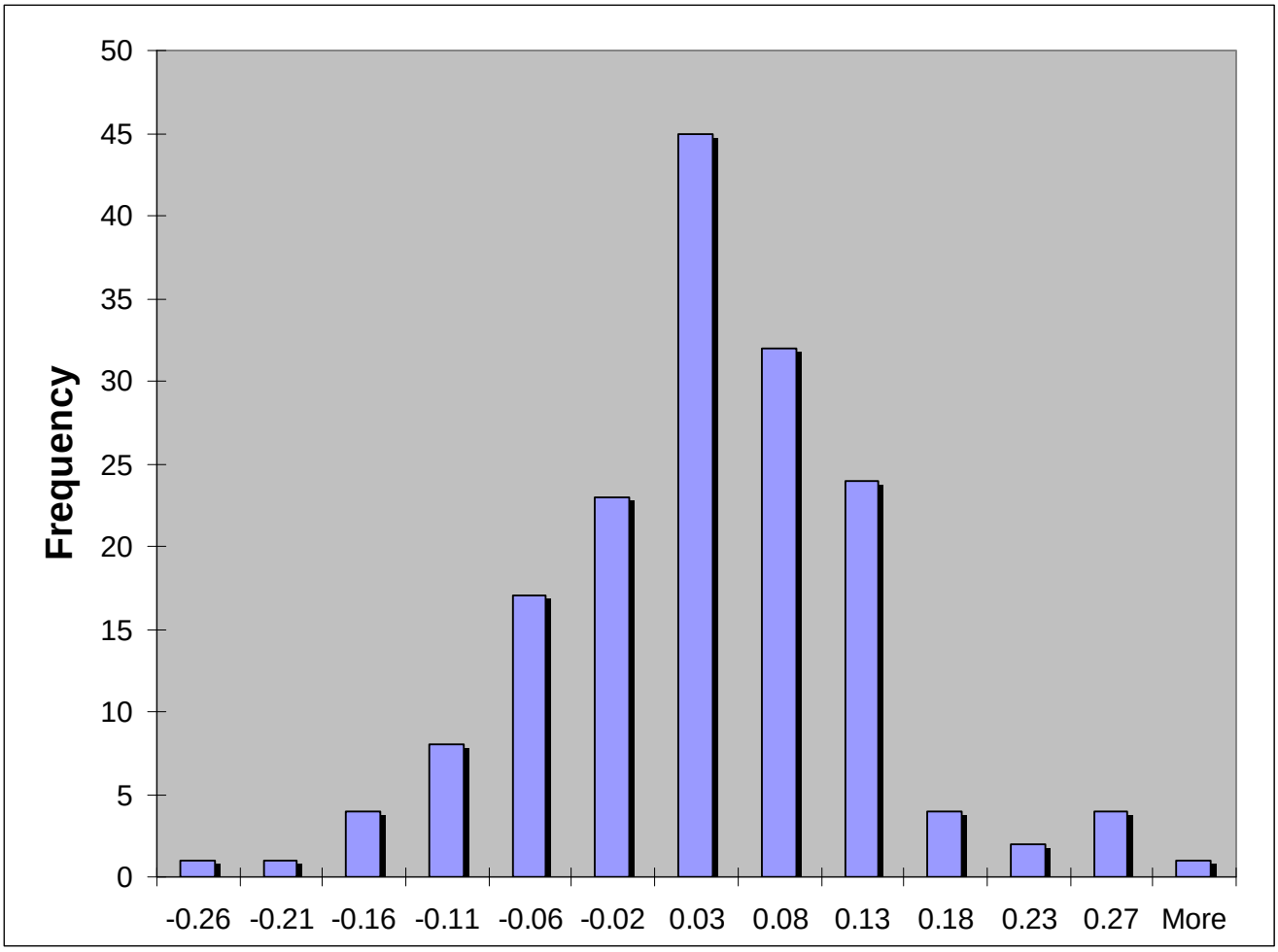

Figure 5. Error Histogram of All Ground Control Points (GCPs)

Fundamental and Consolidated Vertical Accuracy

The data passed the FVA and CVA measures specified in the statement of work (SOW) (Table 1, Figure 4). The measured FVA is 16 cm (29.4, NOAA Coastal Services Center specification; 36.3 cm, FEMA specification) and the CVA is 19 cm (36.3 cm, FEMA specification). None of the 166 points fell outside of the FEMA 36.3 cm specification (Figure 4). The data met and exceeded the FVA and CVA specifications.

Supplemental Vertical Accuracy

All the land cover categories easily passed the 36.3 cm SVA target using the 95^{th} percentile method (Table 2). The lack of divergent points is not taken to be a result of non-vigorous GCP selection. Points were chosen in areas where lidar data were able to penetrate; it was not the goal to test areas where lidar could not penetrate. The abundant coverage of points in forests and other vegetated land categories, and hence the high level of supplemental accuracy, is likely a result of the leaf-off collection conditions. Again, the data met and exceeded the SVA targets.

Spatial Accuracy Trends

An aspect of remote sensing data collected with GPS is the spatial correlation of the error across the collection area, and is associated with the changing quality of positional information (i.e., changes in PDOP, or positional dilution of precision). To define this variation, the accuracies of each point were normalized (divided) against the $Accuracy_z$ of its associated land cover classification. The mean of the normalized values was then generated for each "test site" to produce a relative site error. A site error of about 0.5 would be near the average of the overall data set. The average site error was computed and mapped, and a mathematical surface (spline) was created to highlight any systematic variation (Figure 6). It appears that there are few variations in accuracy within the collection area. The only notable trends appear to be 1) an increase in relative error toward the offshore (i.e., moving away from land) in Charleston County, which is consistent with the use of land-based GPS base-station information, and 2) higher error in the central portion of Colleton County. In both cases, however, the average site errors were just slightly higher than the overall average.

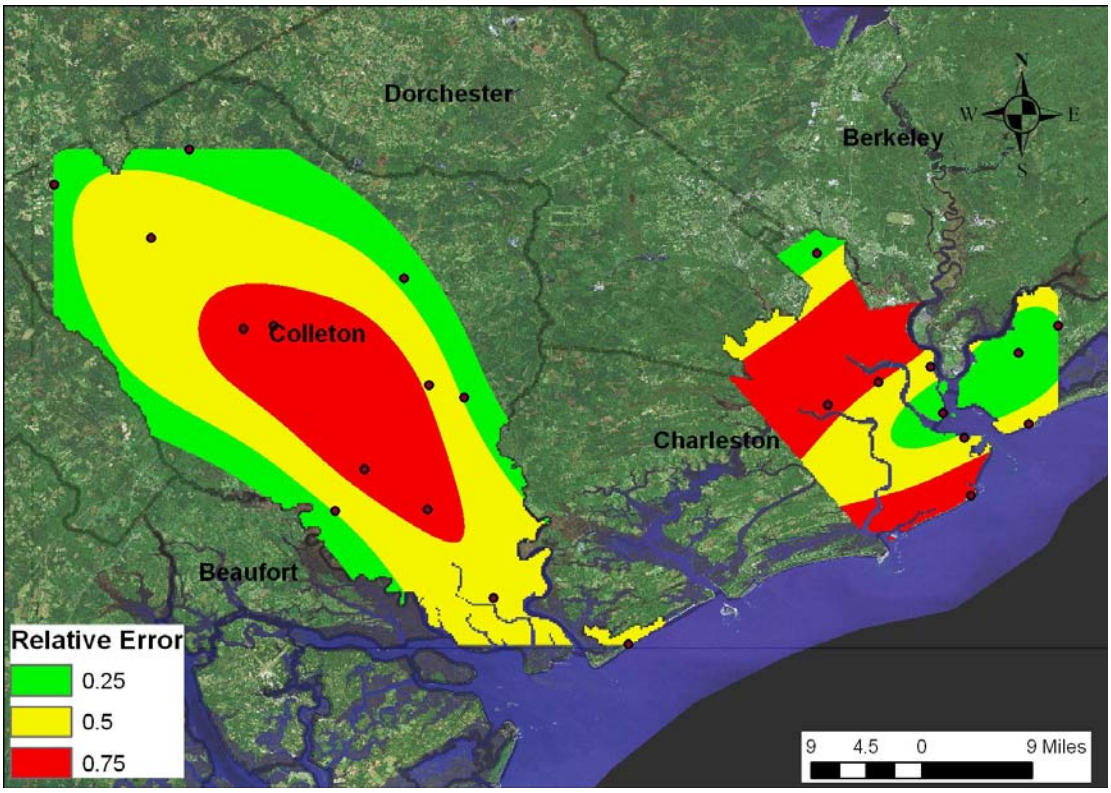

Figure 6. Error Trends in Colleton and Charleston Counties from Lowest (Green) to Highest (Red) Relative Error

Accuracy Assessment Summary

Accuracy testing by the NOAA Coastal Services Center indicates that the lidar data meet the accuracy specified in the statement of work.

- Using Federal Geographic Data Committee (FGDC), Federal Emergency Management Agency (FEMA), National Digital Elevation Program (NDEP), and American Society for Photogrammetry and Remote Sensing (ASPRS) methodology: **Tested 16 cm vertical accuracy at 95% confidence level in open terrain.**
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- Using FGDC and FEMA methodology: **Tested 19 cm vertical accuracy at 95% confidence level in all land cover categories combined.**

Qualitative Assessment of Colleton and Charleston Counties Lidar

The qualitative assessment of the Colleton and Charleston Counties lidar consisted of three procedures. The point data (log ASCII standard, or LAS, files) were checked for macro (i.e., general data and format) and micro (i.e., accuracy and feature processing) issues (Figure 7). Digital elevation models (DEMs) were also provided and inspected for both macro and micro issues. These analyses were performed on the draft data delivery; the highlighted issues were documented in an interim report that was sent to Photo Science to guide them in data review and data correction. Photo Science addressed all the highlighted issues to the satisfaction of the NOAA Coastal Services Center's quality assurance (QA) team.

The LAS files were checked for macro issues such as the existence of data within each file, correct projection, correct file name, data classified, return information, intensity values, and the data having an acceptable format. This was an integrity check to see that all the files were received and were not corrupted. This procedure was used to test about 75% of the files. The LAS files were then checked for micro problems, included checking to see that the specified point density was met, data from different flight lines matched, corn rows or other artifacts were removed, high or low values were either removed or classified, non-earth features were classified, and point smoothing was acceptable. This level of review was carried out for approximately 15 to 20% of the tiles. Taken in total, almost every LAS tile was reviewed at some level (Figure 7).

The DEM files were reviewed separately since they included both the LAS data and breakline information generated as a separate work product. These DEM products will likely be used more by the partners (South Carolina Department of Natural Resources) than by the NOAA Coastal Services Center. DEM files were checked for micro issues similar to the LAS files and were also checked to see if hydro-enforcing was performed (i.e., water runs downstream). A total of 15 to 20% of the DEM tiles were reviewed.

Breaklines provided in the delivery were also reviewed in terms of the statement of work. This data set was an additional product without a clear definition of how the QA was to be formally undertaken. That said, the breaklines were checked using aerial imagery (Google Earth) and areas with potential gaps or issues were noted. More importantly, the DEMs, which were created in part from the breakline data, were checked to see that proper water elevations and surfaces existed.

Procedures

The files were reviewed using several software packages and techniques. The macro reviews were typically carried out in PointVue software, which is a native 3D point-only viewing program. Here the projection and datum, classifications, outliers, intensity, and data format were checked. The micro reviews were primarily performed using LASEdit. Data irregularities were examined using triangulated irregular network (TIN) surfaces generated from the points (primarily those classified as bare earth), as well as 3D views and profiles. Each DEM was checked using the Global Mapper software program with the corresponding DOQQ (Digital Ortho Quarter Quad) and Google Earth images for reference.

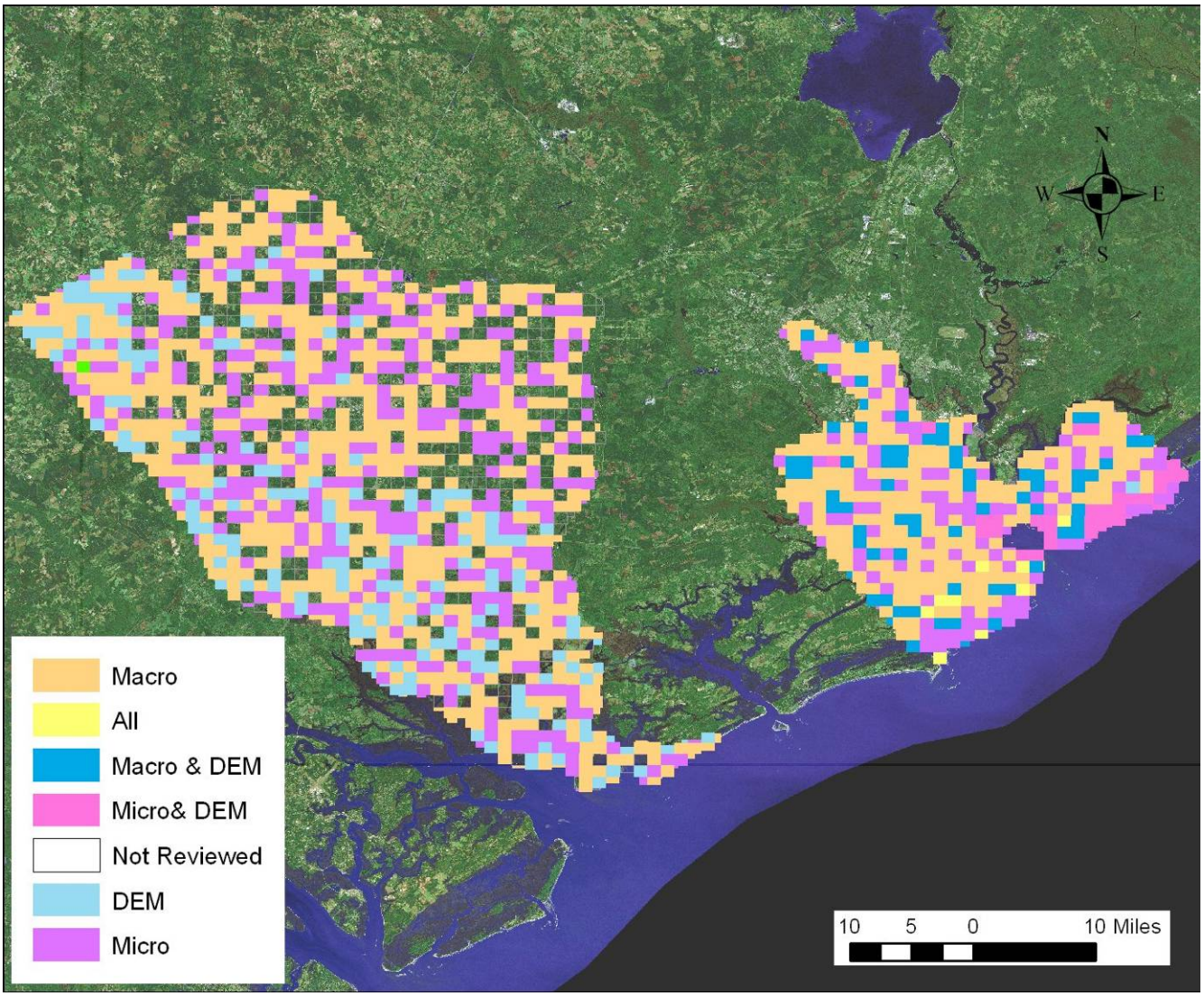


Figure 7. LAS Files in Colleton and Charleston Counties Checked, and the Level of Review Conducted

LAS Reviews

About 90% of the tiles were checked at the macro, micro, or both levels of review. The data were in almost all cases very clean of artifacts, corn rows, and flight line mismatch problems. There were very few issues. The issues that were most apparent stemmed from the extremely flat terrain. Many of the tiles, which were several kilometers wide and long, had elevation changes on the order of 1 meter; this made inconsistency in flight lines the most recognizable artifact or issue. Structure and tree removal were performed well, since the elevation differences between the very flat ground and any tree, shrub, or building were probably easily recognized by the automated classification process. The level of smoothness to the data was also noted—there being very few pits and spikes.

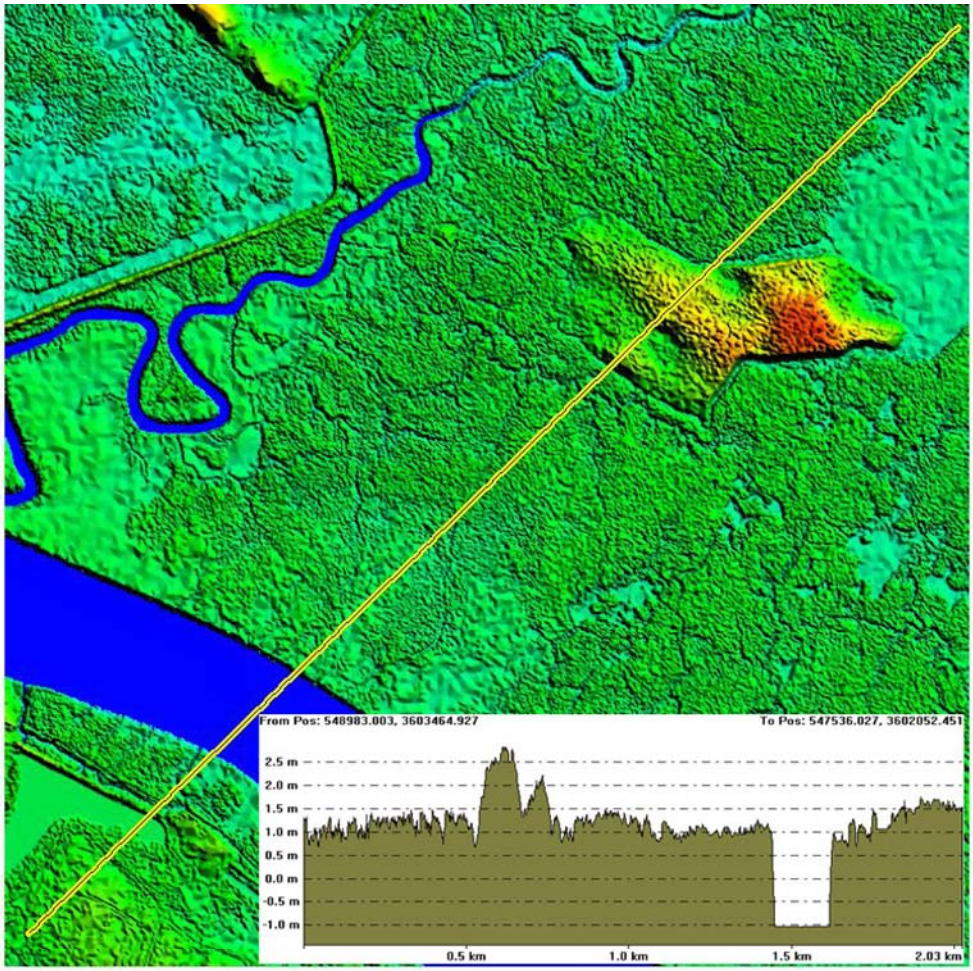


Figure 8. Example of Flat Terrain; Profile Is over 2.0 Kilometers

Results

Macro Review

The results of the macro review confirmed that the data were complete and incorrupt. The points were classified using the specified classes: vegetation and non-bare earth features were classified as "1," bare earth classified as "2," and water classified as "9." There were a few files noted with elevation values out of range; the points were all classified as "unclassified," so they did not affect the bare earth products. They are, however, problematic if looking for vegetation in addition. Most of these extreme elevations were remedied by Photo Science; a few unclassified extreme values remain in the data set.

About the only format issue was with the header information, in that the number of points for each return (i.e., return 1, return 2) was missing. This is not considered a problem, since the processing of the data by the NOAA Coastal Services Center should correct this. Photo Science believes that this problem is a Terrascan/Terrasolid issue.

Micro Review

In general, the LAS files were very clean of artifacts, and very few qualitative issues were noted. This is consistent with the high quality of the data documented in the accuracy assessment. Some tile-

specific issues were noticed, but for the most part these were relatively minor. Of the 500 LAS tiles reviewed in depth, only 50 showed notable issues (Figure 9).

These issues were generally minor, difficult to find, and for the most part related to flight line matches and water classification questions. The terrain is exceedingly flat and low-lying in most of the collection area, so very small offsets become visible and the difference between “land” and “water” can be subtle.

The flight line offsets noted were in all cases less than 25 cm and, more often, only 10 to 15 cm, which is well within the accuracy specifications of the data. Given the very flat terrain, slight flight line mismatches may be important for modeling water flow. Mismatches below about 5 to 10 cm were difficult to see in the data, but above that, they started to become noticeable. Previous QA reports from Florida counties (Northwest Florida Water Management District) suggested that mismatches of 20 to 30 cm was about the cutoff between acceptable and unacceptable. For the terrain in Colleton and Charleston Counties, the cutoff may be a bit lower; 15 cm seems to be about where the differences become clearly visible as changes in terrain contours. Only a few tiles had flight line mismatches above this threshold and all were corrected. Flight line mismatches were addressed by Photo Science to the satisfaction of the NOAA Coastal Services Center’s QA team.

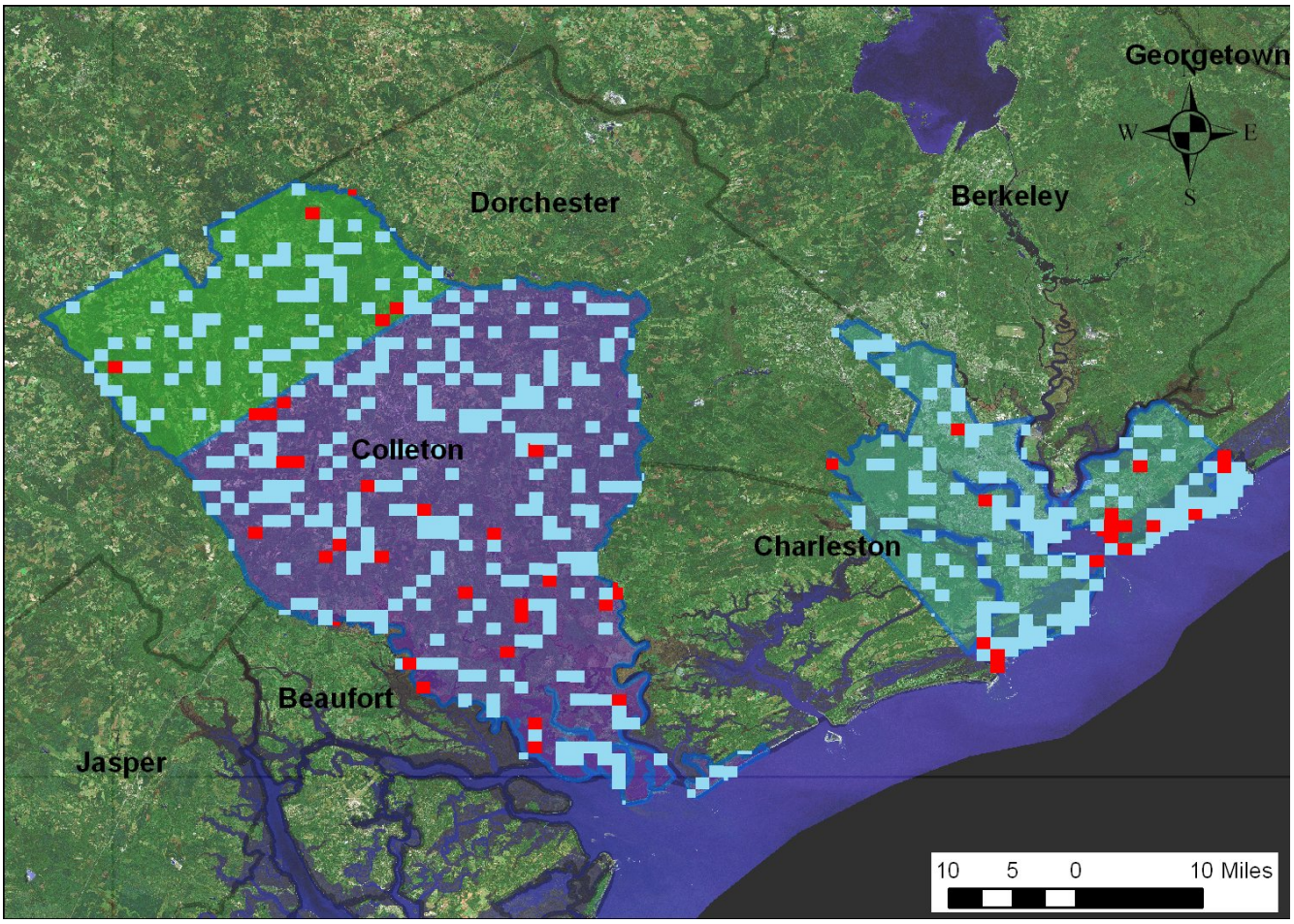


Figure 9. Colleton and Charleston County Tiles Reviewed at Micro Level; Red Tiles Were Flagged for Review and Blue Passed the Review

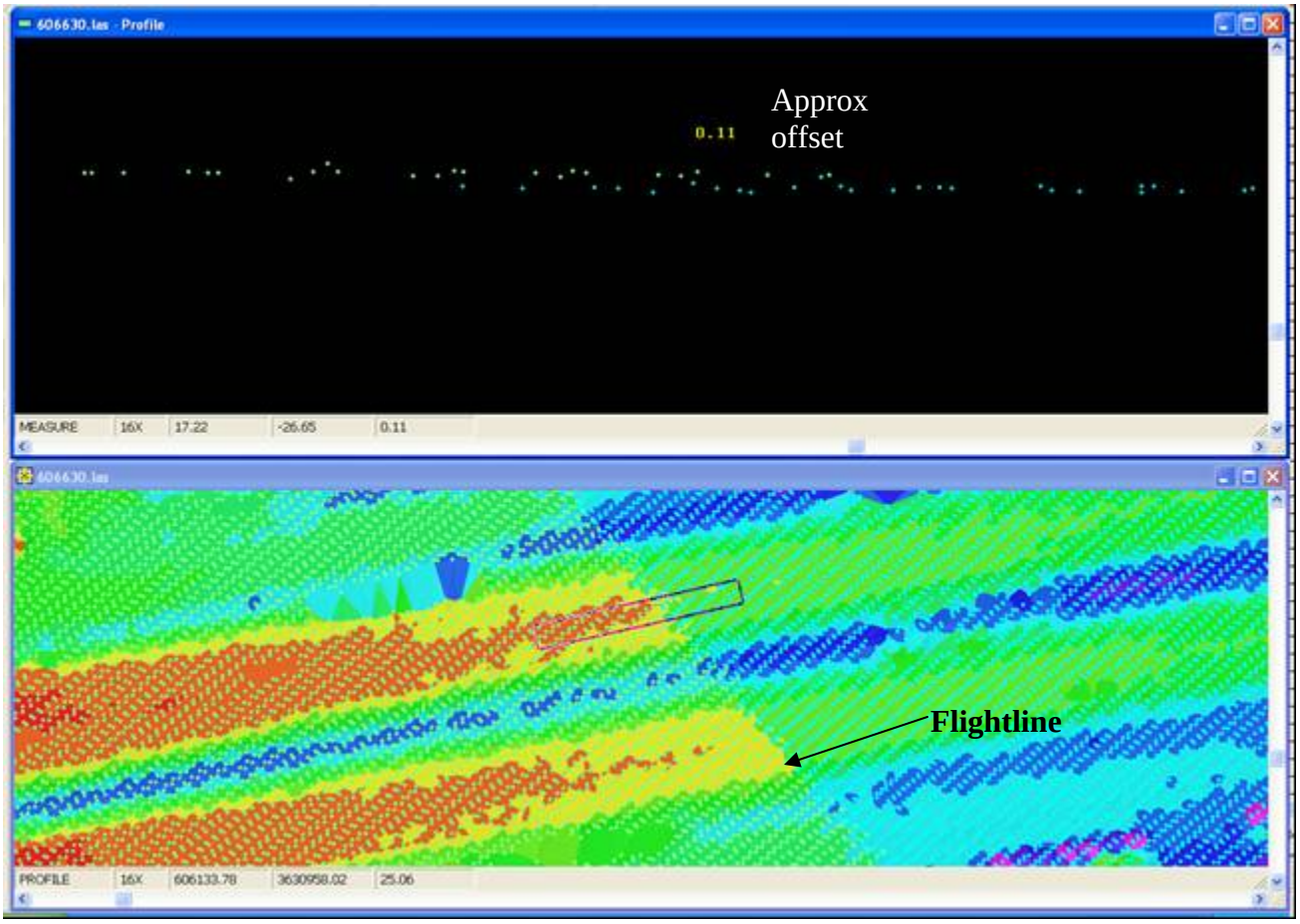


Figure 10. This Example of a Flight Line Error Reveals Minor Differences (11 cm) in the Flat Terrain

The following figures provide examples of the non-flight line mismatches found in the draft data set. As mentioned, these are primarily water classification “calls” and are dependent on both operator definition and tide levels at the time of data collection. These issues are very minor; they are being included mainly for the data user’s general information. In all cases, the issues were addressed and associated impacts from changes to the data evaluated. If clear improvement could be made, the data were corrected; if not, the data remained as reviewed.

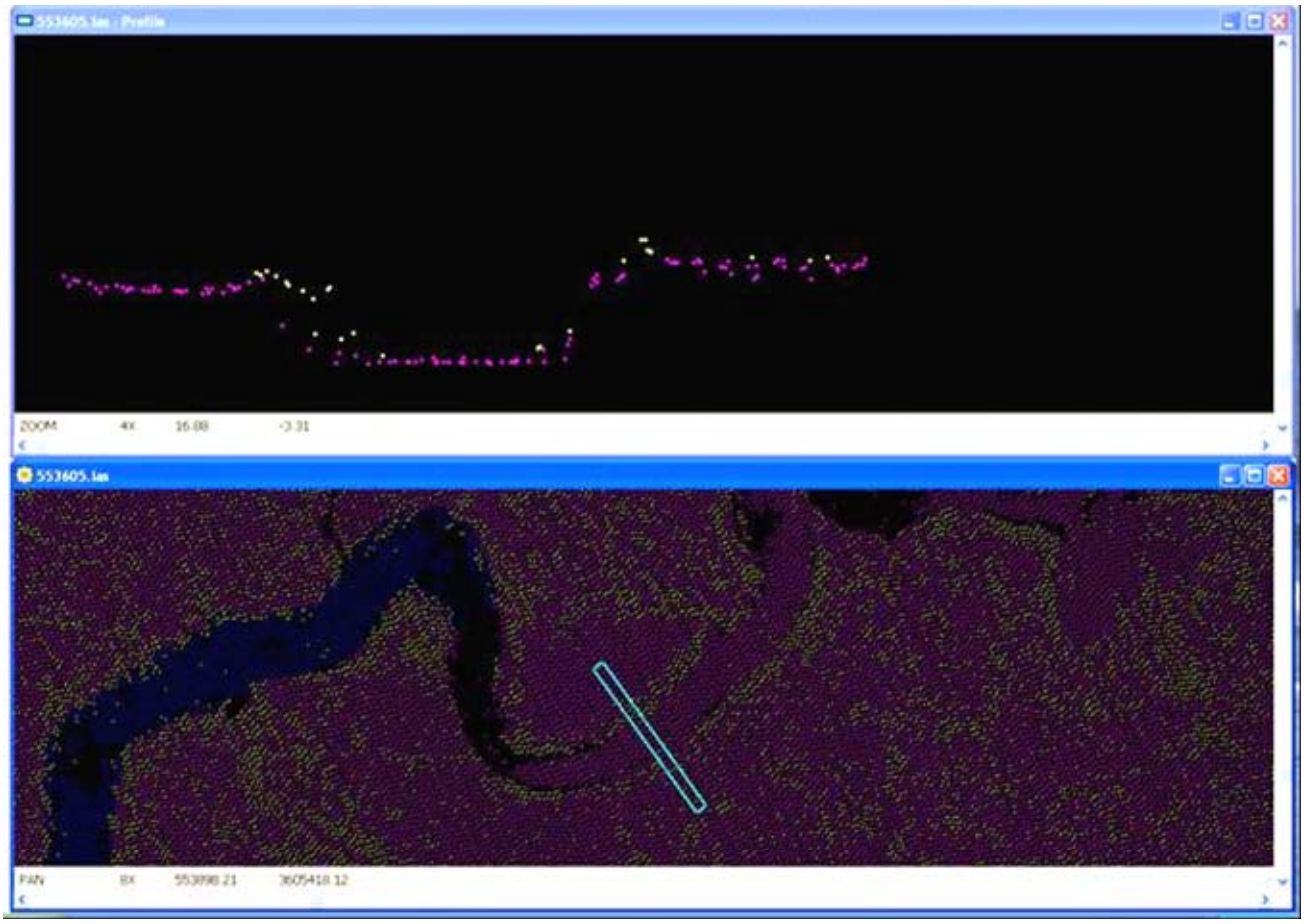


Figure 11. Water Points Classified as Ground Points (Purple) in Small Tidal Creek

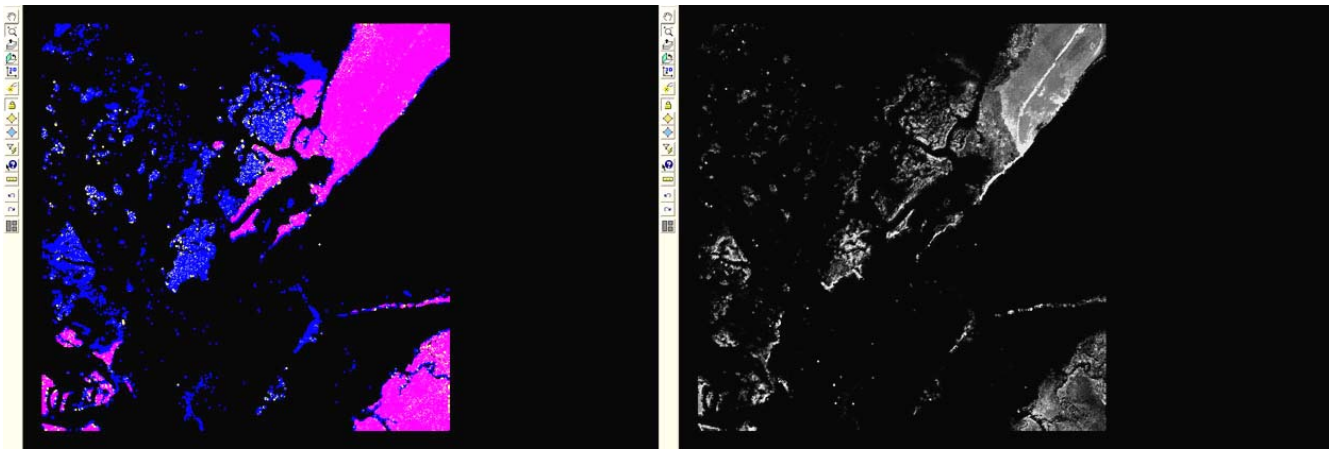


Figure 12. Potential Over-Classification of Water (Blue) in a Marsh Area; the Left Image Shows the Point Classification, and the Right Image Shows the Intensity Data

Digital Elevation Models (DEMs)

The DEM QA results followed the LAS reviews; the DEMs from Colleton and Charleston Counties were, overall, very clean. The tiles chosen for review (about 300) were randomly selected and represent approximately 20% of all tiles (Figure 13). The DEM data are expected to be a highly used product and include both the lidar and breakline information. Some minor issues with the DEMs were found and in many cases were associated with breakline questions. The flagged tiles were submitted to Photo Science for review. Photo Science reviewed and corrected these issues to the satisfaction of the QA team.

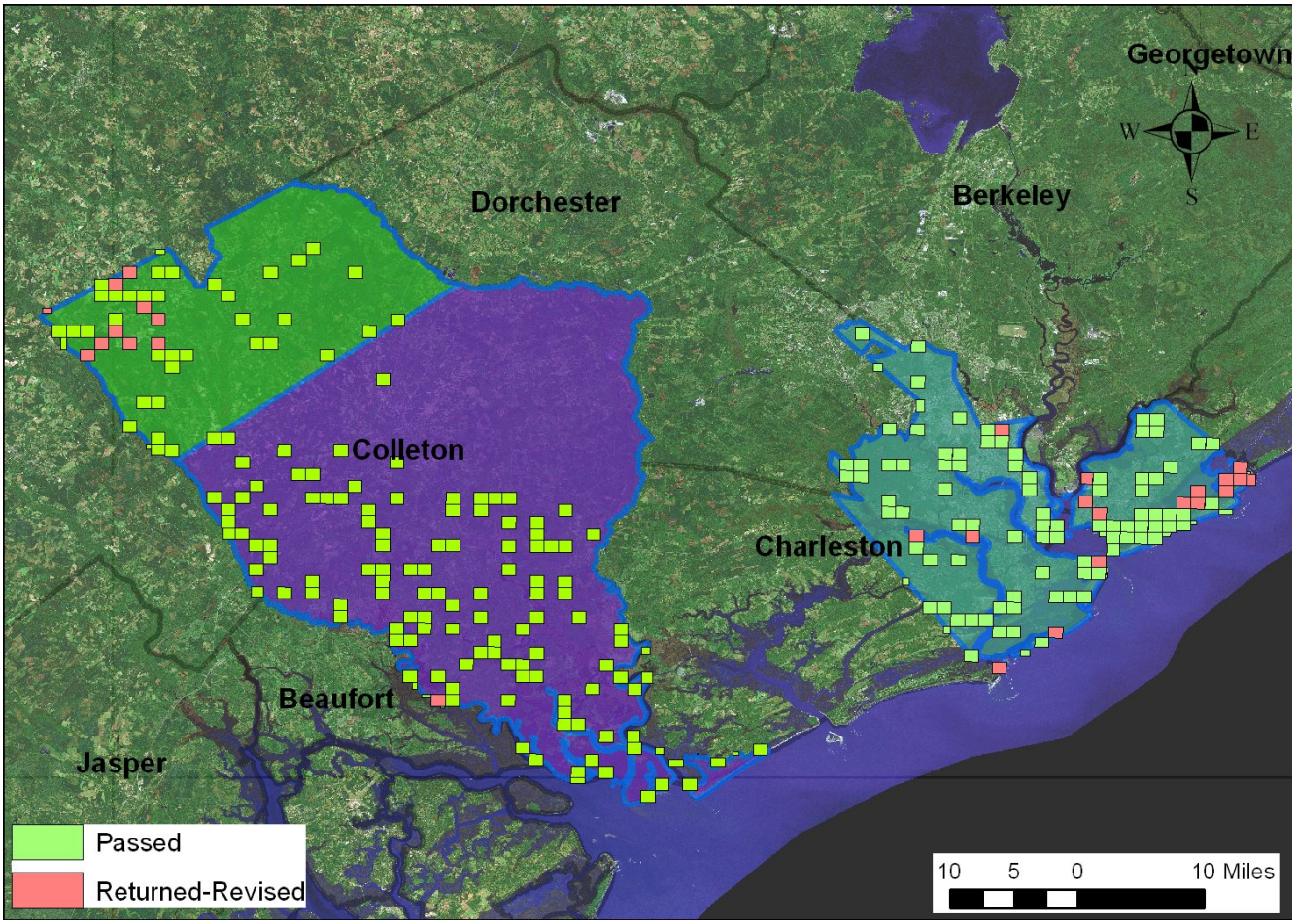


Figure 13. DEMs Reviewed and the Results of the Reviews

Process

Each DEM was checked using the Global Mapper software program with the corresponding DOQQ (Digital Ortho Quarter Quad) and Google Earth images for reference. The DEM tiles were

1. Checked for consistency;
2. Examined for tile edge match with neighboring tiles and match of features across tiles;
3. Checked for flight line match, artifacts, water boundaries, shoreline and road match, and bridge, building, and vegetation removal; and,
4. Reviewed visually for proper hydro-enforcing (i.e., water flowing downstream).

The tiles were reviewed initially to highlight any potential problems and then reviewed by a second reviewer to cross-check the issues. The list of tiles with issues was sent to Photo Science. The issues were mainly small localized artifacts, and in most cases, the professional opinion determined the artifacts to indeed be ground features. The following figures are examples of the minor issues that were found. Given that about 300 tiles were checked, the list is small, which highlights the overall quality of the data set. All the issues have been addressed to the satisfaction of the QA team. The DEMs have been accepted as a very good data set.

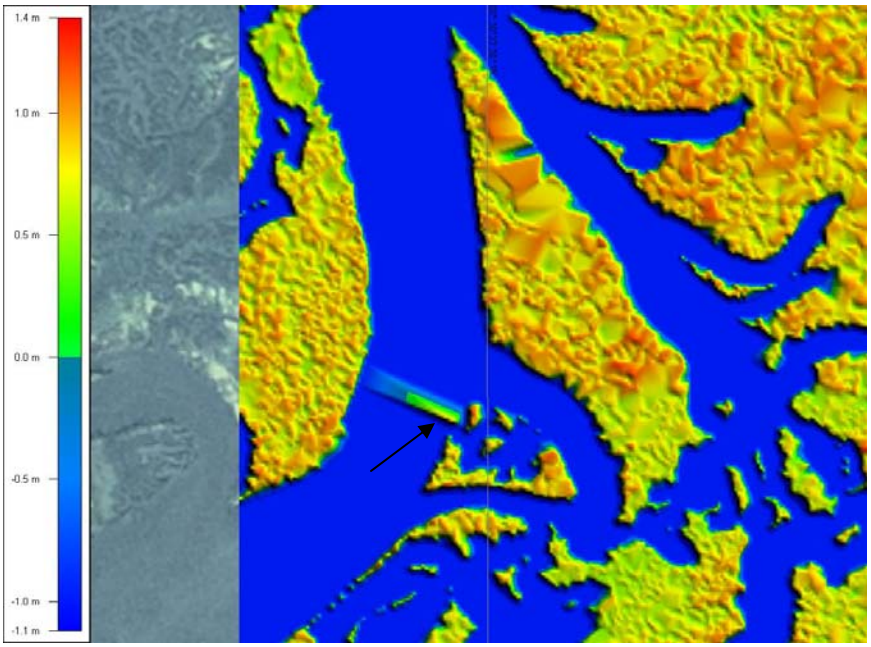


Figure 14. Slight Artifact in Flat Terrain That May Be a Small Barge

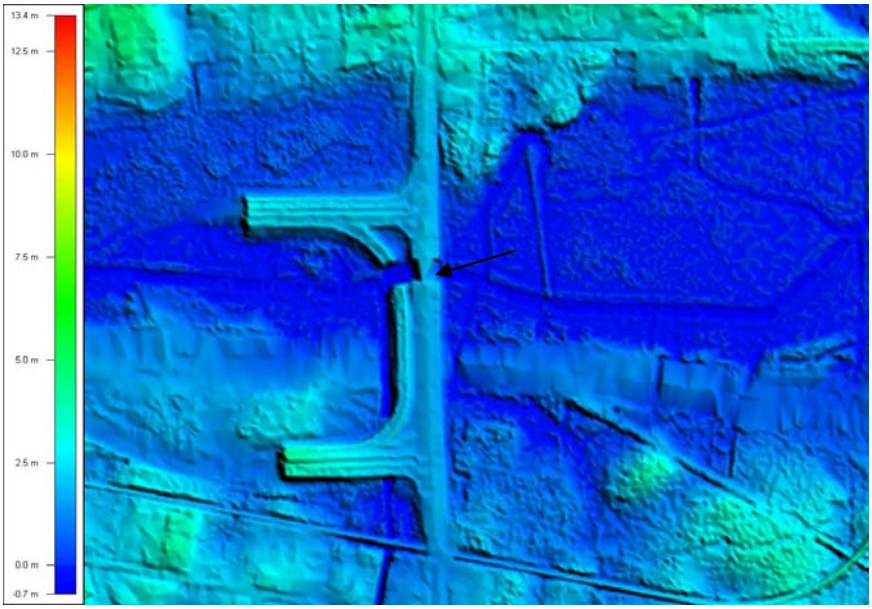


Figure 15. Incomplete Bridge Removal

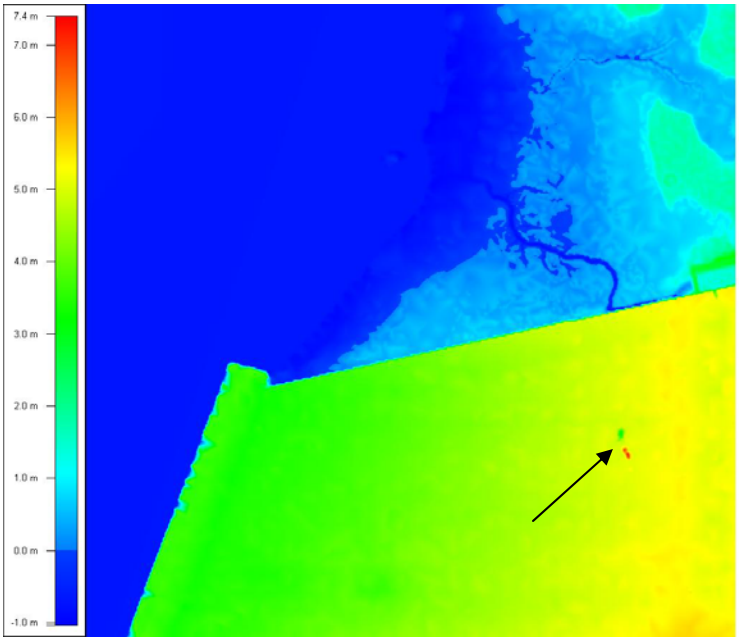
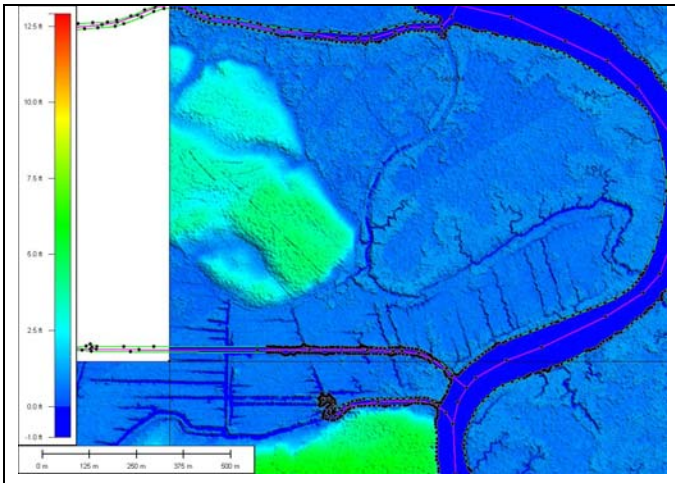


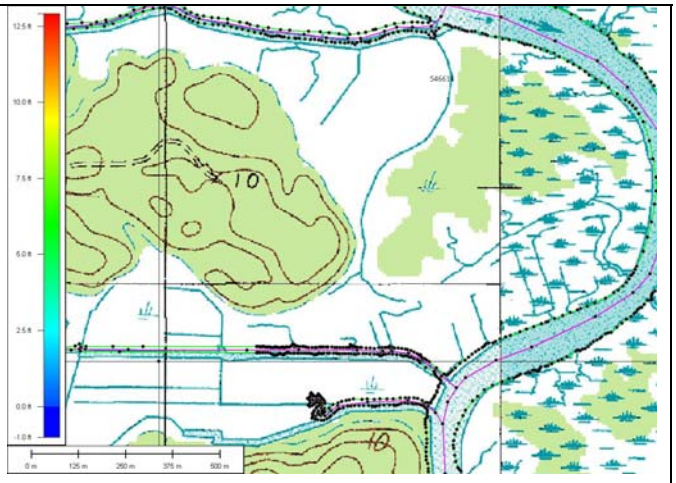
Figure 16. Potential Artifacts in a Flat Concrete Surface

Hydrologic Breaklines

This section is being added primarily for reference. Some slight errors in breaklines were found; however, the bulk of the highlighted issues were in regard to the level of detail required. For example, the SOW (Appendix A) provides guidance on both the width and drainage area for a stream to be included in the breaklines. This does not account for the depth (constrained stream carrying significant water volumes) and also raises questions about changing stream widths (i.e., the stream is narrow for a portion and then increases in width) and how to effectively define the drainage area when performing the QA. That being said, there were some examples provided to Photo Science to review from both Colleton and Charleston Counties.

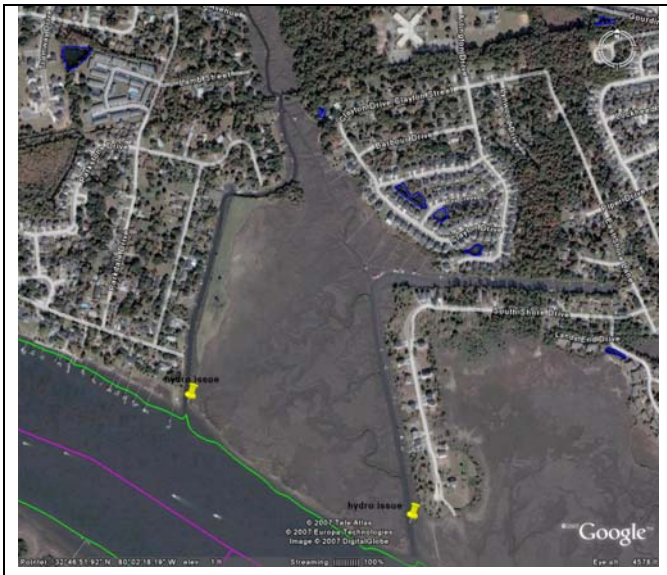


Hydro breaklines on DEMs; note difference in streams and breakline coverage in Colleton County



Breaklines overlain on a U.S. Geological Survey (USGS) quad; same area showing breaklines and USGS water features

Figure 17. One of the Breakline Examples in Colleton County



Judgment call on breakline existence

Apparent disconnect in hydro connectivity

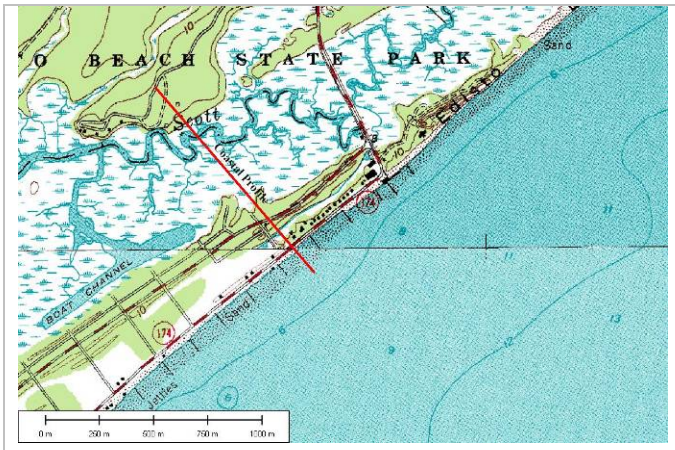
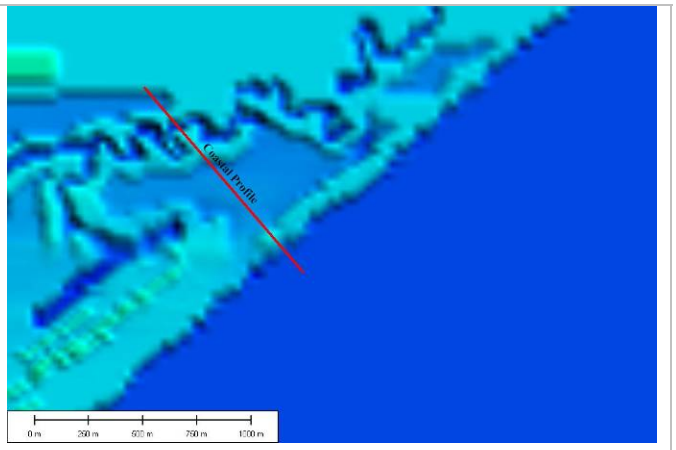
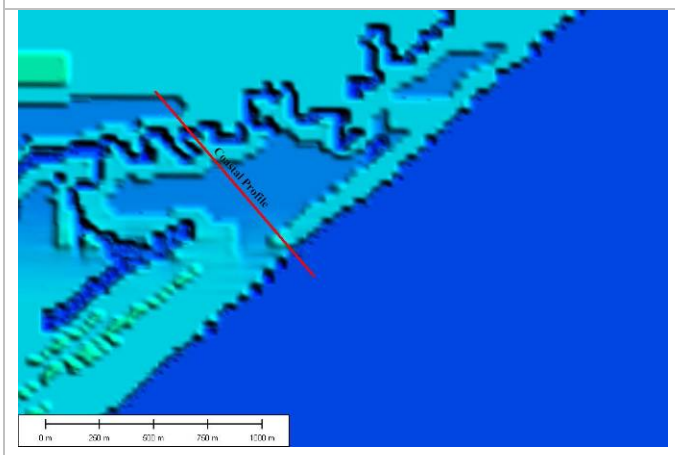
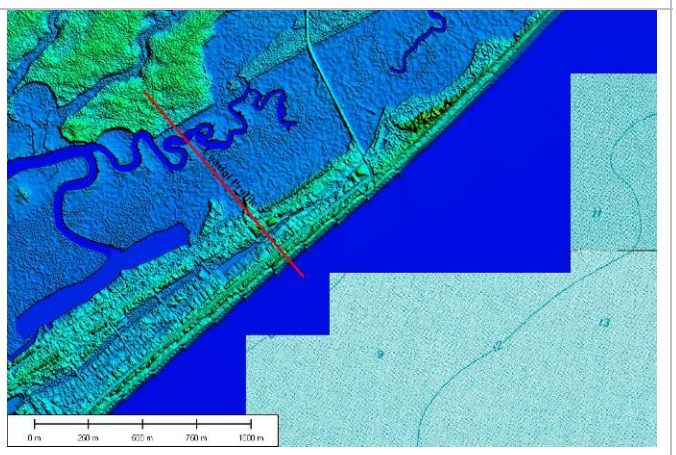
Figure 18. Some of the Breakline Examples in Charleston County

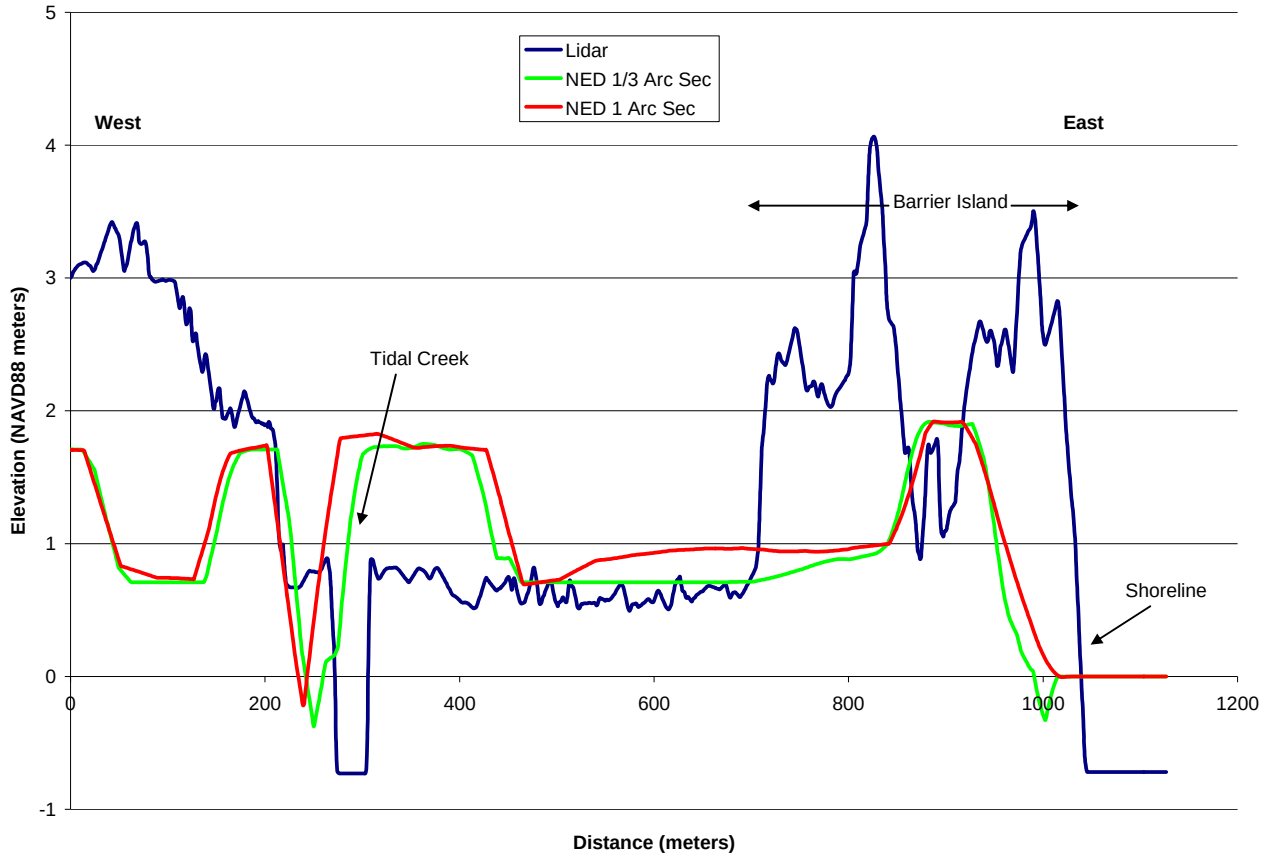
Final acceptance of the breaklines is being passed to the ultimate users of the breakline data. The NOAA Coastal Services Center highlighted some of the more obvious issues related to data integrity (e.g. line work problems) and these were subsequently fixed. Level of detail issues, while raised, have not been fully QA'd.

Coastal Applications

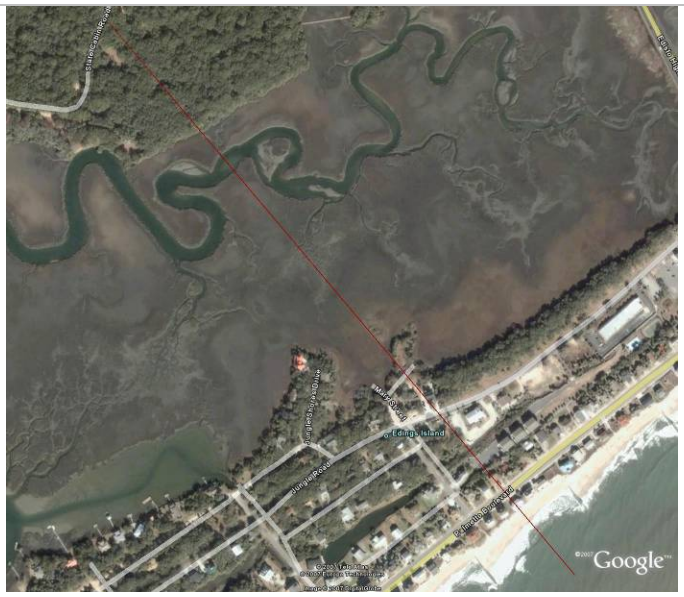
There is a significant amount of coastal marsh in Colleton and Charleston Counties. Also, there are several natural and highly developed barrier islands, and the city of Charleston is located on a peninsula at the convergence of the Ashley, Wando, and Cooper rivers. Therefore, there is a premium placed on micro-topographic change and feature extraction (e.g., dunes, swales). In the coastal zone, a few centimeters can make a large difference in determining major habitats (for restoration among other activities) and projecting commonly flooded areas. The coastal zone is also highly vegetated, which makes it difficult to measure through (e.g., marsh grass, live oak).

An example using these aspects of coastal habitats is presented in Figure 19. In this case, a "coastal profile" is constructed from the upland through a marsh with mixed habitats and then across the barrier island (Edisto Island) (Figure 19, A and F). The available national elevation data (NED) are shown (Figure 19 B and C) in relation to the lidar data that were collected (Figure 19 D). It is clear that there are significant increases in resolution and feature/land form representation. For example, in the NED data, the shape and size of the barrier island are difficult to discern, and the upland has an elevation almost the same as the marsh. This is highlighted in the actual data from the coastal profile (Figure 19 E), where it is clear that the lidar much more accurately captures the extents of coastal features. In this case, the NED data should not be used to map the barrier island extents, let alone more specific features such as dunes.

	
A. Edisto Island with “Coastal Profile” across marsh and barrier island	B. NED 1-arc-second (30-meter) data from area
	
C. NED 1/3-arc-second (10-meter) data from the area	D. Lidar data recently acquired for the area



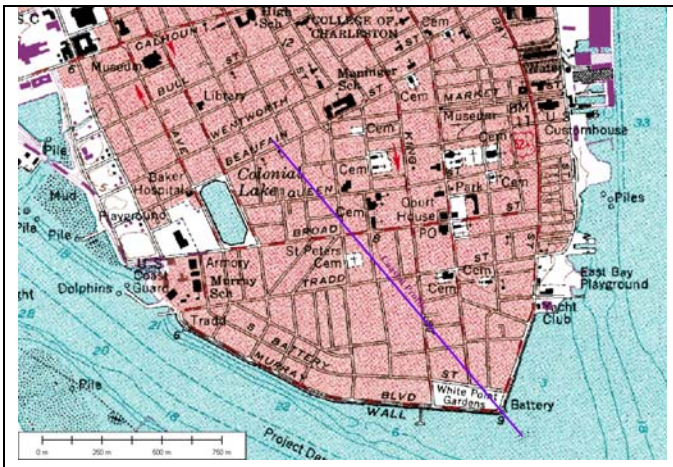
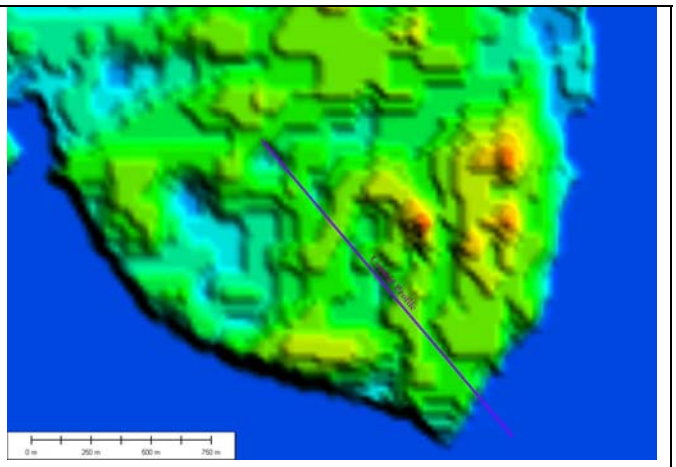
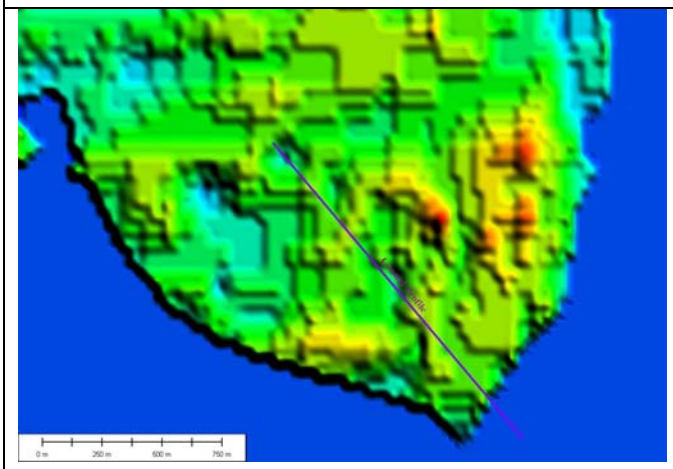
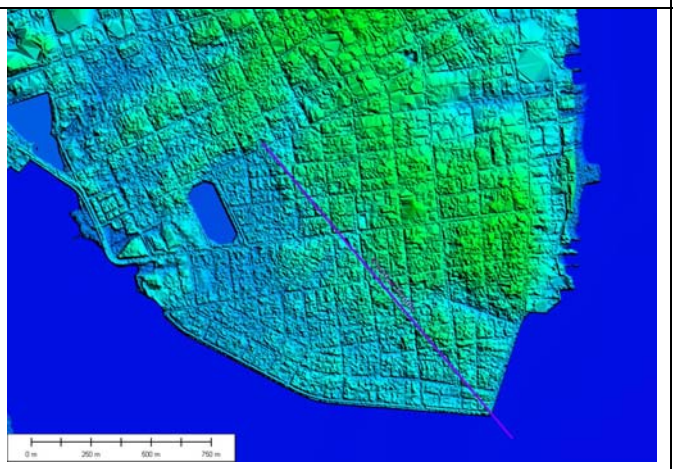
E. Results of the profile data across the marsh and barrier island

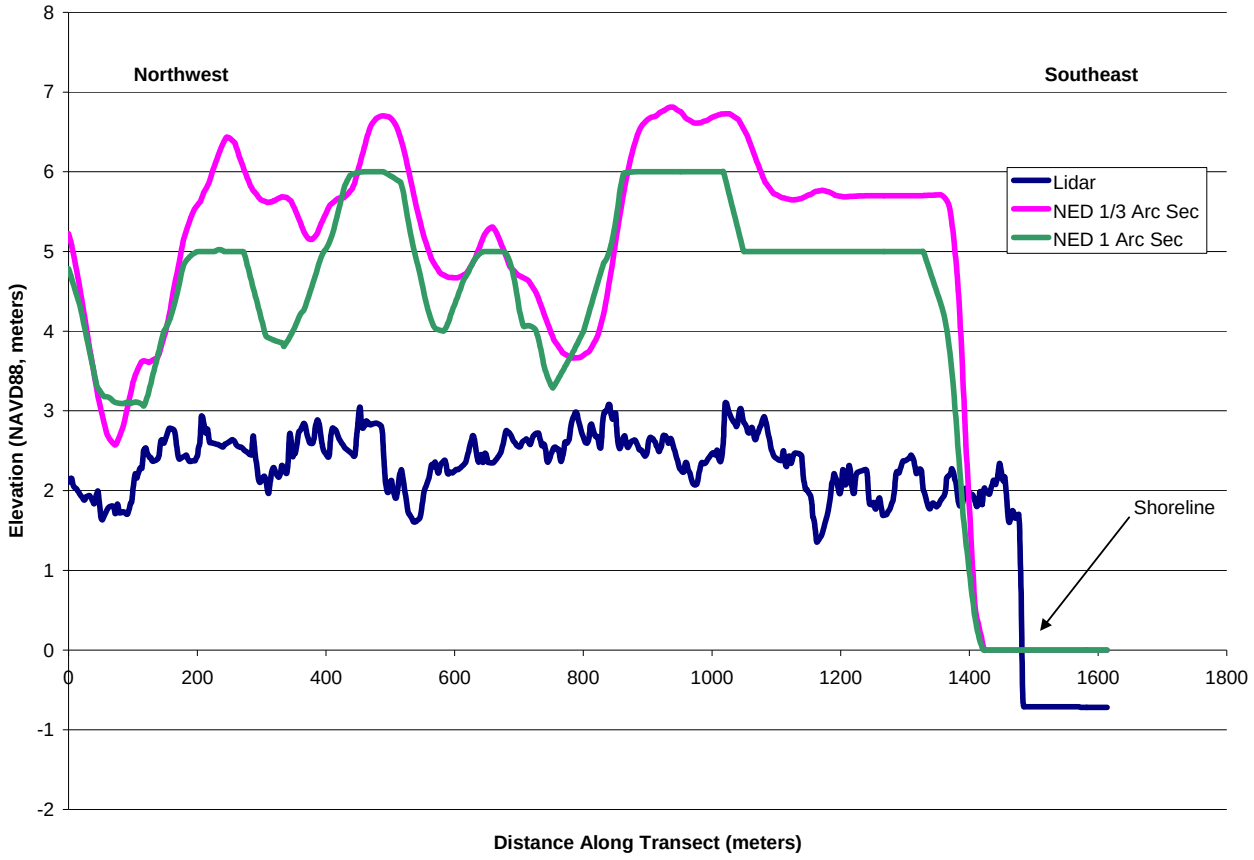


F. Aerial photograph with profile across the island

Figure 19. Colleton County Coastal Area Examined for Lidar Use

In addition to barrier island and marsh land cover, the City of Charleston is also included in the data coverage. Here, the elevation data should help in the creation of flood products such as Digital Flood Insurance Rate Maps (DFIRMs) and public works projects. Instead of vegetation removal and subtle elevation changes that relate to habitat variations, the absolute elevation and removal of “man-made” structures are paramount attributes when using the data for urban settings. In urban areas, the data will likely play a larger role in mapping the aspects related to safety, planning, and development than in habitat definition, so absolute accuracy (more so than relative) is paramount. If an area is mapped at 10 feet, the actual elevation should be very true to this value.

	
A. Coastal Profile in Charleston, South Carolina	B. 1-arc-second (30-meter) NED data for Charleston
	
C. 1/3 arc second (10-meter) NED data for Charleston	D. Lidar data for Charleston, with same elevation colors as NED data.



E. Difference between NED data sets and Lidar data recently collected; the average difference between the 1/3-arc-second NED and the lidar data is more than 2.5 meters (8 feet).

Figure 20. Charleston NED and Lidar Comparison

Figure 20 shows an excellent example of the major difference in absolute values between lidar and NED data, apart from the much higher resolution. The average difference of around 2.5 meters (8 feet) is extremely important in a city where the elevations are, in large part, less than 3 meters (10 feet). In essence, the new lidar data will provide an infinitely more usable product than was previously available.

Conclusions

The data are, in all respects, of very high quality. The minor issues found with the lidar and DEM data either have been corrected or were deemed trivial to the performance of the data for the expected uses. The data collected in both open areas and in areas requiring processing have higher accuracies than called for in the statement of work. The data can be used consistently over the collection area in applications where vertical accuracies of approximately 30 cm (1 foot) are required, even though the data were collected for 2-foot contours. Additionally, relative accuracies may be significantly higher for small areas of investigation where the terrain is not obstructed (e.g., cultivated fields or roads). In these settings, it is likely that 10 cm (4-inch) changes (or less) in the terrain can be mapped with a high level of confidence.

Coastal applications of the data also appear to be supported, since the data show good marsh-cover penetration and clear land-form demarcation. The data's use in the urban setting of Charleston is a striking example of the difference between the previously available data and the updated lidar data.

The accuracy of the data was tested using 166 known points spread over the collection area as ground control. The lidar data were compared to the known points and the following results were calculated.

- Using Federal Geographic Data Committee (FGDC), Federal Emergency Management Agency (FEMA), National Digital Elevation Program (NDEP), and American Society for Photogrammetry and Remote Sensing (ASPRS) methodology: **Tested 16 cm vertical accuracy at 95% confidence level in open terrain.**
- Using NDEP and ASPRS methodology: **Tested 19 cm vertical accuracy at 95% confidence level in all land cover categories combined.**
- Using FGDC and FEMA methodology: **Tested 19 cm vertical accuracy at 95% confidence level in all land cover categories combined.**

References

American Society for Photogrammetry and Remote Sensing (ASPRS). 2004. "ASPRS Guidelines: Vertical Accuracy Reporting for Lidar Data." American Society for Photogrammetry and Remote Sensing. Accessed November 2007 at *www.asprs.org/society/committees/lidar/Downloads/Vertical_Accuracy_Reporting_for_Lidar_Data.pdf*.

Federal Emergency Management Agency (FEMA). 2003. "Guidance for Aerial Mapping and Surveying." Appendix A in *Guidelines and Specifications for Flood Hazard Mapping Partners*. Federal Emergency Management Agency. Accessed November 2007 at *www.fema.gov/plan/prevent/fhm/dl_cgs.shtm*.

Federal Geographic Data Committee (FGDC). 1998. "National Standard for Spatial Data Accuracy." Part 3 of *Geospatial Positioning Accuracy Standards*. FGDC-STD-007.3-1998. Federal Geographic Data Committee. Accessed November 2007 at *www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part3/chapter3*.

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National Oceanic and Atmospheric Administration (NOAA), Coastal Services Center. 2006. "Statement of Work; Jasper County, South Carolina Lidar; Mod 1." November 2006. Unpublished.

Appendices

Appendix A – Statement of Work

Appendix B – Lidar Data Collection Reports

Appendix C – Ground Control Point Collection

Appendix D – Point Data and Calculations

Appendix A

Statement of Work

Coastal Services Center
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

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STATEMENT OF WORK

Jasper County, South Carolina Lidar
Mod 1

November 2006

Table of Contents

List of Acronyms

ASPRS ..... American Society of Photogrammetry and Remote Sensing
CO ..... Contracting Officer
COR ..... Contracting Officer's Representative
CRS ..... Coastal Remote Sensing
CSC ..... Coastal Services Center
FEMA ..... Federal Emergency Management Agency
FGDC ..... Federal Geographic Data Committee
LIDAR ..... Light Detection and Ranging
NAD ..... North American Datum
NAVD ..... North American Vertical Datum
NGA ..... National Geo-spatial Intelligence Agency
NOAA ..... National Oceanic and Atmospheric Administration
NSSDA ..... National Standard for Spatial Data Accuracy
QA ..... Quality Assurance
QC ..... Quality Control
RMSE ..... Root Mean Square Error
SCDNR ..... South Carolina Department of Natural Resources
SOW ..... Statement of Work

1 Overview

This Statement of Work (SOW) has been developed by the National Oceanic and Atmospheric Administration's (NOAA) Coastal Services Center (referred to as the Center) to collect and deliver topographic elevation point data derived from multiple return light detection and ranging (lidar) measurements for areas in coastal South Carolina, specifically Jasper County. Options have been added to this SOW to also acquire lidar data in Colleton and Charleston Counties. The Center is partnering with the South Carolina Department of Natural Resources (SCDNR) Flood Mitigation Program in this project. The data are intended for use in coastal management decision making, including applications such as flood plain mapping. This SOW provides specific information needed by commercial contractors to respond by submitting a technical proposal, a firm fixed price cost proposal, and a timeline detailing how the required products will be produced and delivered for the geographic areas under consideration. An electronic copy of the technical proposal, cost proposal, and timeline shall be provided.

2 Background

The mission of the Center is to support the environmental, social, and economic well being of the coast by linking people, information, and technology. SCDNR'S Flood Mitigation Program mission is to reduce the flood risk to people and property in South Carolina. One of the tools used to help achieve this goal is to provide accurate mapping of flood prone areas, and SCDNR has partnered with Federal Emergency Management Agency (FEMA) to update the Flood Insurance Rate Maps in South Carolina. The data produced from this SOW will support this mission as well as support other local Coastal Zone Managers in their decision-making processes. This data will be used for flood plain mapping and other coastal management applications.

3 Requirements

The Contractor shall provide topographic elevation data for the designated areas of Figure 1 as described in this SOW. Data collection, processing, and delivery shall be accomplished in accordance with the following specifications. The contractor shall provide all necessary labor, equipment, material, software, and supplies to satisfactorily complete the SOW.

3.1 Data Coverage

The project area shall be part of Jasper County, South Carolina. This area is estimated to cover approximately 1000 km^2, but should be verified by the contractor. The county is depicted in Figure 1 for reference. An ESRI shapefile of the county will be provided, but the shapefile cannot be assumed to represent the current shoreline or exact boundaries of collection.

3.2 Data Collection and Delivery

- The Contractor shall deliver the Lidar multiple-return mass points for the specified area(s) in the LAS **1.1** data format. In addition to the measured elevation value, the intensity value for each return shall be included and, at a minimum, returns shall be classified as water, bare-ground, or not bare ground according to the American Society of Photogrammetry and Remote Sensing (ASPRS) LAS format classification table. The point data type used in LAS format shall include the GPS time and the headers shall include the date of collection. **Time information is important for tidal referencing.**
- The time for each data point must be retrievable. For the LAS format, this means that the points within any given file must be from the same GPS week since only one date is provided in the header and the per point time is in terms of seconds of the GPS week. The contractor may elect to use POSIX time instead of GPS time, but this should be clear in the metadata.
- Nominal point spacing for the Lidar mass points shall meet the FEMA flood plain mapping specifications but shall not exceed 2 meters.
- File organization of the point data is at the discretion of the contractor. Thus, it does not need to be tiled if that would prevent the accurate time stamp for the data in LAS format. However, files shall be no more than 2.0 Gigabytes in size. The file naming convention shall be documented.
- **In addition to Lidar mass points a Bare-earth gridded DEM / DTM shall be created from the points that meets or exceeds FEMA flood plain mapping specifications. The DEM/DTM shall be continuous over the entire area (inland water bodies shall have approximate elevations). The DEM/DTM shall be delivered in UTM, zone 17 north, meters; a projection file will be provided upon request. Vertical datum for the gridded product shall be the North American Vertical Datum of 1988 (NAVD88).**
- The Contractor shall collect and deliver all **lidar** point data referenced to the North American Datum of 1983 (NAD83) and the Geodetic Reference System of 1980 (GRS80). Horizontal units shall be in **geographic**. Vertical units shall be in meters above the GRS80 ellipsoid surface. **Note, this is a different vertical datum than the gridded DEM**.
- Lidar data accuracy determination shall employ the National Standard for Spatial Data Accuracy (NSSDA). When compared to GPS survey grade points in generally flat non-vegetated areas, at least 95% of the positions shall have an error less than or equal to 29.4 cm (equivalent to root mean square error of 15 cm if errors were normally distributed). **Additionally, the supplemental and consolidated vertical accuracies (SVA & CVA) should be better than 36.3 cm at the 95% confidence level**. Horizontal accuracy shall be 1 meter RMSE or better.
- Lidar data from different flight lines shall be consistent across flight lines, *i.e.*, there is no vertical offset between adjacent flightlines.

- Spatial coverage prior to vegetation editing shall be continuous in the designated geographic areas. Lidar data gaps between adjacent flight lines larger than two meters will not be acceptable.
- Data delivery shall be by removable hard drive supporting USB 2.0 standards. The hard drive(s) will not be returned by the government.
- The Contractor shall deliver the x,y,z (latitude, longitude, elevation) data from the control points used for quality control. Points shall be delivered in ASCII format on the same media used for the elevation data delivery. The control points shall be delivered with sufficient detail regarding collection to allow the Government to tie into the same survey network of control points for an independent survey.
- Delivered elevation data shall become the property of the Government and will be shared with the public. The contractor shall retain the ability to use and distribute the data as they see fit.

If the contractor believes other delivery formats and/or mechanisms will serve the government's needs in a more efficient manner, the contractor is encouraged to propose alternatives.

3.3 Classification system

The contractor shall use the point classification system endorsed by the ASPRS for the LAS format.

3.4 Records and Metadata

The contractor shall document all delivered data and data products (including options if exercised) according to Executive Order 12906 (http://www.fgdc.gov/publications/documents/geninfo/execord.html) Specifically, the contractor shall deliver for all data and data products, metadata records which detail all flight lines, flight dates and times, datums, reprojections, resampling algorithms, processing steps, field records, and any other pertinent information. The metadata records shall conform to the Content Standards for Digital Geospatial Metadata (FGDC-STD-001-1998) as published on May 1, 2000, by the Federal Geographic Data Committee (FGDC) or to any format that supersedes it as determined by the FGDC. (http://www.fgdc.gov/metadata/csdgm/). Profiles and extensions to the standard that have been endorsed by the FGDC shall be used if they are applicable to the data or data products. The metadata records shall contain any and all elements, including those that are considered optional, wherever applicable to the data or data product. The metadata record shall contain sufficient detail to ensure the data or data product can be fully understood for future use and for posterity. The metadata records shall be delivered free of errors in both content and format as determined by the metadata parser (mp) program developed by the United States Geological Survey or an equivalent. The metadata records will be subject to review and approval prior to final acceptance by the Government.

3.5 Kickoff Meetings

The contractor shall participate in a teleconference kickoff meeting with the NOAA Coastal Services Center within 30 days of contract award unless otherwise agreed upon by NOAA and the contractor. This meeting will serve as an information exchange and planning meeting for future activities such as delivery of government furnished equipment (GFE) and field trips. The contractor shall prepare an agenda for this meeting and issue meeting minutes within 7 days after the meeting.

3.6 Contractor Coordination

Communication and coordination between both the contractor and the Government is considered vital to the satisfactory accomplishment of this SOW. The Contractor shall expect periodic interaction with the Government to ensure clear understanding of the anticipated products and satisfactory progress in the delivery of products.

The contractor shall submit monthly progress reports to the Government summarizing progress made and problems encountered. After submittal of each of these reports the contractor shall schedule a conference call with the government to discuss the progress of the project and any issues that need to be addressed. The contractor shall prepare and distribute an agenda for the call and shall distribute the meeting minutes within 5 days of the conclusion of the call.

3.7 Deliverables

This section contains the complete list of deliverables associated with this project. Each deliverable must include a proposed measure of acceptability. All submitted plans shall be of sufficient detail so that the Government can verify that the contractor has a thorough understanding of the requirements of this SOW. The contractor shall also complete the attached spreadsheet with a percentage of the overall task order that each deliverable represents and the proposed due date for each deliverable. This data will be used to track performance and for approval of invoices. The contractor may propose additional deliverables/ milestones in their technical proposal if they determine they are required. The following project deliverables are required:

1 Work Plan – in some instances, the technical proposal may be accepted as the work plan. In either case, the plan shall be in Microsoft Word format and **shall** include the major milestones and deliverables shown in **Gantt chart format**.
2 Quality Control Plan – including detailed discussion of accuracy assessment methods/plan or other means of proving contract specifications have been met in Microsoft Word format.
3 Project schedule to include dates for all deliverables
4 Monthly progress report in a Microsoft Word, Excel or Project format on the 7th day of the month. In some cases a more appropriate regularly scheduled

reporting timetable may be substituted contingent on agreement by all parties.

5 Final Report – The report shall summarize the project and provide the quality control evaluation showing that the project deliverables meet the contract specifications. The report shall be in Microsoft Word format.

6 FGDC-compliant metadata for all data sets per the project requirements

7 Digital elevation data sets per the requirements of section 3.2. These include:

- Multiple-return classified mass point data in LAS format meeting the specification in section 3.
- Bare-earth DEM meeting or exceeding FEMA flood plain mapping specifications.
- QA/QC validation data

3.8 Product Delivery Schedule Guidance

The contractor shall propose a product delivery schedule in their technical proposal. As a guideline, the government does not expect delivery to require more than nine-months from time of contract award.

3.9 Product Delivery Addresses

The deliverables listed above shall be delivered to the COR at the following address. Technical questions shall be addressed to the Technical POC.

NOAA COR
NOAA Coastal Services Center
2234 South Hobson Avenue
Charleston, SC 29405
Attn: Dennis Hall
(843) 740-1323
Dennis.Hall@noaa.gov

NOAA Technical POC
NOAA Coastal Services Center
2234 South Hobson Avenue
Charleston, SC 29405
Attn: Kirk Waters
(843) 740-1227
Kirk.Waters@noaa.gov

4 Options

The Government reserves the right to exercise the following options. Payment would be made at a negotiated unit price and as described in the task order.

Option 1.

The contractor shall collect, process, and deliver lidar data for the remainder of Jasper County, South Carolina (see figure 1) to the same specifications as the main task order. This option includes development of breaklines for **all of Jasper County (including the base SOW area)** per Attachment A.

Option 2a.
The contractor shall collect, process, and deliver lidar data for coastal Colleton County, South Carolina (see figure 1) to the same specifications as the main task order. This option includes development of breaklines per Attachment A.

Option 2b.
The contractor shall collect, process, and deliver lidar data for inland Colleton County, South Carolina (see figure 1) to the same specifications as the main task order. This option includes development of breaklines per Attachment A.

Option 3a.
The contractor shall collect, process, and deliver lidar data for Charleston County, South Carolina (see figure 1) to the same specifications as the main task order. This option includes development of breaklines per Attachment A.

Option 3b.
The contractor shall collect, process, and deliver lidar data for the remainder of Charleston County, South Carolina (see figure 1) to the same specifications as the main task order. This option includes development of breaklines per Attachment A.

5 Figures and Maps

South Carolina Lidar
Areas

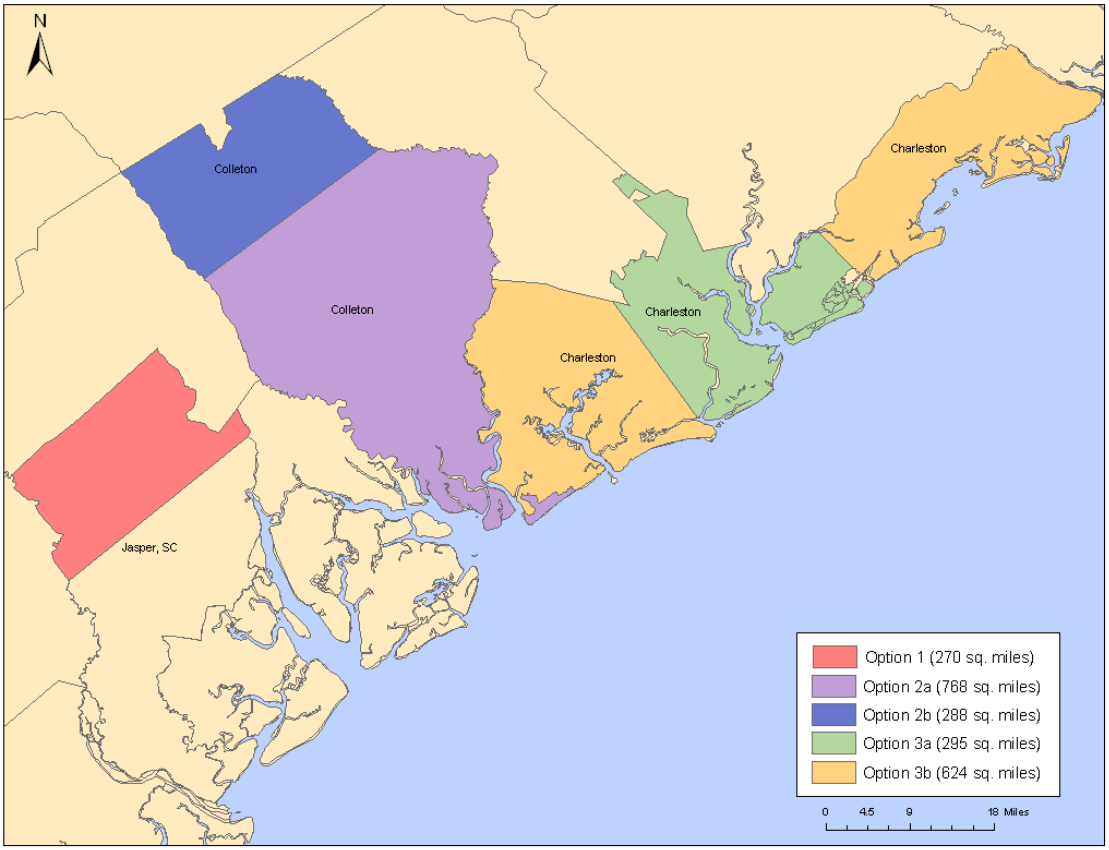


Figure 1. Map showing the areas for Lidar collection covering Jasper County, Colleton, and Charleston Counties..

Attachment A
Generation of a Hydrologically-Corrected Stream Network To Support Floodplain Mapping

A hydrologically-corrected stream network shall be generated such that all hydrologic feature components exhibit a downhill direction of flow, and that they are topologically structured (clipped, joined, and noded) at all line intersections, to maintain connectivity of the stream network. At a minimum, the following hydrologic features will be collected:

- Stream and canal centerlines
- Drainage ditches
- Tops and bottoms of stream banks
- Closed water bodies (lakes and ponds) having a surface area measuring greater than ¼ acre.

Generation Methods: Following are three possible methodologies for producing the hydrologically-corrected stream network:

1. Stereo aerial photography available of a scale suitable to meet the desired vertical accuracy for the end product(s) can be used. Depending on the scale and date of the photography, there may be discrepancies in horizontal location and elevation data between the imagery and elevation data. These discrepancies should be resolved in favor of the lidar data to ensure consistency in the final TIN used for modeling. *Note this is not time efficient or cost effective if appropriate imagery does not already exist.*

2. Stereo imagery can be created from the lidar intensity data and the stream network can be digitized in the same manner as if one were using stereo aerial photography. This process is often referred to as “lidargrammetry”. Because lidar intensity data can be more difficult to interpret than aerial photography, and because it can be somewhat difficult to accurately see the ground in heavy vegetation, it is recommended that the stream network be reviewed against a lidar-derived bare earth hillshade and edited as necessary.

3. The final approach, which has been proven to generate a reliable hydrologically-corrected stream network, is to digitize the horizontal location of hydrologic features from the best source digital orthophotography, and perform the same breakline-to-hillshade comparison and edit as described. The planimetric features are then draped on the lidar-derived bare earth surface and z values are interpolated for each of the XY vertices along each breakline segment. Vertical smoothing must be performed to ensure continuous downstream flow.

Development Rules: The following rules will apply to developing the hydrologically-corrected stream network:

1. Centerlines shall be generated for all streams, canals and ditches that drain an area greater than one square mile.
2. Centerlines shall remain unbroken through closed water bodies (lakes and ponds). ***See Example No. 1***
3. Centerlines shall remain unbroken where it is clearly evident where they meet road or railroad edges and pass through culverts or under bridges to the opposite side. ***See Example No. 2***
4. Streams having a width greater than 40 feet for a distance greater than 540 feet shall be captured as a centerline with a double line stream channel that forms a closed polygon where the stream narrows or joins another stream channel polygon at a confluence.
5. All streamlines that are initially captured in 2D shall undergo a process that will assign elevations to the vertices of the centerline based on the surrounding lidar-derived bare earth points.
6. All streamlines regardless of capture method shall be hydro-enforced to ensure smooth continuous downhill flow. ***See Example No. 3***
7. Unique attribution shall be applied to single line streams, double line streams, so they are easily distinguishable from one another.

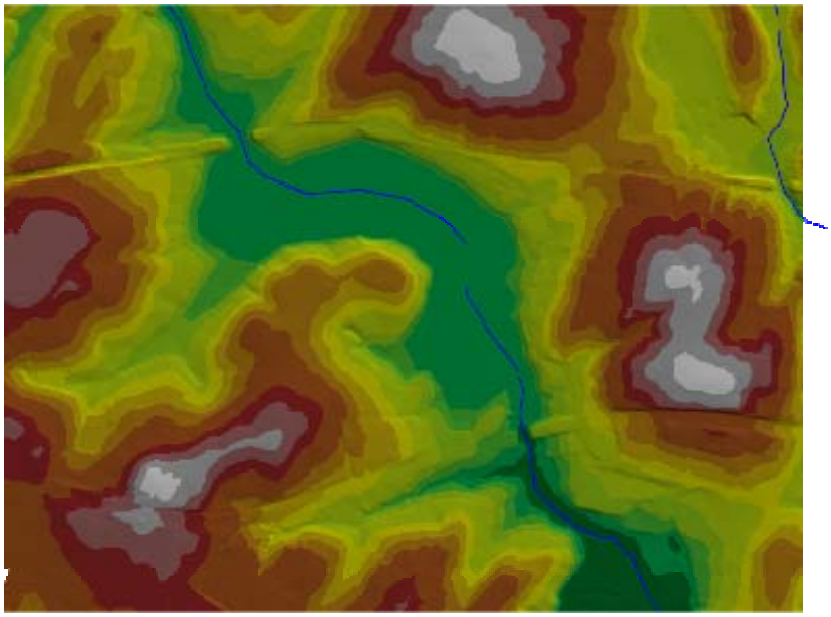
Other Lidar Data Requirements

- **Obscured Areas:** Heavily vegetated areas such as dense forested areas, mangroves, palmetto scrub, where the lidar bare earth point spacing is too sparse to accurately model the terrain surface, shall be delineated by "obscured area" polygons.

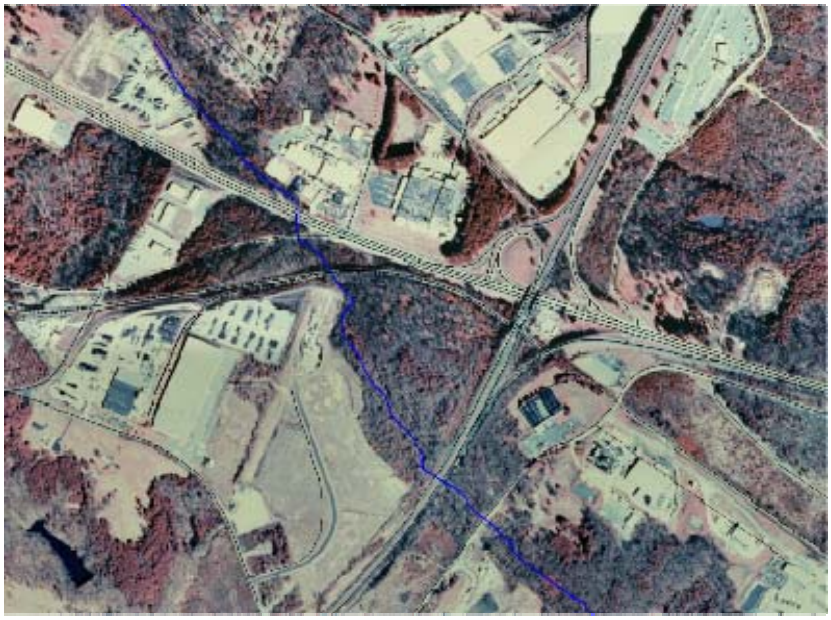
- **Data Cleanliness:** It is strongly recommended that the lidar data be processed to a true bare earth surface, by removing all above ground points. To facilitate the hydraulic modeling of riverine study areas, it is important to remove all bridges and large box culverts from the bare earth data set. Bridge and culvert points should be given a unique classification in the .LAS file.

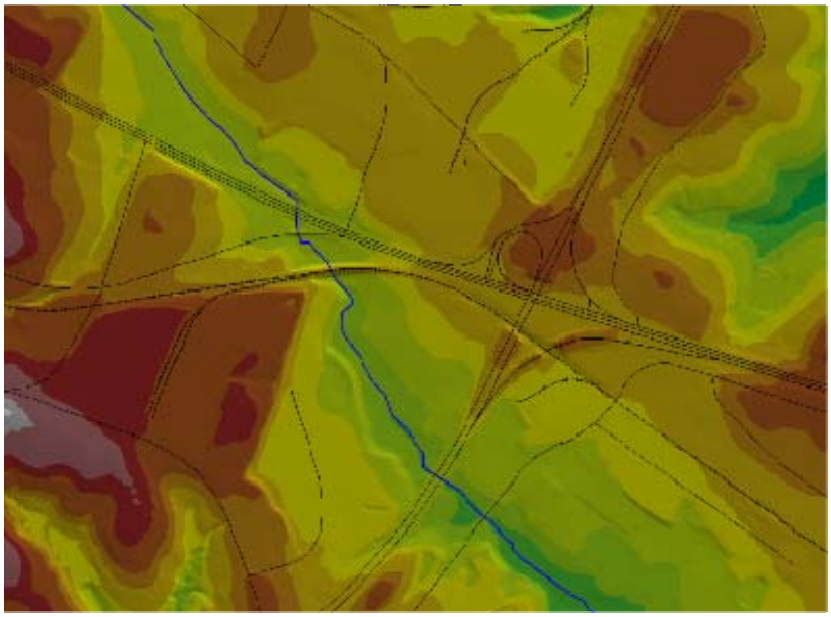
- **Water Points:**3D Polygons should be captured for all closed water body greater that ¼ acre in size as described above, **ALL** water points should be reclassified as water in the all-points lidar deliverable; they should be removed from the bare earth point file.

Example No. 1
Continuous path lines through closed water bodies

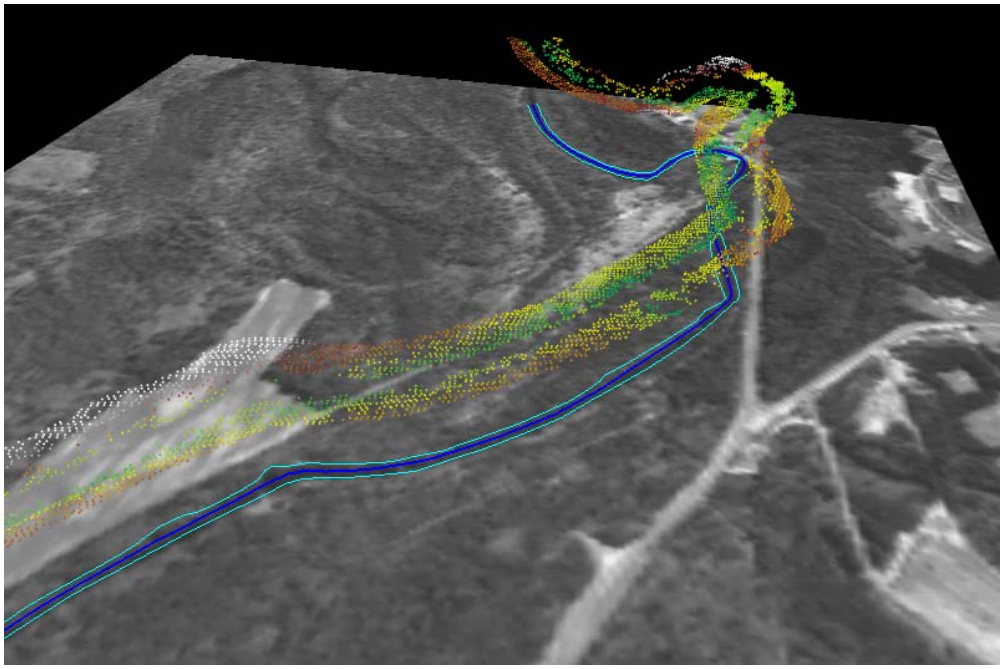


Example No. 2
Continuous path lines under roads and railroads

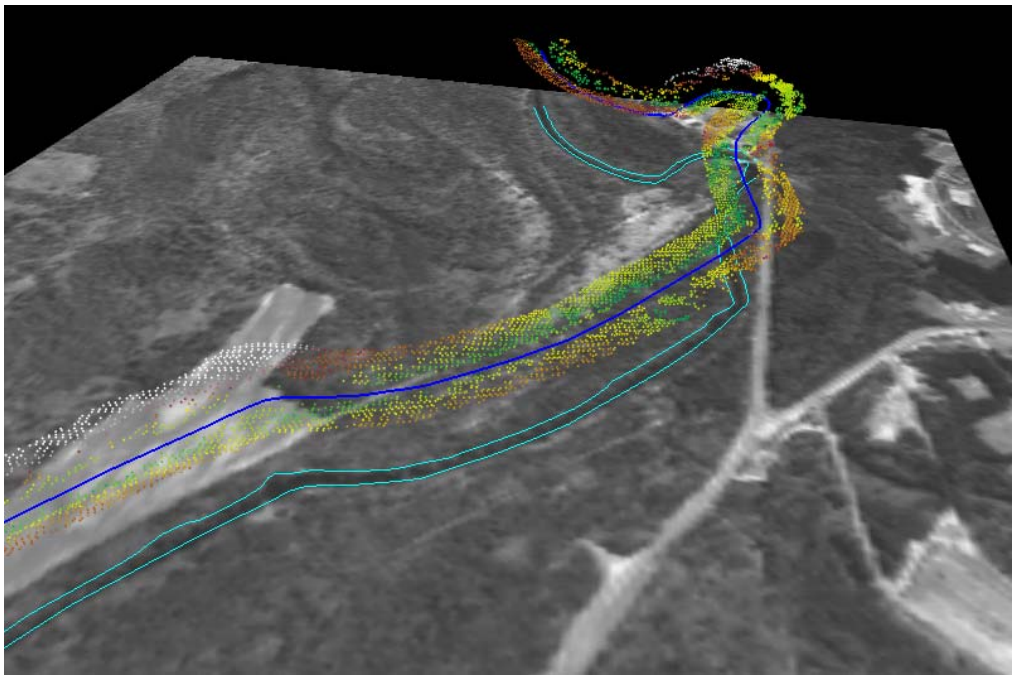




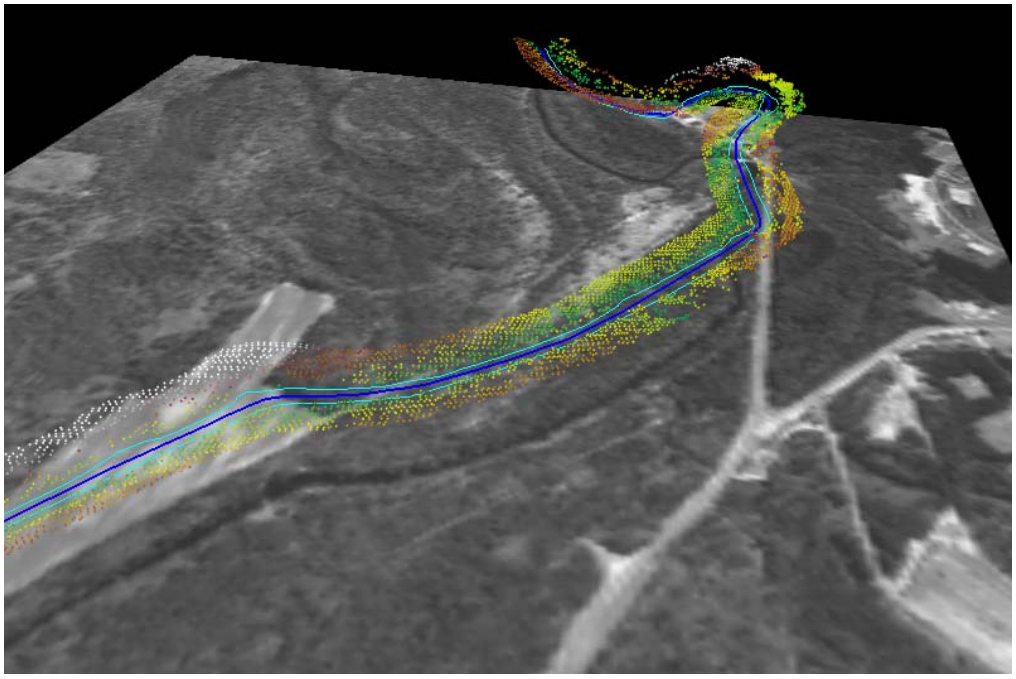
Example No. 3
Hydro-enforced 3D Breaklines



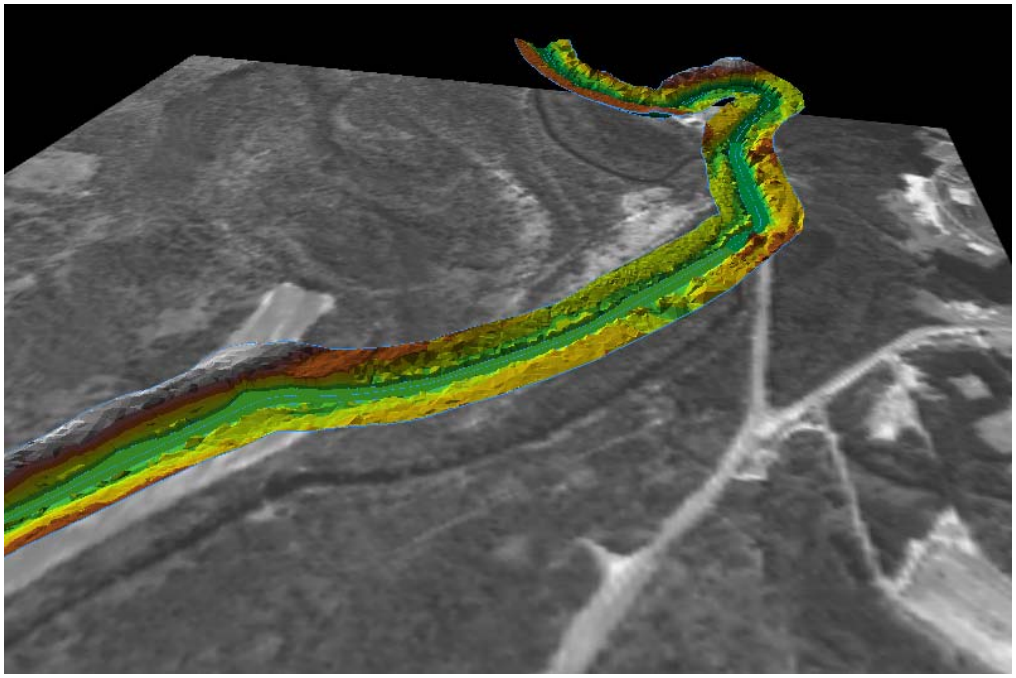
This shows the LIDAR Points at their true elevations above the orthophoto and new line work at 0 elevation



At this step, the vertices of the stream centerline have been assigned elevations from the LIDAR points, and the line has been smoothed to enforce a continuous downhill flow.



The vertices of the Edge-of-Bank lines are then adjusted vertically to match the stream centerline vertices.



A new TIN is then created from the remaining LIDAR points and the newly synthesized breaklines. This TIN shows the stream channel clearly defined at a level below the adjacent land.

Appendix B

Lidar Data Collection Reports

Lidar Report

for

Charleston County, SC

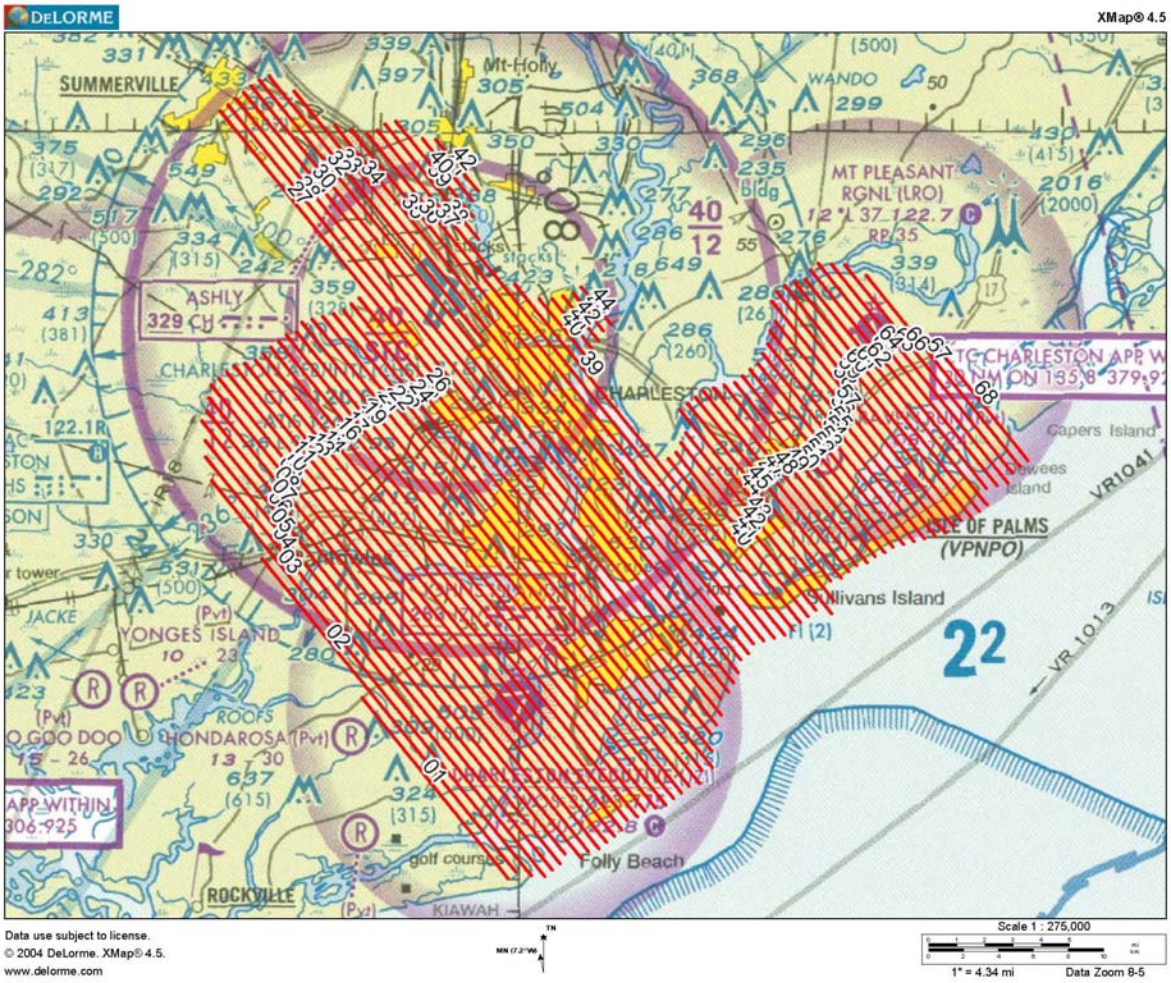
January 14, 2008

PHOTO SCIENCE
Geospatial Solutions

Table of Contents

Project Description

The purpose of this project is to provide professional surveying and mapping services for the creation of a high-resolution digital elevation model developed from LIDAR data for a portion of Charleston County, South Carolina. The project area is shown in the graphic below.



Aerial Platform / Lidar Sensor

All flights for the project were accomplished with customized single-engine Cessna 206s which provide an ideal, stable aerial base for Lidar acquisition. This platform has relatively fast cruise speeds that are beneficial for project mobilization / demobilization while maintaining relatively slow stall speeds which can prove ideal for collection of a high-density, consistent data posting.

The Lidar sensor used for this project was one of our two Leica ALS-50 sensors. This system is capable of collecting data at a maximum frequency of 150 kHz, which affords elevation data collection of up to 150,000 points per second. This sensor is also equipped with the ability to measure up to 4 returns per outgoing pulse from the laser and these come in the form of 1st, 2nd, 3rd, and last returns. The intensity of the first three returns is also captured during the aerial acquisition. This project was flown in its entirety with our Leica SN059 sensor.

Flight Parameters

Detailed project planning was performed for this project. This planning was based on project specific requirements and the characteristics of the project site. The basis of this planning included the required accuracies, type of development, amount and type of vegetation within the project area, the required data posting, and potential altitude restrictions for flights in the general area. A brief summary of the aerial acquisition parameters for this project are shown in the table below:

Parameter	Value
Flying Height (AMT)	4500 feet
Nominal ground speed	110 knots
Field of View	33˚
Laser Rate	41 kHz
Scan Rate	75.4 Hz
Maximum Cross Track Posting	1.5 meters
Maximum Along Track Posting	1.5 meters
Nominal Sidelap	28%

These collection parameters resulted in a swath width of 2,300 feet and an average point distribution of 1.4 points per square meter.

Dates Flown

Collection occurred as weather permitted between February 22 and February 26, 2007. In all, a total of 8 lifts were flown within this time frame.

Base Stations Used

ABGPS stations were Trimble 5700 data collection units, logging at 2 hertz, paired with Trimble Zephyr Geodetic antennas, which were mounted on variable height tripods with the H.I. measured at the beginning and end of each logging session.

The overall study area required two separate base stations, described on following pages, each flown in relation to at least one GPS base station with local CORS SCCC used as a backup for each lift.

Aside from weather, aircraft airworthiness, and sensor readiness, there were other limiting factors. One was no data collection during periods of PDOP above 3.5 or periods with less than 6 visible satellites, and another was no collection with excessive aircraft yaw. To these ends, PDOP was checked each morning with a fresh almanac from Trimble's website and newly updated satellite health status from the US Coast Guard Navigation Center website. Excessive yaw (or crab), such as used to compensate for crosswinds while maintaining aircraft track and speed during flight lines, was referenced periodically throughout each flight, using 15 degrees as an upper limit, to ensure preservation of sidelap and even point distribution.

GPS Collection Parameters

Collection parameters for this project included the following:

Parameter	Value
Maximum PDOP	3.5
Minimum number of SVs	6
Ground collection epoch	2 Hz (0.5 sec)

Projection / Datum

All data for this project were reduced to UTM Zone 17, using NAD 83. All elevations were presented as ellipsoidal heights. Horizontal and vertical units were meters.

Data Processing

Leica software was used in the post-processing of the airborne GPS and inertial data that is critical to the positioning of the sensor during all flights. This software suite includes Applanix's PosPac and Waypoint's GrafNav solutions. PosPac provides the smoothed best estimate of trajectory (SBET) that is necessary for Leica's post processor to develop the point cloud from the Lidar missions. The point cloud is the mathematical three dimensional collection of all returns from all laser pulses as determined from the aerial mission. At this point this data is ready for analysis, classification, and filtering to generate a bare earth surface model in which the above ground features are removed from the data set.

The point cloud was manipulated within the Leica software, GeoCue, TerraScan, and TerraModeler software was used for the automated data classification, manual cleanup, and bare earth generation from this data. Project specific macros were used to classify the ground and to remove the side overlap between parallel flight lines. All data was manually reviewed and any remaining artifacts removed using functionality provided by TerraScan and TerraModeler.

QA/QC Analysis

A total of 14 points were established in the field for check points assessing the accuracy of the Lidar surface. Points in open areas over existing NGS benchmarks were established. For those benchmarks without an accurate horizontal position, short GPS observations were conducted and submitted to OPUS-RS. The OPUS-RS position was used only for the horizontal position of the point. The published benchmark elevation, adjusted to the surrounding ground surface, was used as the basis of the elevation. This provided the maximum accuracy in the vertical component. The table below lists the statistics of this analysis:

Parameter	Value
Number of QA/QC Points	14
Minimum difference	-0.12 meters
Maximum difference	+0.14 meters
RMSE	0.08 meters

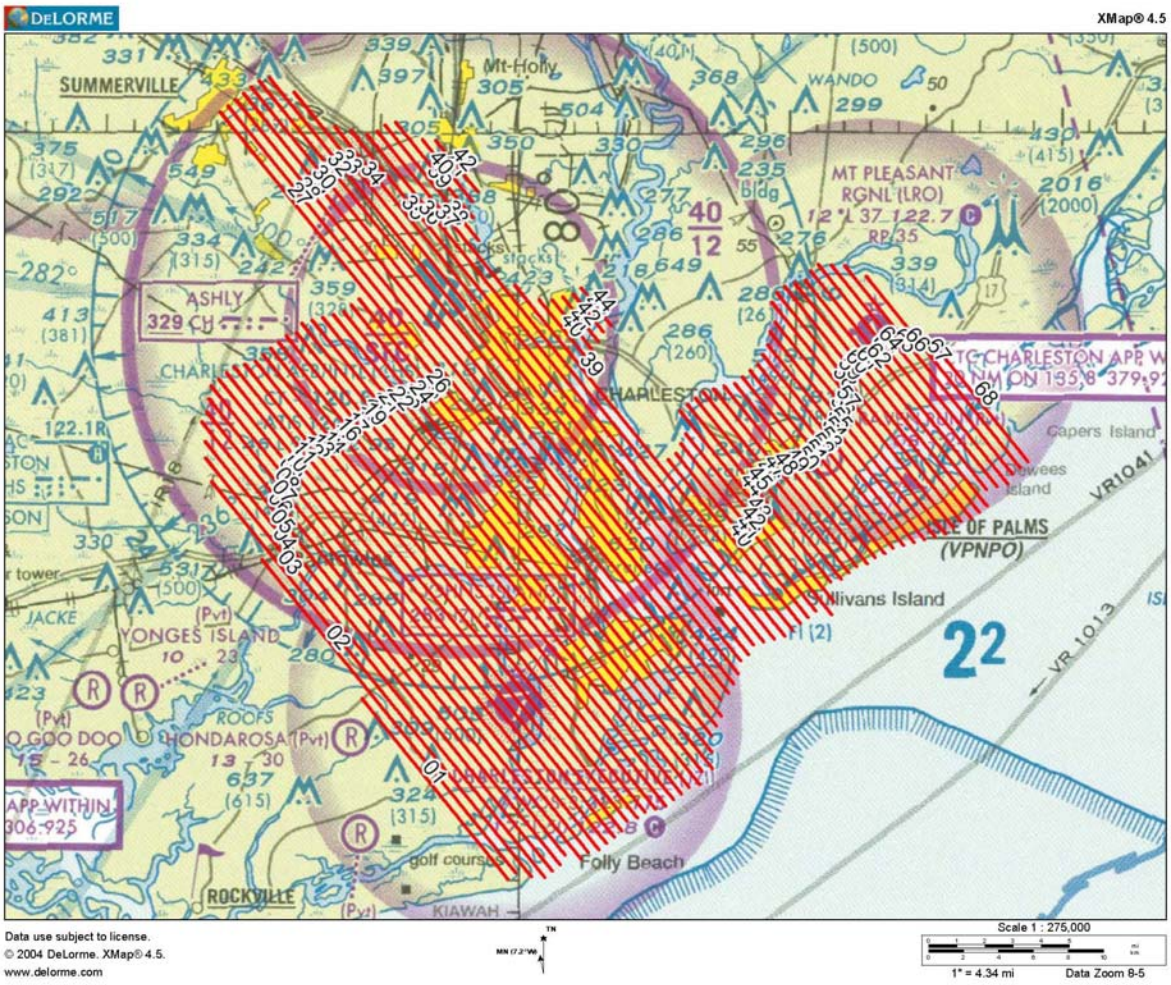
The RMSE of 8 cm is well within the contract requirements of 15 cm.

Problems Encountered

Problems encountered during this project were minimal. There were times of clouds, which is to be expected in a coastal environment. There were also a few times with winds outside what we consider an acceptable range. High cross winds result in crab and can minimize the overlap between adjacent flight strips. There were also some times with less than acceptable GPS configuration in terms of high PDOP or less than 6 satellites available for tracking. The crew checked the expected GPS configuration daily along with the weather and did not fly during less than ideal times.

Flight Line Layout

The flight line layout is shown in the graphic below. A total of 68 flight lines were required to cover the project area.



Appendix
Datasheets for Ground Base Stations

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
DATABASE = Sybase ,PROGRAM = datasheet, VERSION = 7.58
1        National Geodetic Survey,   Retrieval Date = JANUARY 16, 2008
 CJ1485 ***********************************************************************
 CJ1485  PACS        -  This is a Primary Airport Control Station.
 CJ1485  DESIGNATION -  FAA 8S5 A
 CJ1485  PID         -  CJ1485
 CJ1485  STATE/COUNTY-  SC/CHARLESTON
 CJ1485  USGS QUAD   -  CAINHOY (1971)
 CJ1485
 CJ1485                        *CURRENT SURVEY CONTROL
 CJ1485  ______________________________________________________________________
 CJ1485* NAD 83(2007)-  32 53 51.64960(N)    079 46 57.09669(W)     ADJUSTED
 CJ1485* NAVD 88     -         2.91   (meters)       9.5    (feet)  GPS OBS
 CJ1485  ______________________________________________________________________
 CJ1485  EPOCH DATE  -        2002.00
 CJ1485  X           -     950,893.095 (meters)                     COMP
 CJ1485  Y           -  -5,275,609.918 (meters)                     COMP
 CJ1485  Z           -   3,444,419.658 (meters)                     COMP
 CJ1485  LAPLACE CORR-          -2.27  (seconds)                    DEFLEC99
 CJ1485  ELLIP HEIGHT-         -30.508 (meters)          (02/10/07) ADJUSTED
 CJ1485  GEOID HEIGHT-         -33.37  (meters)                     GEOID03
 CJ1485
 CJ1485  ------- Accuracy Estimates (at 95% Confidence Level in cm) --------
 CJ1485  Type    PID    Designation                       North   East  Ellip
 CJ1485  ----------------------------------------------------------------------
 CJ1485  NETWORK CJ1485 FAA 8S5 A                          0.49   0.47   1.53
 CJ1485  ----------------------------------------------------------------------
 CJ1485
 CJ1485.This mark is at East Cooper Airport (8S5)
 CJ1485
 CJ1485.The horizontal coordinates were established by GPS observations
 CJ1485.and adjusted by the National Geodetic Survey in February 2007.
 CJ1485
 CJ1485.The datum tag of NAD 83(2007) is equivalent to NAD 83(NSRS2007).
 CJ1485.See National Readjustment for more information.
 CJ1485.The horizontal coordinates are valid at the epoch date displayed above.
 CJ1485.The epoch date for horizontal control is a decimal equivalence
 CJ1485.of Year/Month/Day.
 CJ1485
 CJ1485.The orthometric height was determined by GPS observations and a
 CJ1485.high-resolution geoid model.
 CJ1485
 CJ1485.GPS derived orthometric heights for airport stations designated as
 CJ1485.PACS or SACS are published to 2 decimal places.  This maintains
 CJ1485.centimeter relative accuracy between the PACS and SACS.  It does
 CJ1485.not indicate centimeter accuracy relative to other marks which are
```

```
CJ1485.part of the NAVD 88 network.
CJ1485
CJ1485.The X, Y, and Z were computed from the position and the ellipsoidal ht.
CJ1485
CJ1485.The Laplace correction was computed from DEFLEC99 derived deflections.
CJ1485
CJ1485.The ellipsoidal height was determined by GPS observations
CJ1485.and is referenced to NAD 83.
CJ1485
CJ1485.The geoid height was determined by GEOID03.
CJ1485
CJ1485;                    North         East     Units Scale Factor Converg.
CJ1485;SPC SC       -   118,707.328   723,492.036   MT  0.99988365   +0 40 29.9
CJ1485;SPC SC       -   389,459.74  2,373,661.54   iFT  0.99988365   +0 40 29.9
CJ1485;UTM  17      - 3,640,601.013   613,865.902   MT  0.99975987   +0 39 40.8
CJ1485
CJ1485!             -  Elev Factor  x  Scale Factor =   Combined Factor
CJ1485!SPC SC       -   1.00000479  x   0.99988365  =   0.99988844
CJ1485!UTM  17      -   1.00000479  x   0.99975987  =   0.99976466
CJ1485
CJ1485:                Primary Azimuth Mark                     Grid Az
CJ1485:SPC SC       -  FAA 8S5 B                                346 21 05.6
CJ1485:UTM  17      -  FAA 8S5 B                                346 21 54.7
CJ1485
CJ1485|---------------------------------------------------------------------|
CJ1485| PID    Reference Object                    Distance      Geod. Az  |
CJ1485|                                                          dddmmss.s |
CJ1485| CJ1486 FAA 8S5 B                         APPROX. 0.5 KM 3470135.5 |
CJ1485|---------------------------------------------------------------------|
CJ1485
CJ1485                          SUPERSEDED SURVEY CONTROL
CJ1485
CJ1485  NAD 83(2001)-  32 53 51.64986(N)    079 46 57.09656(W) AD(       ) B
CJ1485  ELLIP H (02/10/03)  -30.518  (m)                       GP(       ) 4 2
CJ1485  NAD 83(1995)-  32 53 51.64978(N)    079 46 57.09671(W) AD(       ) B
CJ1485  ELLIP H (09/29/97)  -30.489  (m)                       GP(       ) 4 2
CJ1485  NAD 83(1986)-  32 53 51.66106(N)    079 46 57.09963(W) AD(       ) 1
CJ1485  NAD 83(1986)-  32 53 51.65888(N)    079 46 57.09883(W) AD(       ) 3
CJ1485
CJ1485.Superseded values are not recommended for survey control.
CJ1485.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
CJ1485.See file dsdata.txt to determine how the superseded data were derived.
CJ1485
CJ1485_U.S. NATIONAL GRID SPATIAL ADDRESS: 17SPS1386640601(NAD 83)
CJ1485_MARKER: DH = HORIZONTAL CONTROL DISK
CJ1485_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
CJ1485_SP_SET: CONCRETE POST
CJ1485_STAMPING: FAA 8S5 A 1992
CJ1485_MARK LOGO: NGS
CJ1485_MAGNETIC: N = NO MAGNETIC MATERIAL
CJ1485_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO
CJ1485+STABILITY: SURFACE MOTION
CJ1485_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
CJ1485+SATELLITE: SATELLITE OBSERVATIONS - July 14, 2004
CJ1485
CJ1485  HISTORY     - Date     Condition        Report By
CJ1485  HISTORY     - 1992     MONUMENTED       SCGS
```

```
CJ1485  HISTORY     - 19930121 GOOD
CJ1485  HISTORY     - 19950801 GOOD            SCGS
CJ1485  HISTORY     - 19960325 GOOD            SCGS
CJ1485  HISTORY     - 19971212 GOOD            NGS
CJ1485  HISTORY     - 20040714 GOOD            INDIV
CJ1485
CJ1485                          STATION DESCRIPTION
CJ1485
CJ1485'DESCRIBED BY SOUTH CAROLINA GEODETIC SURVEY 1992
CJ1485'STATION IS LOCATED 8.8 MILES (14.2 KM) NORTHEAST OF MOUNT PLEASANT,
CJ1485'3.5 MILES (5.6 KM) SOUTHEAST OF WANDO, AT THE EAST COOPER AIRPORT.
CJ1485'OWNERSHIP--CHARLESTON AVIATION AUTHORITY, P.O. BOX 10308, CHARLESTON,
CJ1485'SC 29411, AIRPORT MANAGER-SAM HOERTER, PHONE 803-767-7000.
CJ1485'TO REACH THE STATION FROM THE JUNCTION OF U.S. HIGHWAYS 17, 701 AND
CJ1485'STATE HIGHWAY 41, 6.25 MILES (10.06 KM) NORTHEAST OF MOUNT PLEASANT,
CJ1485'GO NORTHEAST ON HIGHWAY 17 AND 701 FOR 2.05 MILES (3.30 KM) TO A
CJ1485'PAVED ROAD LEFT (EAST COOPER AIRPORT ENTRANCE, TURN LEFT ON THE
CJ1485'ENTRANCE ROAD FOR 1.8 MILES (2.9 KM) TO A ROAD LEFT, TURN LEFT
CJ1485'PASSING THROUGH GATE FOR 0.05 MILE (0.08 KM) TO THE AIRPORT OFFICE,
CJ1485'OBTAIN PERMISSION AND PASS THROUGH 2ND GATE ACROSS AIRPORT APRON FOR
CJ1485'0.1 MILE (0.2 KM) TO THE TAXI APPROACH, CONTINUE ALONG THE NORTH SIDE
CJ1485'OF TAXI WAY FOR 0.05 MILE (0.08 KM) TO A RUNWAY AND THE STATION IN
CJ1485'THE NORTHEAST ANGLE AND IN LINE WITH TWO TAXI LIGHTS AND A RUNWAY
CJ1485'LIGHT.
CJ1485'STATION IS A CONCRETE POST FLUSH WITH THE GROUND AND LEVEL WITH THE
CJ1485'TAXIWAY, 86.3 FEET (26.3 M) EAST OF THE EAST EDGE OF THE RUNWAY, 38.3
CJ1485'FEET (11.7 M) NORTH OF A BLUE TAXI LIGHT, 39.2 FEET (11.9 M) EAST OF
CJ1485'A WHITE RUNWAY LIGHT WITH A CONCRETE BASE NUMBER 1-7, 65.9 FEET
CJ1485'(20.1 M) NORTH OF THE CENTER OF THE TAXIWAY, 2.1 FEET (0.6 M) WEST OF
CJ1485'A WITNESS POST.
CJ1485'DESCRIBED BY R.W. ROBERTS.
CJ1485
CJ1485                          STATION RECOVERY (1993)
CJ1485
CJ1485'RECOVERED 1993
CJ1485'RECOVERED IN GOOD CONDITION.
CJ1485
CJ1485                          STATION RECOVERY (1995)
CJ1485
CJ1485'RECOVERY NOTE BY SOUTH CAROLINA GEODETIC SURVEY 1995 (DDW)
CJ1485'RECOVERED AS DESCRIBED.
CJ1485
CJ1485                          STATION RECOVERY (1996)
CJ1485
CJ1485'RECOVERY NOTE BY SOUTH CAROLINA GEODETIC SURVEY 1996 (DDW)
CJ1485'STATION IS LOCATED 8.8 MILES (14.2 KM) NORTHEAST OF MOUNT PLEASANT,
CJ1485'3.5 MILES (5.6 KM) SOUTHEAST OF WANDO, AT THE EAST COOPER AIRPORT.
CJ1485'OWNERSHIP--CHARLESTON AVIATION AUTHORITY, MR.  FRED CHAPIN, DIRECTOR
CJ1485'OF OPERATIONS, 5500 INTERNATIONAL BOULEVARD NUMBER 101, CHARLESTON, SC
CJ1485'29418-6911, PHONE 803-767-7019.  NOTE-CONTACT FRED CHAPIN BEFORE
CJ1485'OBSERVATIONS, HE WILL FAX REQUIRED INFORMATION FOR ACCESS.  TO REACH
CJ1485'THE STATION FROM THE JUNCTION OF U.S.  HIGHWAYS 17, 701 AND STATE
CJ1485'HIGHWAY 41, 6.25 MILES (10.06 KM) NORTHEAST OF MOUNT PLEASANT, GO
CJ1485'NORTHEAST ON HIGHWAY 17 AND 701 FOR 2.05 MILES (3.30 KM) TO A PAVED
CJ1485'ROAD LEFT (EAST COOPER AIRPORT ENTRANCE, TURN LEFT ON THE ENTRANCE
CJ1485'ROAD FOR 1.8 MILES (2.9 KM) TO A ROAD LEFT, TURN LEFT PASSING THROUGH
CJ1485'GATE FOR 0.05 MILE (0.08 KM) TO THE AIRPORT OFFICE, OBTAIN PERMISSION
```

```
CJ1485'AND PASS THROUGH 2ND GATE ACROSS AIRPORT APRON FOR 0.1 MILE (0.2 KM)
CJ1485'TO THE TAXI APPROACH, CONTINUE ALONG THE NORTH SIDE OF TAXI WAY FOR
CJ1485'0.05 MILE (0.08 KM) TO A RUNWAY AND THE STATION IN THE NORTHEAST ANGLE
CJ1485'AND IN LINE WITH TWO TAXI LIGHTS AND A RUNWAY LIGHT.  STATION IS A
CJ1485'CONCRETE POST FLUSH WITH THE GROUND AND LEVEL WITH THE TAXIWAY, 86.3
CJ1485'FEET (26.3 M) EAST OF THE EAST EDGE OF THE RUNWAY, 38.3 FEET (11.7 M)
CJ1485'NORTH OF A BLUE TAXI LIGHT, 39.2 FEET (11.9 M) EAST OF A WHITE RUNWAY
CJ1485'LIGHT WITH A CONCRETE BASE NUMBER 1-7, 65.9 FEET (20.1 M) NORTH OF THE
CJ1485'CENTER OF THE TAXIWAY, 72.3 FEET (22.0 M) WEST NORTHWEST OF THE SOUTH
CJ1485'LEG OF A METAL SIGN (UNICOM 122.7) .  THIS STATION IS DESIGNATED AS
CJ1485'THE PRIMARY AIRPORT STATION.  RECOVERED BY R.W.  ROBERTS.
CJ1485
CJ1485                          STATION RECOVERY (1997)
CJ1485
CJ1485'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 1997 (ED)
CJ1485'STATION IS LOCATED 8.8 MILES (14.2 KM) NORTHEAST OF MOUNT PLEASANT,
CJ1485'3.5 MILES (5.6 KM) SOUTHEAST OF WANDO, AT THE EAST COOPER AIRPORT.
CJ1485'OWNERSHIP--CHARLESTON AVIATION AUTHORITY, MR.  FRED CHAPIN, DIRECTOR
CJ1485'OF OPERATIONS, 5500 INTERNATIONAL BOULEVARD NUMBER 101, CHARLESTON, SC
CJ1485'29418-6911, PHONE 803-767-7019.  NOTE-CONTACT FRED CHAPIN BEFORE
CJ1485'OBSERVATIONS, HE WILL FAX REQUIRED INFORMATION FOR ACCESS.  TO REACH
CJ1485'THE STATION FROM THE JUNCTION OF U.S.  HIGHWAYS 17, 701 AND STATE
CJ1485'HIGHWAY 41, 6.25 MILES (10.06 KM) NORTHEAST OF MOUNT PLEASANT, GO
CJ1485'NORTHEAST ON HIGHWAY 17 AND 701 FOR 2.05 MILES (3.30 KM) TO A PAVED
CJ1485'ROAD LEFT (EAST COOPER AIRPORT ENTRANCE, TURN LEFT ON THE ENTRANCE
CJ1485'ROAD FOR 1.8 MILES (2.9 KM) TO A ROAD LEFT, TURN LEFT PASSING THROUGH
CJ1485'GATE FOR 0.05 MILE (0.08 KM) TO THE AIRPORT OFFICE, OBTAIN PERMISSION
CJ1485'AND PASS THROUGH 2ND GATE ACROSS AIRPORT APRON FOR 0.1 MILE (0.2 KM)
CJ1485'TO THE TAXI APPROACH, CONTINUE ALONG THE NORTH SIDE OF TAXI WAY FOR
CJ1485'0.05 MILE (0.08 KM) TO A RUNWAY AND THE STATION IN THE NORTHEAST ANGLE
CJ1485'AND IN LINE WITH TWO TAXI LIGHTS AND A RUNWAY LIGHT.  STATION IS A
CJ1485'CONCRETE POST FLUSH WITH THE GROUND AND LEVEL WITH THE TAXIWAY, 86.3
CJ1485'FEET (26.3 M) EAST OF THE EAST EDGE OF THE RUNWAY, 38.3 FEET (11.7 M)
CJ1485'NORTH OF A BLUE TAXI LIGHT, 39.2 FEET (11.9 M) EAST OF A WHITE RUNWAY
CJ1485'LIGHT WITH A CONCRETE BASE NUMBER 1-7, 65.9 FEET (20.1 M) NORTH OF THE
CJ1485'CENTER OF THE TAXIWAY, 72.3 FEET (22.0 M) WEST NORTHWEST OF THE SOUTH
CJ1485'LEG OF A METAL SIGN (UNICOM 122.7) .  THIS STATION IS DESIGNATED AS
CJ1485'THE PRIMARY AIRPORT STATION.  RECOVERED BY R.W.  ROBERTS.
CJ1485
CJ1485                          STATION RECOVERY (2004)
CJ1485
CJ1485'RECOVERY NOTE BY INDIVIDUAL CONTRIBUTORS 2004 (JDB)
CJ1485'RECOVERED AS DESCRIBED BY PHOTOSCIENCE, INC.



1       National Geodetic Survey,   Retrieval Date = JANUARY 16, 2008
 CK2744 ***********************************************************************
 CK2744  DESIGNATION -  EXEC
 CK2744  PID         -  CK2744
 CK2744  STATE/COUNTY-  SC/CHARLESTON
 CK2744  USGS QUAD   -  LEGAREVILLE (1971)
 CK2744
 CK2744                          *CURRENT SURVEY CONTROL
 CK2744  ______________________________________________________________________
 CK2744* NAD 83(2007)-  32 42 02.89145(N)    080 00 37.79408(W)     ADJUSTED
 CK2744* NAVD 88     -         4.937  (meters)      16.20   (feet)  ADJUSTED
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CK2744  ____________________________________________________________________
CK2744  EPOCH DATE  -        2002.00
CK2744  X           -     931,946.747 (meters)                      COMP
CK2744  Y           -  -5,291,001.571 (meters)                      COMP
CK2744  Z           -   3,426,068.077 (meters)                      COMP
CK2744  LAPLACE CORR-          -2.86  (seconds)                     DEFLEC99
CK2744  ELLIP HEIGHT-         -28.110 (meters)          (02/10/07) ADJUSTED
CK2744  GEOID HEIGHT-         -33.05  (meters)                     GEOID03
CK2744  DYNAMIC HT  -           4.932 (meters)      16.18  (feet)  COMP
CK2744
CK2744  ------- Accuracy Estimates (at 95% Confidence Level in cm) --------
CK2744  Type    PID    Designation                        North   East  Ellip
CK2744  ------------------------------------------------------------------
CK2744  NETWORK CK2744 EXEC                                0.51   0.55   1.88
CK2744  ------------------------------------------------------------------
CK2744  MODELED GRAV-     979,536.7   (mgal)                        NAVD 88
CK2744
CK2744  VERT ORDER  -  FIRST     CLASS II
CK2744
CK2744.This mark is at Charleston Exec Airport (JZI)
CK2744
CK2744.The horizontal coordinates were established by GPS observations
CK2744.and adjusted by the National Geodetic Survey in February 2007.
CK2744
CK2744.The datum tag of NAD 83(2007) is equivalent to NAD 83(NSRS2007).
CK2744.See National Readjustment for more information.
CK2744.The horizontal coordinates are valid at the epoch date displayed above.
CK2744.The epoch date for horizontal control is a decimal equivalence
CK2744.of Year/Month/Day.
CK2744
CK2744.The orthometric height was determined by differential leveling
CK2744.and adjusted in June 1991.
CK2744
CK2744.The X, Y, and Z were computed from the position and the ellipsoidal ht.
CK2744
CK2744.The Laplace correction was computed from DEFLEC99 derived deflections.
CK2744
CK2744.The ellipsoidal height was determined by GPS observations
CK2744.and is referenced to NAD 83.
CK2744
CK2744.The geoid height was determined by GEOID03.
CK2744
CK2744.The dynamic height is computed by dividing the NAVD 88
CK2744.geopotential number by the normal gravity value computed on the
CK2744.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
CK2744.degrees latitude (g = 980.6199 gals.).
CK2744
CK2744.The modeled gravity was interpolated from observed gravity values.
CK2744
CK2744;                    North         East     Units Scale Factor Converg.
CK2744;SPC SC       -    96,648.751   702,375.538   MT  0.99993532   +0 32 54.9
CK2744;SPC SC       -   317,089.08  2,304,381.69   iFT  0.99993532   +0 32 54.9
CK2744;UTM  17      - 3,618,551.454   592,747.778   MT  0.99970607   +0 32 04.6
CK2744
CK2744!             -  Elev Factor  x  Scale Factor =   Combined Factor
CK2744!SPC SC       -   1.00000441  x   0.99993532  =   0.99993973
CK2744!UTM  17      -   1.00000441  x   0.99970607  =   0.99971048
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CK2744
CK2744                          SUPERSEDED SURVEY CONTROL
CK2744
CK2744  NAD 83(2001)-  32 42 02.89175(N)    080 00 37.79328(W) AD(       ) 1
CK2744  ELLIP H (03/27/03)  -28.066  (m)                       GP(       ) 4 2
CK2744  NAD 83(1995)-  32 42 02.89151(N)    080 00 37.79427(W) AD(       ) 1
CK2744  ELLIP H (12/20/99)  -28.117  (m)                       GP(       ) 4 1
CK2744  NAD 83(1986)-  32 42 02.89935(N)    080 00 37.79749(W) AD(       ) 1
CK2744  NAD 27      -  32 42 02.28724(N)    080 00 38.49408(W) AD(       ) 3
CK2744  NGVD 29 (03/21/89)    5.235  (m)           17.18   (f) ADJUSTED    1 2
CK2744
CK2744.Superseded values are not recommended for survey control.
CK2744.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
CK2744.See file dsdata.txt to determine how the superseded data were derived.
CK2744
CK2744_U.S. NATIONAL GRID SPATIAL ADDRESS: 17SNS9274818551(NAD 83)
CK2744_MARKER: DS = TRIANGULATION STATION DISK
CK2744_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
CK2744_SP_SET: CONCRETE POST
CK2744_STAMPING: EXEC 1984
CK2744_MARK LOGO: NGS
CK2744_PROJECTION: FLUSH
CK2744_MAGNETIC: O = OTHER; SEE DESCRIPTION
CK2744_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO
CK2744+STABILITY: SURFACE MOTION
CK2744_SATELLITE: THE SITE LOCATION WAS REPORTED AS NOT SUITABLE FOR
CK2744+SATELLITE: SATELLITE OBSERVATIONS - March 12, 2005
CK2744
CK2744  HISTORY     - Date     Condition        Report By
CK2744  HISTORY     - 1984     MONUMENTED       NGS
CK2744  HISTORY     - 1984     GOOD             SCGS
CK2744  HISTORY     - 1985     GOOD             NGS
CK2744  HISTORY     - 19870318 GOOD
CK2744  HISTORY     - 19870415 GOOD
CK2744  HISTORY     - 19900419 GOOD             NGS
CK2744  HISTORY     - 19910416 GOOD             SCGS
CK2744  HISTORY     - 20050312 GOOD             RICCRO
CK2744
CK2744                           STATION DESCRIPTION
CK2744
CK2744'DESCRIBED BY NATIONAL GEODETIC SURVEY 1984 (VDN)
CK2744'THE STATION IS LOCATED ABOUT 5.0 KM (3.1 MI)
CK2744'SOUTH OF THE HIGHWAY 700 BRIDGE OVER THE STONO RIVER, 2.0 KM (1.25
CK2744'MI) WEST OF THE STONO RIVER, ON JOHNS ISLAND AND AT THE CHARLESTON
CK2744'EXECUTIVE AIRPORT.
CK2744'OWNERSHIP--CHARLESTON EXECUTIVE AIRPORT, MR MARION REID AIRPORT
CK2744'MANAGER, ROUTE 5 BOX 216, JOHNS ISLAND SC 29455, PHONE 803-559-0773.
CK2744'
CK2744'TO REACH THE STATION FROM THE JOHNS ISLAND POST OFFICE, GO
CK2744'NORTHEAST ON STATE HIGHWAY 700 FOR 0.2 KM (0.15 MI) TO A CROSSROAD,
CK2744'RIVER ROAD.  TURN RIGHT, SOUTHEAST ON RIVER ROAD FOR 5.3 KM (3.3
CK2744'MI) TO THE AIRPORT ENTRANCE ON THE LEFT.  TURN LEFT, EAST ON PAVED
CK2744'ROAD FOR 0.3 KM (0.2 MI) TO A TAXI STRIP.  TURN RIGHT, SOUTH, FOR
CK2744'30 METERS (100 FT) TO THE STATION ON THE LEFT.
CK2744'
CK2744'THE STATION IS A STANDARD NGS DISK
CK2744'STAMPED---EXEC 1984---,
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CK2744'SET INTO THE TOP OF A ROUND CONCRETE MONUMENT
CK2744'30 CM IN DIAMETER FLUSH WITH GROUND. LOCATED
CK2744'27.7 METERS (91 FT) NORTH FROM THE APPROXIMATE CENTER OF A PAVED
CK2744'ROAD,
CK2744'22.3 METERS (73.3 FT) EAST FROM THE EAST EDGE OF A TAXIWAY AND
CK2744'11.0 METERS (36.2 FT) WEST FROM THE CENTER OF A 20 CM IN DIAMETER
CK2744'LIVE OAK.
CK2744'THE UNDERGROUND MARK IS A STANDARD NGS DISK
CK2744'STAMPED---EXEC 1984---,
CK2744'SET INTO AN IRREGULAR MASS OF CONCRETE 1.1 METERS BELOW THE SURFACE.
CK2744'
CK2744'REFERENCE POINT NO. 1 IS A STANDARD NGS BASELINE DISK
CK2744'STAMPED---0 1979---,
CK2744'SET INTO THE TOP OF A ROUND CONCRETE MONUMENT
CK2744'60 CM IN DIAMETER FLUSH WITH GROUND. LOCATED
CK2744'76.5 METERS (251 FT) SOUTH FROM THE APPROXIMATE CENTER OF A PAVED
CK2744'ROAD,
CK2744'38.7 METERS (127 FT) SOUTHEAST FROM A POWER POLE AND
CK2744'2.2 METERS (7.3 FT) EAST FROM THE EAST EDGE OF A TAXIWAY.
CK2744'MARK IS 0.5 METERS ABOVE THE STATION.
CK2744'
CK2744'REFERENCE POINT NO. 2 IS A STANDARD MSL DISK
CK2744'STAMPED---17.84 MSL 17.84 MSL---,
CK2744'SET INTO A DRILL HOLE IN A CONCRETE SLAB (TAXI STRIP) SET FLUSH.
CK2744'LOCATED
CK2744'40.5 METERS (132.8 FT) NORTHEAST FROM A POWER POLE,
CK2744'20.1 METERS (66.0 FT) SOUTH FROM THE APPROXIMATE CENTER OF A PAVED
CK2744'ROAD AND
CK2744'0.3 METER (1.0 FT) EAST FROM THE WEST EDGE OF A NORTH-SOUTH
CK2744'TAXIWAY.
CK2744'MARK IS 0.5 METER ABOVE THE STATION.
CK2744'
CK2744'AZIMUTH POINT NO. 1 IS A STANDARD NGS BASELINE DISK
CK2744'STAMPED---1000 1979---,
CK2744'SET INTO THE TOP OF A ROUND CONCRETE MONUMENT
CK2744'50 CM IN DIAMETER FLUSH WITH GROUND. LOCATED
CK2744'57.3 METERS (188 FT) WEST FROM THE WEST EDGE OF A NORTH-SOUTH
CK2744'RUNWAY AND
CK2744'2.0 METERS (6.6 FT) EAST FROM THE EAST EDGE OF A NORTH-SOUTH
CK2744'TAXIWAY.
CK2744'TO REACH THE AZIMUTH FROM THE STATION,
CK2744'GO SOUTH FOR 1.0 KM (0.6 MI) ON THE TAXIWAY TO THE MARK ON THE LEFT.
CK2744'
CK2744'HEIGHT OF LIGHT SHOWN WAS 34.5 METERS ABOVE THE MARK.
CK2744'
CK2744'AN EDM TIE WAS MADE TO STATIONS SC BASE 1000 AND COMPASS. SEE
CK2744'DESCRIPTIONS THEREOF.
CK2744'
CK2744'A TAPED TRAVERSE WAS MADE TO STATIONS SC BASE 0 AND 17.84 MSL. SEE
CK2744'DESCRIPTIONS THEREOF.
CK2744'
CK2744'DESCRIBED BY R.T. WOODRUFF.
CK2744
CK2744   STATION RECOVERY (1984)
CK2744
CK2744'RECOVERY NOTE BY SOUTH CAROLINA GEODETIC SURVEY 1984
CK2744'IN JOHNS ISLAND AIRPORT.

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CK2744'THE MARK IS 0.40 M BELOW ENTRANCE ROAD.
CK2744'0.2 KILOMETER (0.1 MILE) EAST ALONG STATE HIGHWAY 700 FROM THE JOHNS
CK2744'ISLAND POST OFFICE, THENCE 5.3 KILOMETERS (3.3 MILES) SOUTHERLY ALONG
CK2744'COUNTY ROAD S-10-54 TO THE ENTRANCE TO THE CHARLESTON EXECUTIVE
CK2744'AIRPORT, THENCE 0.4 KILOMETER (0.25 MILE) EAST ALONG THE ENTRANCE ROAD
CK2744'TO THE INTERSECTION OF A TAXI WAY NOW ABANDONED, SET IN THE SOUTHEAST
CK2744'ANGLE OF THE INTERSECTION, 72.8 METERS (239.0 FEET) EAST-SOUTHEAST OF
CK2744'THE APPROXIMATE CENTER OF A THREE-FOOT HIGH ELECTRICAL POWER BOX
CK2744'COVER, 27.5 METERS (90.7 FEET) SOUTH-SOUTHEAST OF THE CENTERLINE OF
CK2744'THE ENTRANCE ROAD, 29.9 METERS (98.4 FEET) EAST-NORTHEAST OF THE
CK2744'APPROXIMATE CENTER OF THE TAXI WAY.
CK2744
CK2744                          STATION RECOVERY (1985)
CK2744
CK2744'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 1985 (GRH)
CK2744'THE STATION WAS RECOVERED AT THIS DATE.
CK2744'
CK2744'THE STATION IS LOCATED AT THE CHARLESTON EXECUTIVE AIRPORT, AT THE
CK2744'JUNCTION OF THE ENTRANCE ROAD AND AN UNUSED TAXI STRIP.
CK2744'OWNERSHIP--BARBARA WILEY, PO BOX 417, JOHNS ISLAND SC 29455. PHONE
CK2744'803-559-2401.  (TO WORK ON RUNWAYS CALL AIRPORT MANAGER JOSEPH
CK2744'LEAHY, CHARLESTON INTERNATIONAL AIRPORT, PHONE 803-767-1100).
CK2744'
CK2744'TO REACH THE STATION FROM THE JOHNS ISLAND POST OFFICE, GO
CK2744'NORTHEAST FOR 0.2 KM (0.1 MI) ON STATE HIGHWAY 700 TO A CROSSROAD.
CK2744'TURN RIGHT AND GO SOUTH FOR 5.3 KM (3.3 MI) ON S-10-54 (RIVER ROAD)
CK2744'TO A ROAD LEFT.
CK2744'TURN LEFT AND GO EAST FOR 0.4 KM (0.25 MI) ON THE AIRPORT ENTRANCE
CK2744'ROAD TO THE OLD TAXI STRIP AND STATION ON THE RIGHT.
CK2744'
CK2744'THE STATION IS A STANDARD NGS DISK
CK2744'STAMPED---EXEC 1984---,
CK2744'SET INTO THE TOP OF A ROUND CONCRETE MONUMENT
CK2744'30 CM IN DIAMETER FLUSH WITH GROUND.  LOCATED
CK2744'27.5 METERS (90.2 FT) SOUTH FROM THE ROAD CENTER,
CK2744'22.3 METERS (73.2 FT) EAST FROM THE EDGE OF THE TAXI STRIP,
CK2744'30.6 METERS (100 FT) SOUTHEAST FROM THE TOP CENTER OF THE SOUTH END
CK2744'OF A METAL DRAIN PIPE AT ROAD AND TAXI STRIP JUNCTION,
CK2744'10.9 METERS (35.8 FT) WEST FROM A 30-CM LIVE OAD TREE WITH METAL
CK2744'WITNESS SIGN FACING WEST.
CK2744'
CK2744'DESCRIBED BY G.R. HEID, TYPED BY R.L. ZURFLUH.
CK2744
CK2744                          STATION RECOVERY (1987)
CK2744
CK2744'RECOVERED 1987
CK2744'RECOVERED IN GOOD CONDITION.
CK2744
CK2744                          STATION RECOVERY (1987)
CK2744
CK2744'RECOVERED 1987
CK2744'RECOVERED IN GOOD CONDITION.
CK2744
CK2744                          STATION RECOVERY (1990)
CK2744
CK2744'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 1990
CK2744'RECOVERED IN GOOD CONDITION.
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CK2744
CK2744                          STATION RECOVERY (1991)
CK2744
CK2744'RECOVERY NOTE BY SOUTH CAROLINA GEODETIC SURVEY 1991
CK2744'STATION IS LOCATED AT THE CHARLESTON EXECUTIVE AIRPORT ON JOHNS
CK2744'ISLAND.  OWNERSHIP--CHARLESTON EXECUTIVE AIRPORT, JOHNS ISLAND, SC
CK2744'29455, PHONE 803-767-7019 (FRED CHAPIN, DIRECTOR).
CK2744'TO REACH THE STATION FROM THE JUNCTION OF STATE HIGHWAYS 171 (FOLLY
CK2744'ROAD) AND 700 (MAYBANK HIGHWAY) ON JAMES ISLAND, GO SOUTHWEST ON
CK2744'HIGHWAY 700 FOR 4.15 MILES (6.68 KM) TO THE JUNCTION OF STATE ROAD 54
CK2744'(RIVER ROAD), TURN LEFT ON ROAD 54 FOR 3.3 MILES (5.3 KM) TO A PAVED
CK2744'ROAD LEFT (FORT TRENHOLM ROAD) AND THE ENTRANCE TO THE CHARLESTON
CK2744'EXECUTIVE AIRPORT, TURN LEFT ON THE PAVED ROAD FOR 0.15 MILE
CK2744'(0.24 KM) TO A CHAIN LINK FENCE GATE, CONTINUE THROUGH THE GATE ON
CK2744'THE PAVED ROAD FOR 0.05 MILE (0.08 KM) TO AN OLD ABANDONED TAXIWAY
CK2744'AND A CHAIN LINK FENCE GATE ON THE LEFT AND RIGHT, TURN RIGHT THROUGH
CK2744'THE GATE ON THE TAXIWAY FOR 50-FEET TO THE STATION ON THE LEFT.
CK2744'STATION IS A CONCRETE POST FLUSH WITH THE GROUND AND 1.5 FOOT (0.5 M)
CK2744'BELOW THE TAXIWAY, 73.2 FEET (22.3 M) EAST OF THE EAST EDGE OF THE
CK2744'TAXIWAY, 121.7 FEET (37.1 M) SOUTHEAST OF THE EASTERN MOST GATE POST,
CK2744'41.4 FEET (12.6 M) WEST SOUTHWEST OF THE WEST CORNER OF A MOBILE
CK2744'OFFICE TRAILER, 60.8 FEET (18.5 M) SOUTH OF THE CHAIN LINK FENCE
CK2744'LINE, 153.0 FEET (46.6 M) NORTH NORTHEAST OF CALIBRATION STATION 0.
CK2744'RECOVERED BY J.R. WERNER.
CK2744
CK2744                          STATION RECOVERY (2005)
CK2744
CK2744'RECOVERY NOTE BY RICHARD CROUSE AND ASSOCIATES 2005 (JW)
CK2744'RECOVERED IN GOOD CONDITION.
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Appendix C

GPS Ground Control Reports

Project : Colleton

User name	Jim.Harrington	Date & Tim	12/19/2007 13:45
Coordinate System	US State Plane 1983	Zone	South Carolina 3900
Project Datum	NAD 1983 (Conus)		
Vertical Datum	NAVD88	Geoid Mod	GEOID03(CONUS)
Coordinate Units	Meters		
Distance Units	Meters		
Height Units	US survey feet		

GPS Baselines

ID	Source	From Pt	To Point	Solution/Quality	Ratio	Reference Variance	RMS	Slope Distance
B1	DC file (COLLIDAR.dc)	SCWT	15 031	Fixed	?	?	0.004m	4985.809m
B2	DC file (COLLIDAR.dc)	SCWT	15 031A	Fixed	?	?	0.003m	4999.394m
B3	DC file (COLLIDAR.dc)	SCWT	15 031B	Fixed	?	?	0.004m	5004.986m
B4	DC file (COLLIDAR.dc)	SCWT	15 031C	Fixed	?	?	0.004m	5020.708m
B5	DC file (COLLIDAR.dc)	SCWT	15 031D	Fixed	?	?	0.003m	5023.146m
B6	DC file (COLLIDAR.dc)	SCWT	15 031DD	Fixed	?	?	0.006m	5023.144m
B7	DC file (COLLIDAR.dc)	SCWT	15 031E	Fixed	?	?	0.005m	4989.126m
B8	DC file (COLLIDAR.dc)	SCWT	15 031F	Fixed	?	?	0.004m	4958.354m
B9	DC file (COLLIDAR.dc)	SCWT	5 WLC1	Fixed	?	?	0.007m	8119.752m
B10	DC file (COLLIDAR.dc)	SCWT	5 WLC11	Fixed	?	?	0.003m	8119.739m
B11	DC file (COLLIDAR.dc)	SCWT	5 WLC12	Fixed	?	?	0.003m	8119.766m
B12	DC file (COLLIDAR.dc)	SCWT	SSMC	Fixed	?	?	0.004m	20047.382m
B13	DC file (COLLIDAR.dc)	SCWT	SSMC1	Fixed	?	?	0.005m	20096.269m
B14	DC file (COLLIDAR.dc)	SCWT	SSMC11	Fixed	?	?	0.005m	20096.265m
B15	DC file (COLLIDAR.dc)	SCWT	SSMC2	Fixed	?	?	0.004m	20047.370m
B16	DC file (COLLIDAR.dc)	SCWT	WILLOW SWAMP	Fixed	?	?	0.006m	32846.512m
B17	DC file (COLLIDAR.dc)	SCWT	WILLOW SWAMP1	Fixed	?	?	0.006m	32898.564m
B18	DC file (COLLIDAR.dc)	SCWT	WILLOW SWAMP2	Fixed	?	?	0.008m	32902.512m
B19	DC file (COLLIDAR.dc)	SCWT	WILLOW SWAMP11	Fixed	?	?	0.007m	32898.649m
B20	DC file (COLLIDAR.dc)	SCWT	ERVIN	Fixed	?	?	0.004m	24647.703m
B21	DC file (COLLIDAR.dc)	SCWT	ERVIN1	Fixed	?	?	0.004m	24688.250m
B22	DC file (COLLIDAR.dc)	SCWT	ERVIN2	Fixed	?	?	0.004m	24668.235m
B23	DC file (COLLIDAR.dc)	SCWT	ERVIN3	Fixed	?	?	0.005m	24670.777m
B24	DC file (COLLIDAR.dc)	SCWT	15 011	Fixed	?	?	0.005m	10789.458m
B25	DC file (COLLIDAR.dc)	SCWT	15 011A	Fixed	?	?	0.007m	10785.446m
B26	DC file (COLLIDAR.dc)	SCWT	15 011B	Fixed	?	?	0.006m	10785.451m
B27	DC file (COLLIDAR.dc)	SCWT	15 080	Fixed	?	?	0.004m	16448.929m
B28	DC file (COLLIDAR.dc)	SCWT	15 080A	Fixed	?	?	0.003m	16433.958m
B29	DC file (COLLIDAR.dc)	SCWT	15 080B	Fixed	?	?	0.003m	16424.654m
B30	DC file (COLLIDAR.dc)	SCWT	15 080C	Fixed	?	?	0.004m	16419.420m
B31	DC file (COLLIDAR.dc)	SCWT	15 080D	Fixed	?	?	0.007m	16417.291m
B32	DC file (COLLIDAR.dc)	SCWT	15 080DD	Fixed	?	?	0.005m	16417.346m
B33	DC file (COLLIDAR.dc)	SCWT	15 080E	Fixed	?	?	0.003m	16432.847m
B34	DC file (COLLIDAR.dc)	SCWT	15 080F	Fixed	?	?	0.005m	16448.886m
B35	DC file (COLLIDAR.dc)	SCWT	15 080G	Float	?	?	0.024m	16452.146m
B36	DC file (COLLIDAR.dc)	SCWT	15 0800	Fixed	?	?	0.003m	16448.934m
B37	DC file (COLLIDAR.dc)	SCWT	15 083	Fixed	?	?	0.004m	20755.619m
B38	DC file (COLLIDAR.dc)	SCWT	15 083A	Fixed	?	?	0.007m	20692.763m
B39	DC file (COLLIDAR.dc)	SCWT	15 083AA	Fixed	?	?	0.009m	20692.726m
B40	DC file (COLLIDAR.dc)	SCWT	15 120	Fixed	?	?	0.006m	21998.846m
B41	DC file (COLLIDAR.dc)	SCWT	15 088	Fixed	?	?	0.005m	21930.015m
B42	DC file (COLLIDAR.dc)	SCWT	15 089	Fixed	?	?	0.003m	21930.029m
B43	DC file (COLLIDAR.dc)	SCWT	15 0888	Fixed	?	?	0.005m	21930.035m
B44	DC file (COLLIDAR.dc)	SCWT	15 1200	Fixed	?	?	0.006m	21998.853m
B45	DC file (COLLIDAR.dc)	SCWT	15 123	Fixed	?	?	0.003m	26821.477m
B46	DC file (COLLIDAR.dc)	SCWT	15 123A	Fixed	?	?	0.006m	26799.449m
B47	DC file (COLLIDAR.dc)	SCWT	15 123B	Fixed	?	?	0.004m	26777.848m
B48	DC file (COLLIDAR.dc)	SCWT	15 123C	Fixed	?	?	0.005m	26770.123m
B49	DC file (COLLIDAR.dc)	SCWT	15 123D	Fixed	?	?	0.006m	26758.339m
B50	DC file (COLLIDAR.dc)	SCWT	15 1233	Fixed	?	?	0.005m	26760.129m
B51	DC file (COLLIDAR.dc)	SCWT	15 123E	Fixed	?	?	0.008m	26810.670m
B52	DC file (COLLIDAR.dc)	SCWT	15 123F	Fixed	?	?	0.004m	26791.168m
B53	DC file (COLLIDAR.dc)	SCWT	15 123AA	Fixed	?	?	0.005m	26821.504m

Coordinates

ID	Point Name	Source	Latitude	Longitude	Height	Elevation
C1(geod-WGS)	SCWT	DC file (CO	32°54'12.35317"N	80°40'06.27435"W	-6.479sft	?
C2(geod-WGS)	SCHN	DC file (CO	32°51'37.29914"N	81°05'37.01244"W	5.222sft	?

GPS Vector data

Project : Charleston Lidar

User name	Jim.Harrington	Date & Time	10/11/2007 11:50
Coordinate System	US State Plane 1983	Zone	South Carolina 3900
Project Datum	NAD 1983 (Conus)		
Vertical Datum	NAVD88	Geoid Model	GEOID03(CONUS)
Coordinate Units	Meters		
Distance Units	Meters		
Height Units	US survey feet		

From Point Name	To Point Name	DeltaX	DeltaY	DeltaZ	Slope Distance	RMS
SCCC	T1	1312.457m	122.005m	-207.785m	1334.392m	0.002m
SCCC	TIDE	1246.268m	134.807m	-171.093m	1265.160m	0.002m
SCCC	T2	1155.864m	103.100m	-194.745m	1176.680m	0.002m
SCCC	T3	1123.276m	92.211m	-202.992m	1145.189m	0.001m
SCCC	T4	1214.921m	-4.656m	-375.249m	1271.561m	0.002m
SCCC	T5	1220.306m	-22.903m	-403.277m	1285.420m	0.003m
SCCC	T6	1214.850m	-18.301m	-394.924m	1277.561m	0.004m
SCCC	FOLLY1	5820.197m	-4928.542m	-9172.302m	11928.803m	0.006m
SCCC	FOLLY2	5823.549m	-4936.537m	-9187.581m	11945.491m	0.008m
SCCC	FOLLY3	5330.659m	-5205.228m	-9463.310m	12044.275m	0.004m
SCCC	FOLLY4	5362.129m	-5177.731m	-9430.465m	12020.607m	0.005m
SCCC	FOLLY5	5406.271m	-5153.357m	-9405.015m	12009.961m	0.004m
SCCC	FOLLY6	5455.885m	-5108.551m	-9349.237m	11969.636m	0.002m
SCCC	FOLLY7	5435.654m	-5129.304m	-9375.980m	11990.208m	0.004m
SCCC	FOLLY8	5436.065m	-5132.449m	-9381.216m	11995.834m	0.007m
SCCC	FOLLY9	5282.874m	-5243.239m	-9508.517m	12075.272m	0.005m
SCCC	FOLLY10	5260.117m	-5238.121m	-9495.924m	12053.187m	0.006m
SCCC	HOL1	3697.221m	-1439.748m	-3246.702m	5126.732m	0.004m
SCCC	HOL2	3624.890m	-1465.309m	-3266.376m	5094.720m	0.003m
SCCC	HOL3	3628.363m	-1468.945m	-3272.854m	5102.391m	0.003m
SCCC	HOL4	3635.659m	-1469.735m	-3275.807m	5109.701m	0.003m
SCCC	HOL5	3681.856m	-1446.248m	-3252.783m	5121.357m	0.003m
SCCC	KS1	8747.495m	5679.947m	6256.068m	12162.190m	0.005m
SCCC	KS2	8746.742m	5682.997m	6260.495m	12165.350m	0.003m
SCCC	KS3	8731.682m	5672.564m	6249.329m	12143.902m	0.006m
SCCC	KS4	8769.673m	5662.149m	6223.400m	12153.098m	0.004m
SCCC	KS5	8754.673m	5672.487m	6243.464m	12157.395m	0.004m
SCCC	PW1 1	3048.959m	8321.769m	9100.114m	17953.809m	0.005m
SCCC	PW2 1	3066.016m	8326.702m	9102.688m	17969.799m	0.005m
SCCC	PW3 1	3105.329m	8326.347m	9092.443m	17993.061m	0.005m
SCCC	PW4 1	3019.412m	8289.078m	9058.310m	17896.002m	0.007m
SCCC	PW5 1	3033.214m	8280.262m	9041.764m	17893.600m	0.004m
SCCC	PW6 1	2971.806m	8295.000m	9080.171m	17875.242m	0.005m
SCCC	PW7 1	2901.810m	8298.249m	9104.220m	17838.286m	0.004m
SCCC	SI1 1	0807.493m	934.976m	-1559.004m	10959.315m	0.004m
SCCC	SI2 1	0846.366m	902.123m	-1619.612m	11003.664m	0.004m
SCCC	SI3 1	0848.120m	894.907m	-1631.227m	11006.520m	0.004m
SCCC	SI4 1	0867.855m	875.703m	-1665.963m	11029.622m	0.004m
SCCC	SI5 BM 1	0880.840m	853.290m	-1703.431m	11046.378m	0.004m
SCCC	SI6 1	0900.870m	846.257m	-1720.845m	11068.262m	0.003m

SCCC	SI7	1	0916.044m	839.730m	-1732.670m	11084.552m	0.004m
SCCC	SI8	1	0807.285m	941.215m	-1549.394m	10958.280m	0.006m
SCCC	SI9	1	0782.757m	934.677m	-1552.777m	10934.011m	0.005m
SCCC	LUTHERAN	-	6142.685m	731.072m	2747.364m	6768.682m	0.003m
SCCC	LUTHERAO	-	6135.902m	744.473m	2765.779m	6771.489m	0.003m
SCCC	LUTHERAP	-	6135.902m	744.442m	2765.785m	6771.488m	0.002m
SCCC	LUTHERAN	-	6142.687m	731.072m	2747.366m	6768.684m	0.003m
SCCC	LUTHERAN1	-	6135.886m	744.455m	2765.747m	6771.460m	0.003m
SCCC	LUTHERAN2	-	6123.816m	748.621m	2769.007m	6762.319m	0.002m
SCCC	AG1	-1	1354.079m	-1543.751m	663.076m	11477.715m	0.004m
SCCC	AG2	-1	1366.556m	-1547.211m	661.214m	11490.416m	0.003m
SCCC	AG3	-1	1368.543m	-1550.970m	655.268m	11492.548m	0.003m
SCCC	AG4	-1	1291.491m	-1538.419m	653.574m	11414.537m	0.004m
SCCC	AG5	-1	1298.696m	-1536.855m	658.223m	11421.721m	0.003m
SCCC	AG6	-1	1585.541m	-1543.761m	724.271m	11710.360m	0.004m
SCCC	AG7	-1	1575.908m	-1536.817m	731.890m	11700.390m	0.004m
SCCC	SAL1	-1	4239.127m	8774.611m	17171.610m	23971.039m	0.006m
SCCC	SAL2	-1	4267.132m	8776.489m	17181.548m	23995.487m	0.006m
SCCC	SAL3	-1	4441.394m	8698.206m	17103.850m	24015.710m	0.003m
SCCC	SAL4	-1	4450.199m	8698.326m	17105.927m	24022.529m	0.003m
SCCC	SAL5	-1	4436.410m	8705.044m	17113.078m	24021.765m	0.005m
SCCC	SAL6	-1	4427.803m	8699.504m	17102.501m	24007.049m	0.006m
SCCC	8300H	-1	4270.483m	8789.125m	17202.513m	24017.116m	0.003m

Appendix D

Final Points and Calculated Error Values

Ground Control Points: Colleton and Charleston Counties South Carolina

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December 14, 2007

Overview

The following (attached) is a list of the ground control points collected in association with the QA task for Colleton and Charleston Counties, South Carolina. The points were collected with and under the supervision of South Carolina's State Geodetic Advisor from the National Geodetic Survey (NGS). The points were collected using a total station and Global Positioning System (GPS) with the Virtual Reference System (VRS). The elevation data has a nominal accuracy between than 2 and 5 cm, which is at least 3X better than the expected lidar data.

County	Name	Land use	Picture	Date	Type	Elev_ft	Elev_m	Lidar	Error	Absolute
Charleston	8300H	Bare Earth	8300H	10/10/2007	GPS	-71.83	-21.894	-22.062	-0.168	0.168
Charleston	Ag1	Weeds/Crops	Ag1	9/21/2007	GPS	-99.772	-30.411	-30.476	-0.066	0.066
Charleston	Ag2	Bare Earth	Ag2	9/21/2007	GPS	-99.62	-30.364	-30.485	-0.121	0.121
Charleston	Ag3	Weeds/Crops	Ag3	9/21/2007	GPS	-100.919	-30.760	-30.859	-0.099	0.099
Charleston	Ag4	Forest	Ag4	9/21/2007	GPS	-101.345	-30.890	-30.915	-0.024	0.024
Charleston	Ag5	Bare Earth	Ag5	9/21/2007	GPS	-100.762	-30.712	-30.842	-0.129	0.129
Charleston	Ag6	Bare Earth	Ag6	9/21/2007	GPS	-101.194	-30.844	-31.011	-0.167	0.167
Charleston	Ag7	Forest	Ag7	9/21/2007	GPS	-101.936	-31.070	-31.288	-0.218	0.218
Charleston	CSC10	Weeds/Crops	CSC10	10/10/2007	Total Station	-105.26	-32.083	-31.985	0.098	0.098
Charleston	CSC11	Weeds/Crops	CSC11	10/10/2007	Total Station	-106.28	-32.394	-32.321	0.073	0.073
Charleston	CSC12	Weeds/Crops	CSC12	10/10/2007	Total Station	-106.25	-32.385	-32.318	0.067	0.067
Charleston	CSC13	Bare Earth	CSC13	10/10/2007	Total Station	-106.23	-32.379	-32.342	0.037	0.037
Charleston	CSC14	Scrub/Shrub	CSC14	10/10/2007	Total Station	-105.56	-32.175	-32.069	0.106	0.106
Charleston	CSC2	Bare Earth	CSC2	10/10/2007	Total Station	-103.67	-31.599	-31.641	-0.042	0.042
Charleston	CSC3	Urban	CSC3	10/10/2007	Total Station	-102.7	-31.303	-31.246	0.057	0.057
Charleston	CSC4	Forest	CSC4	10/10/2007	Total Station	-102.4	-31.212	-31.237	-0.025	0.025
Charleston	CSC5	Bare Earth	CSC5	10/10/2007	Total Station	-99.46	-30.315	-30.282	0.034	0.034
Charleston	CSC6	Weeds/Crops	CSC6	10/10/2007	Total Station	-98.72	-30.090	-30.099	-0.009	0.009
Charleston	CSC7	Forest	CSC7	10/10/2007	Total Station	-99.97	-30.471	-30.441	0.030	0.030
Charleston	CSC8	Scrub/Shrub	CSC8	10/10/2007	Total Station	-99.59	-30.355	-30.217	0.138	0.138
Charleston	CSC9	Bare Earth	CSC9	10/10/2007	Total Station	-103.17	-31.446	-31.274	0.172	0.172
Charleston	Folly10	Forest	Folly10	9/20/2007	GPS	-102.935	-31.375	-31.630	-0.256	0.256
Charleston	Folly7	Urban	Folly7	9/20/2007	GPS	-101.193	-30.844	-30.975	-0.131	0.131
Charleston	Folly8	Weeds/Crops	Folly8	9/20/2007	GPS	-101.72	-31.004	-31.113	-0.108	0.108
Charleston	Folly9	Bare Earth	Folly9	9/20/2007	GPS	-100.302	-30.572	-30.709	-0.137	0.137
Charleston	Hol1	Bare Earth	Hol1	9/20/2007	GPS	-101.456	-30.924	-30.886	0.038	0.038
Charleston	Hol2	Forest	Hol2	9/20/2007	GPS	-101.842	-31.042	-30.974	0.067	0.067
Charleston	Hol3	Bare Earth	Hol3	9/20/2007	GPS	-101.781	-31.023	-31.003	0.020	0.020
Charleston	Hol4	Scrub/Shrub	Hol4	9/20/2007	GPS	-101.348	-30.891	-30.789	0.102	0.102
Charleston	Hol5	Urban	Hol5	9/20/2007	GPS	-101.938	-31.071	-31.037	0.034	0.034
Charleston	KS1	Bare Earth	KS1	9/20/2007	GPS	-91.384	-27.854	-27.866	-0.012	0.012
Charleston	KS2	Urban	KS2	9/20/2007	GPS	-92.145	-28.086	-28.079	0.007	0.007
Charleston	KS3	Forest	KS3	9/20/2007	GPS	-91.04	-27.749	-27.737	0.012	0.012
Charleston	KS4	Scrub/Shrub	KS4	9/20/2007	GPS	-90.449	-27.569	-27.588	-0.019	0.019
Charleston	KS5	Forest	KS5	9/20/2007	GPS	-90.084	-27.458	-27.553	-0.095	0.095
Charleston	L1	Bare Earth	L1	9/21/2007	GPS	-86.326	-26.312	-26.351	-0.039	0.039
Charleston	L2	Urban	L2	9/21/2007	GPS	-86.063	-26.232	-26.407	-0.175	0.175
Charleston	L3	Forest	L3	9/21/2007	Total Station	-85.4	-26.030	-26.139	-0.109	0.109
Charleston	L4	Forest	L4	9/21/2007	Total Station	-85.8	-26.152	-26.147	0.005	0.005
Charleston	L5	Forest	L5	9/21/2007	Total Station	-86.79	-26.454	-26.585	-0.131	0.131
Charleston	L6	Forest	L6	9/21/2007	Total Station	-86.45	-26.350	-26.476	-0.126	0.126
Charleston	L7	Scrub/Shrub	L7	9/21/2007	Total Station	-85.46	-26.048	-26.131	-0.083	0.083
Charleston	L8	Bare Earth	L8	9/21/2007	Total Station	-85.44	-26.042	-26.126	-0.083	0.083
Charleston	Lutheran	Bare Earth	Lutheran	9/21/2007	GPS	-85.98	-26.207	-26.304	-0.097	0.097
Charleston	PW1	Bare Earth	PW1	9/21/2007	GPS	-96.144	-29.305	-29.253	0.052	0.052
Charleston	PW2	Urban	PW2	9/21/2007	GPS	-96.6	-29.444	-29.405	0.039	0.039
Charleston	PW3	Bare Earth	PW3	9/21/2007	GPS	-94.675	-28.857	-28.856	0.001	0.001
Charleston	PW4	Forest	PW4	9/21/2007	GPS	-96.395	-29.381	-29.411	-0.030	0.030
Charleston	PW5	Scrub/Shrub	PW5	9/21/2007	GPS	-95.215	-29.022	-28.922	0.100	0.100
Charleston	PW6	Forest	PW6	9/21/2007	GPS	-96.773	-29.496	-29.436	0.061	0.061
Charleston	PW7	Bare Earth	PW7	9/21/2007	GPS	-96.946	-29.549	-29.574	-0.024	0.024
Charleston	SAL1	Bare Earth	SAL1	10/10/2007	GPS	-72.79	-22.186	-22.249	-0.063	0.063
Charleston	SAL2	Urban	SAL2	10/10/2007	GPS	-73.43	-22.382	-22.431	-0.050	0.050
Charleston	SAL3	Weeds/Crops	SAL3	10/10/2007	GPS	-82.58	-25.170	-25.165	0.005	0.005
Charleston	SAL4	Scrub/Shrub	SAL4	10/10/2007	GPS	-83.38	-25.414	-25.416	-0.002	0.002
Charleston	SAL5	Bare Earth	SAL5	10/10/2007	GPS	-82.28	-25.079	-25.054	0.025	0.025
Charleston	SAL6	Forest	SAL6	10/10/2007	GPS	-82.06	-25.012	-25.053	-0.041	0.041
Charleston	SI1	Urban	SI1	9/21/2007	GPS	-102.106	-31.122	-31.094	0.028	0.028
Charleston	SI2	Bare Earth	SI2	9/21/2007	GPS	-101.562	-30.956	-30.926	0.031	0.031
Charleston	SI3	Scrub/Shrub	SI3	9/21/2007	GPS	-101.737	-31.009	-30.819	0.191	0.191
Charleston	SI4	Weeds/Crops	SI4	9/21/2007	GPS	-101.647	-30.982	-30.854	0.128	0.128
Charleston	SI5	Bare Earth	SI5	9/21/2007	GPS	-100.889	-30.751	-30.694	0.057	0.057
Charleston	SI6	Weeds/Crops	SI6	9/21/2007	GPS	-103.039	-31.406	-31.400	0.006	0.006
Charleston	SI7	Bare Earth	SI7	9/21/2007	GPS	-98.914	-30.149	-30.342	-0.193	0.193
Charleston	SI8	Forest	SI8	9/21/2007	GPS	-102.083	-31.115	-31.107	0.008	0.008
Charleston	SI9	Bare Earth	SI9	9/21/2007	GPS	-102.294	-31.179	-31.175	0.005	0.005
Charleston	T2	Bare Earth	T2	9/20/2007	GPS	-101.067	-30.805	-30.819	-0.014	0.014
Charleston	T3	Urban	T3	9/20/2007	GPS	-101.869	-31.050	-31.075	-0.025	0.025
Colleton	15011	Grass/Weeds	7312006001	7/30/2007	GPS, Bench	-56.83	-17.322	-17.370	-0.048	0.048
Colleton	15080	Scrub/Shrub	7312007017	7/31/2007	GPS,Bench	-95.23	-29.025	-28.972	0.054	0.054
Colleton	15 083A	Bare Earth	7312007018	7/31/2007	Total Station	-73.67	-22.455	-22.389	0.066	0.066
Colleton	15 083B	Forest	7312007019	7/31/2007	Total Station	-74.02	-22.561	-22.509	0.053	0.053
Colleton	15 083C	Forest	7312007020	7/31/2007	Total Station	-73.48	-22.397	-22.309	0.088	0.088
Colleton	15 083D	Scrub/Shrub	7312007021	7/31/2007	Total Station	-75.88	-23.128	-23.142	-0.014	0.014

Colleton	15 083E	Grass/Weeds	7312007022	7/31/2007	Total Station	-75.91	-23.137	-23.163	-0.026	0.026
Colleton	15 083F	Urban	7312007023	7/31/2007	Total Station	-73.75	-22.479	-22.495	-0.016	0.016
Colleton	15 123 BM	Grass/Weeds	7312007032	7/31/2007	GPS	-92.015	-28.046	-28.014	0.032	0.032
Colleton	15 123 F	Bare Earth	7312007038	7/31/2007	GPS	-91.154	-27.784	-27.815	-0.031	0.031
Colleton	15 123A	Forest	7312007033	7/31/2007	GPS	-97.388	-29.684	-29.718	-0.034	0.034
Colleton	15 123B	Bare Earth	7312007034	7/31/2007	GPS	-92.259	-28.121	-28.216	-0.095	0.095
Colleton	15 123C	Scrub/Shrub	7312007035	7/31/2007	GPS	-92.75	-28.270	-28.373	-0.103	0.103
Colleton	15 123D	Urban	7312007036	7/31/2007	GPS	-91.464	-27.878	-27.909	-0.030	0.030
Colleton	15 123E	Forest	7312007037	7/31/2007	GPS	-94.431	-28.783	-28.792	-0.010	0.010
Colleton	15-011A	Grass/Weeds/Crops	7312007003	7/31/2007	Total Station	-56.75	-17.297	-17.328	-0.030	0.030
Colleton	15-011B	Forest	7312007004	7/31/2007	Total Station	-57.05	-17.389	-17.335	0.054	0.054
Colleton	15-011C	Grass/Weeds	7312007005	7/31/2007	Total Station	-57.25	-17.450	-17.492	-0.043	0.043
Colleton	15-011D	Bare Earth	7312007006	7/31/2007	Total Station	-56.13	-17.108	-17.122	-0.013	0.013
Colleton	15-011E	Forest	7312007007	7/31/2007	Total Station	-58.21	-17.742	-17.734	0.009	0.009
Colleton	15-011F	Urban	7312007008	7/31/2007	Total Station	-56.21	-17.133	-17.199	-0.066	0.066
Colleton	15-011G	Scrub/Shrub	7312007009	7/31/2007	Total Station	-56.29	-17.157	-17.147	0.010	0.010
Colleton	15-020E	Forest	7312007030	7/31/2007	Total Station	-79.17	-24.131	-23.810	0.321	0.321
Colleton	15-031B	Scrub/Shrub	028_27	7/30/2007	GPS	-8.39	-2.524	-2.408	0.116	0.116
Colleton	15-031C	Scrub/Shrub	027_26	7/30/2007	GPS	-9.40	-2.832	-2.628	0.204	0.204
Charleston	T4	Urban		9/20/2007	GPS	-100.55	-30.648	-30.635	0.013	0.013
Charleston	T5	Bare Earth		9/20/2007	GPS	-98.18	-29.925	-29.818	0.107	0.107
Charleston	T6	Forest		9/20/2007	GPS	-98.474	-30.015	-30.100	-0.085	0.085
Charleston	Folly1	Weeds/Crops		9/20/2007	GPS	-99.687	-30.385	-30.357	0.027	0.027
Charleston	Folly3	Urban		9/20/2007	GPS	-100.393	-30.600	-30.703	-0.104	0.104
Charleston	Folly4	Scrub/Shrub		9/20/2007	GPS	-101.706	-31.000	-30.966	0.035	0.035
Charleston	Folly5	Forest		9/20/2007	GPS	-101.486	-30.933	-31.072	-0.139	0.139
Colleton	15-031D	Grass/Weeds	026_25	7/30/2007	GPS	-9.65	-2.908	-2.643	0.264	0.264
Colleton	15-031E	Bare Earth	025_24	7/30/2007	GPS	-9.11	-2.743	-2.691	0.052	0.052
Colleton	15-031F	Urban	023_22	7/30/2007	GPS	-8.04	-2.451	-2.412	0.038	0.038
Colleton	15080-A	Scrub/Shrub	7312007010	7/31/2007	GPS	-95.70	-29.168	-29.080	0.088	0.088
Colleton	15080-B	Grass/Weeds	7312007011	7/31/2007	GPS	-96.02	-29.265	-29.110	0.156	0.156
Colleton	15080-C	Bare Earth	7312007012	7/31/2007	GPS	-94.91	-28.929	-28.919	0.010	0.010
Colleton	15080-D	Forest	7312007013	7/31/2007	GPS	-95.19	-29.013	-28.920	0.093	0.093
Colleton	15080-E	Scrub/Shrub	7312007014	7/31/2007	GPS	-95.35	-29.062	-28.959	0.102	0.102
Colleton	15080-F	Urban	7312007015	7/31/2007	GPS	-94.57	-28.825	-28.775	0.050	0.050
Colleton	15-088	Bare Earth	7312007031	7/31/2007	GPS	-78.53	-23.936	-23.776	0.160	0.160
Colleton	15-120	Bare Earth	7312007024	7/31/2007	Total Station	-82.50	-25.146	-25.069	0.077	0.077
Colleton	15-120A	Grass/Weeds	7312007025	7/31/2007	Total Station	-81.74	-24.914	-24.795	0.119	0.119
Colleton	15-120B	Forest	7312007026	7/31/2007	Total Station	-78.86	-24.037	-23.946	0.090	0.090
Colleton	15-120C	Bare Earth	7312007028	7/31/2007	Total Station	-79.21	-24.143	-24.057	0.087	0.087
Colleton	15-120D	Urban	7312007029	7/31/2007	Total Station	-79.07	-24.101	-23.978	0.123	0.123
Colleton	5 WLC1	Bare Earth	022_21	7/30/2007	GPS	-7.21	-2.198	-2.145	0.052	0.052
Colleton	5 WLC2	Forest	021_20	7/30/2007	Total Station	-7.05	-2.149	-1.885	0.264	0.264
Colleton	5 WLC3	Scrub/Shrub	020_19	7/30/2007	Total Station	-7.32	-2.231	-2.105	0.126	0.126
Colleton	5 WLC4	Scrub/Shrub	019_18	7/30/2007	Total Station	-7.4	-2.256	-2.180	0.075	0.075
Colleton	5 WLC5	Urban	018_17	7/30/2007	Total Station	-6.69	-2.039	-1.969	0.070	0.070
Colleton	5 WLC6	Grass/Weeds	016_15	7/30/2007	Total Station	-6.6	-2.012	-1.935	0.077	0.077
Colleton	CK4302A	Bare Earth	8142007010	9/14/2007	GPS	-100.55	-30.648	-30.757	-0.109	0.109
Colleton	CK4302B	Forest	8142007011	9/14/2007	GPS	-100.57	-30.654	-30.704	-0.050	0.050
Colleton	CK4302C	Urban	8142007012	9/14/2007	GPS	-100.23	-30.550	-30.673	-0.123	0.123
Colleton	CK4302D	Grass/Weeds/Crops	8142007013	9/14/2007	GPS	-102.24	-31.163	-31.253	-0.090	0.090
Colleton	CK4302E	Scrub/Shrub	8142007014	9/14/2007	GPS	-103.28	-31.480	-31.384	0.096	0.096
Colleton	E2	Bare Earth	028 -27	7/30/2007	GPS	3.574	1.089	1.119	0.029	0.029
Colleton	E3	Forest	027_26	7/30/2007	GPS	4.703	1.433	1.420	-0.013	0.013
Colleton	E4	Scrub/Shrub	025_24	7/30/2007	Total Station	1.71	0.521	0.596	0.075	0.075
Colleton	E5	Grass/Weeds	024_23	7/30/2007	Total Station	-1.03	-0.314	-0.259	0.055	0.055
Colleton	E6	Forest	023_22	7/30/2007	Total Station	0.63	0.192	0.185	-0.007	0.007
Colleton	E7	Urban	022_21	7/30/2007	Total Station	0.46	0.140	0.171	0.031	0.031
Colleton	E8	CheckPoint(BE)		7/30/2007	Total Station	4.58	1.396	1.420	0.024	0.024
Colleton	ED-1	Urban	8142007035	9/14/2007	GPS	-101.08	-30.809	-30.792	0.017	0.017
Colleton	ED-2	Bare Earth	8142007037	9/14/2007	GPS	-99.48	-30.322	-30.193	0.128	0.128
Colleton	ED-3	Forest	8142007039	9/14/2007	GPS	-100.24	-30.553	-30.542	0.011	0.011
Colleton	ED-4	Bare Earth	8142007041	9/14/2007	GPS	-100.31	-30.574	-30.566	0.009	0.009
Colleton	ED-5	Scrub/Shrub	8142007043	9/14/2007	GPS	-98.75	-30.099	-30.062	0.037	0.037
Colleton	ED-6	rass/Dune/Tall Gras	8142007045	9/14/2007	GPS	-95.38	-29.072	-29.038	0.034	0.034
Colleton	ED-7	Beach	8142007047	9/14/2007	GPS	-96.67	-29.465	-29.442	0.023	0.023
Colleton	ED-9	Grass/Weeds/Crops	8142007051	9/14/2007	GPS	-103.83	-31.647	-31.387	0.260	0.260
Colleton	ERVIN	Bare Earth	none	7/30/2007	Benchmark	4.06	1.237	1.263	0.026	0.026
Colleton	ERVIN1	Urban	026_25	7/30/2007	GPS	1.96	0.597	0.625	0.028	0.028
Colleton	NERR-2	Bare Earth	8142007016	9/14/2007	GPS	-96.58	-29.438	-29.384	0.054	0.054
Colleton	NERR-3	Forest	8142007019	9/14/2007	Total Station	-99.53	-30.337	-30.222	0.114	0.114
Colleton	NERR-4	Scrub/Shrub	8142007021	9/14/2007	Total Station	-100.44	-30.614	-30.524	0.090	0.090
Colleton	NERR-5	Forest	8142007023	9/14/2007	Total Station	-99.70	-30.389	-30.287	0.101	0.101
Colleton	NERR-6	Grass/Weeds	8142007025	9/14/2007	Total Station	-96.99	-29.563	-29.450	0.112	0.112
Colleton	NERR-7	Urban	8142007027	9/14/2007	Total Station	-96.79	-29.502	-29.400	0.101	0.101

Colleton	NERR-8	Bare Earth	8142007029	9/14/2007	Total Station	-98.72	-30.090	-30.064	0.026	0.026
Colleton	NERR-9	Urban	8142007031	9/14/2007	Total Station	-98.22	-29.937	-29.868	0.069	0.069
Colleton	SSMC	Bare Earth	009_08	7/30/2007	Benchmark	-28.80	-8.778	-8.781	-0.003	0.003
Colleton	SSMC-1	Bare Earth	014_13	7/30/2007	GPS	-27.28	-8.315	-8.293	0.021	0.021
Colleton	SSMC-2	Forest	013_12	7/30/2007	Total Station	-29.91	-9.117	-8.884	0.233	0.233
Colleton	SSMC-3	Grass/Weeds	012_11	7/30/2007	Total Station	-30.43	-9.275	-9.237	0.038	0.038
Colleton	SSMC-4	Scrub/Shrub	011_10	7/30/2007	Total Station	-30.61	-9.330	-9.226	0.104	0.104
Colleton	SSMC-5	Urban	010_9	7/30/2007	Total Station	-30.43	-9.275	-9.255	0.020	0.020
Colleton	WS	Grass/Weeds		7/30/2007	Benchmark	-1.07	-0.326	-0.434	-0.108	0.108
Colleton	WS-11	Grass/Weeds	008_7	7/30/2007	GPS	-0.91	-0.277	-0.250	0.028	0.028
Colleton	WS-2	Forest	001_0	7/30/2007	Total Station	-1.02	-0.311	-0.363	-0.052	0.052
Colleton	WS-3	Forest	007_6	7/30/2007	Total Station	-2.50	-0.762	-0.802	-0.040	0.040
Colleton	WS-4	Scrub/shrub	006_5	7/30/2007	Total Station	-3.20	-0.975	-0.969	0.007	0.007
Colleton	WS-5	Grass/Weeds/Crops	005_4	7/30/2007	Total Station	-3.12	-0.951	-0.930	0.021	0.021
Colleton	WS-6	Urban	004_3	7/30/2007	Total Station	-0.70	-0.213	-0.225	-0.012	0.012
Colleton	WS-7	Grass/Weeds/Crops	003_2	7/30/2007	Total Station	-1.41	-0.430	-0.507	-0.078	0.078
Colleton	WS-8	Bare Earth	002_1	7/30/2007	Total Station	-0.82	-0.250	-0.300	-0.050	0.050

Charleston County Points and Photo ID's

Sample Point ID	Lat N	Long W	Ellipsoid Height (US Survey Ft)	Land Cover Type	Photo ID	Sample Date	Sample Method
Tidal 13	32 46 52.33542	79 55 28.70940	-101.611			9/20/2007	GPS
T1	32 46 50.90865	79 55 26.29075	-100.012			9/20/2007	GPS
T2	32 46 51.41886	79 55 32.34251	-101.067	Bare Earth	1652 1653	9/20/2007	GPS
T3	32 46 51.10555	79 55 33.64867	-101.869	Urban	1654	9/20/2007	GPS
T4	32 46 44.44630	79 55 30.83245	-100.55	Urban	1655	9/20/2007	GPS
T5	32 46 43.34905	79 55 30.75135	-98.18	Bare Earth	1656	9/20/2007	GPS
T6	32 46 43.67341	79 55 30.92684	-98.474	Forest	1657	9/20/2007	GPS
Folly1	32 41 04.96645	79 53 09.84332	-99.687	Grass/Weeds	1658 1659	9/20/2007	GPS
Folly2	32 41 04.40071	79 53 09.77053	-103.396	Beach/Sand	1660 1662	9/20/2007	GPS
Folly3	32 40 53.74714	79 53 30.20721	-100.393	Urban		9/20/2007	GPS
Folly4	32 40 55.02224	79 53 28.83271	-101.706	Scrub/Shrub		9/20/2007	GPS
Folly5	32 40 56.00239	79 53 27.00041	-101.486	Forest		9/20/2007	GPS
Folly6	32 40 58.14697	79 53 24.82366	-100.426	Forest		9/20/2007	GPS
Folly7	32 40 57.12039	79 53 25.72801	-101.193	Urban		9/20/2007	GPS
Folly8	32 40 56.92179	79 53 25.73366	-101.72	Grass/Weeds		9/20/2007	GPS
Folly9	32 40 52.00302	79 53 32.26899	-100.302	Bare Earth		9/20/2007	GPS
Folly10	32 40 52.50540	79 53 33.09450	-102.935	Forest		9/20/2007	GPS
Hol1	32 44 53.60442	79 54 06.59315	-101.456	Bare Earth		9/20/2007	GPS
Hol2	32 44 52.84814	79 54 09.50026	-101.842	Forest		9/20/2007	GPS
Hol3	32 44 52.59773	79 54 09.39341	-101.781	Bare Earth		9/20/2007	GPS
Hol4	32 44 52.48100	79 54 09.12283	-101.348	Scrub/Shrub		9/20/2007	GPS
Hol5	32 44 53.37342	79 54 07.21752	-101.938	Urban		9/20/2007	GPS
KS1	32 51 00.52189	79 50 07.37429	-91.384	Bare Earth		9/20/2007	GPS
KS2	32 51 00.69778	79 50 07.38207	-92.145	Urban		9/20/2007	GPS
KS3	32 51 00.25927	79 50 08.02297	-91.04	Forest		9/20/2007	GPS
KS4	32 50 59.25361	79 50 06.65557	-90.449	Scrub/Shrub		9/20/2007	GPS
KS5	32 51 00.02654	79 50 07.15320	-90.084	Forest	1681	9/20/2007	GPS
PW1	32 52 50.46536	79 47 06.55661	-96.144	Bare Earth	1684 1685	9/21/2007	GPS
PW2	32 52 50.56776	79 47 05.87716	-96.6	Urban	1686 1687	9/21/2007	GPS
PW3	32 52 50.15945	79 47 04.39116	-94.675	Bare Earth	1688 1689	9/21/2007	GPS
PW4	32 52 48.85108	79 47 07.89829	-96.395	Forest	1691 1692	9/21/2007	GPS
PW5	32 52 48.20399	79 47 07.43589	-95.215	Scrub/Shrub	1693 1694	9/21/2007	GPS
PW6	32 52 49.69852	79 47 09.66028	-96.773	Forest	1695 1696	9/21/2007	GPS
PW7	32 52 50.62919	79 47 12.28825	-96.946	Bare Earth	1698 1699	9/21/2007	GPS
SI1	32 45 58.75500	79 49 21.64202	-102.106	Urban	1700	9/21/2007	GPS
SI2	32 45 56.41184	79 49 20.39503	-101.562	Bare Earth	1701	9/21/2007	GPS
SI3	32 45 55.96454	79 49 20.37765	-101.737	Scrub/Shrub	1702	9/21/2007	GPS
SI4	32 45 54.62301	79 49 19.76176	-101.647	Grass/Weeds	1703	9/21/2007	GPS
SI5	32 45 53.17301	79 49 19.42365	-100.889		1704 1705	9/21/2007	GPS
SI6	32 45 52.51327	79 49 18.71318	-103.039	Grass/Weeds	1706	9/21/2007	GPS
SI7	32 45 52.03049	79 49 18.18367	-98.914	Dune/Bare Earth	1707	9/21/2007	GPS
SI8	32 45 59.12585	79 49 21.60754	-102.083	Forest	1708	9/21/2007	GPS
SI9	32 45 58.99657	79 49 22.57947	-102.294	Bare Earth	1709	9/21/2007	GPS
Lutheran	32 48 44.93844	80 00 04.35764	-85.98	Bare Earth	1710 1712	9/21/2007	GPS
L1	32 48 45.65178	80 00 04.01123	-86.326	Bare Earth	1713	9/21/2007	GPS
L2	32 48 45.77534	80 00 03.52610	-86.063	Urban	1714	9/21/2007	GPS
L3	32 48 44.65977	80 00 04.94842	-85.4	Forest	1715 1716	9/21/2007	Total Station
L4	32 48 44.12551	80 00 05.86399	-85.8	Forest	1717 1718	9/21/2007	Total Station
L5	32 48 43.95161	80 00 03.08608	-86.79	Forest	1719 1720	9/21/2007	Total Station
L6	32 48 45.91990	80 00 03.07435	-86.45	Forest	1722 1723	9/21/2007	Total Station
L7	32 48 45.49054	80 00 04.34471	-85.46	Scrub/Shrub	1724 1725	9/21/2007	Total Station
L8	32 48 45.29678	80 00 04.68550	-85.44	Bare Earth	1726	9/21/2007	Total Station
Ag1	32 47 24.53324	80 03 36.77616	-99.772	Grass/Weeds	1727	9/21/2007	GPS
Ag2	32 47 24.46036	80 03 37.27141	-99.62	Bare Earth	1728	9/21/2007	GPS
Ag3	32 47 24.23904	80 03 37.37157	-100.919	Weeds/Crops	1729	9/21/2007	GPS
Ag4	32 47 24.17632	80 03 34.37153	-101.345	Forest	1730	9/21/2007	GPS
Ag5	32 47 24.35213	80 03 34.63389	-100.762	Bare Earth	1731	9/21/2007	GPS
Ag6	32 47 26.90530	80 03 45.53816	-101.194	Bare Earth	1732	9/21/2007	GPS
Ag7	32 47 27.20424	80 03 45.12748	-101.936	Forest	1733	9/21/2007	GPS
EMR	32 49 57.65610	79 56 16.38968	-104.06	Benchmark	DSCN1060	10/10/2007	Total Station

CSC2	32 50 00.52474	79 56 16.61655	-103.67	Bare Earth	DSCN1073	10/10/2007	Total Station
CSC3	32 49 57.62336	79 56 16.84368	-102.7	Urban	DSCN1059	10/10/2007	Total Station
CSC4	32 49 57.64532	79 56 17.14009	-102.4	Forest	DSCN1061	10/10/2007	Total Station
CSC5	32 49 55.31913	79 56 17.97861	-99.46	Bare Earth	DSCN1062	10/10/2007	Total Station
CSC6	32 49 54.73191	79 56 18.35298	-98.72	Weeds	DSCN1065	10/10/2007	Total Station
CSC7	32 49 54.69879	79 56 18.65269	-99.97	Forest	DSCN1066	10/10/2007	Total Station
CSC8	32 49 55.00378	79 56 18.99479	-99.59	Scrub/shrub	DSCN1067	10/10/2007	Total Station
CSC9	32 49 57.57052	79 56 16.47270	-103.17	Bare Earth	DSCN1068	10/10/2007	Total Station
CSC10	32 49 57.40749	79 56 16.24489	-105.26	Weeds/High Marsh	DSCN1069	10/10/2007	Total Station
CSC11	32 49 58.46790	79 56 15.80330	-106.28	Marsh Grass	DSCN1070	10/10/2007	Total Station
CSC12	32 49 58.97289	79 56 15.56158	-106.25	Marsh Grass	DSCN1071	10/10/2007	Total Station
CSC13	32 49 59.20276	79 56 15.47602	-106.23	Mud	DSCN1072	10/10/2007	Total Station
CSC14	32 49 59.38704	79 56 15.37645	-105.56	Scrub/shrub	DSCN1074	10/10/2007	Total Station
8300H	32 58 03.64550	80 04 18.71301	-71.83	Bare Earth	DSCN1081	10/10/2007	GPS
SAL1	32 58 02.45594	80 04 17.61987	-72.79	Bare Earth	DSCN1075	10/10/2007	GPS
SAL2	32 58 02.84456	80 04 18.66967	-73.43	Urban	DSCN1076	10/10/2007	GPS
SAL3	32 57 59.89713	80 04 25.79935	-82.58	Weeds/Grass	DSCN1077	10/10/2007	GPS
SAL4	32 57 59.98259	80 04 26.13254	-83.38	Scrub/Shrub	DSCN1078	10/10/2007	GPS
SAL5	32 58 00.25225	80 04 25.56492	-82.28	Bare Earth	DSCN1079	10/10/2007	GPS
SAL6	32 57 59.84159	80 04 25.27520	-82.06	Forest	DSCN1080	10/10/2007	GPS